

# SINAMICS G120

## SINAMICS G120C Inverter

Operating Instructions · 01/2011



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### SINAMICS G120C SINAMICS G120C Inverter

#### Operating Instructions

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## 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.

 <b>DANGER</b>
indicates that death or severe personal injury <b>will</b> result if proper precautions are not taken.

 <b>WARNING</b>
indicates that death or severe personal injury <b>may</b> result if proper precautions are not taken.

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

<b>NOTICE</b>
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

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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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## 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).



### **DANGER**

#### **Risk of electrical shock!**

Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off.

It is not permissible to carry out any installation work before this time has expired!



### **WARNING**

#### **General**

This equipment contains dangerous voltages and controls potentially dangerous rotating mechanical parts.

Protection in case of direct contact by means of SELV / PELV 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 must be applied e.g. protective insulation.

The inverter must always be grounded. As the earth leakage for this product can be greater than 3.5 mA a.c., a fixed earth connection is required and the minimum size of the protective earth conductor shall comply with the local safety regulations for high leakage current equipment.

Install the inverter on a metal mounting plate. The mounting plate has to be unpainted and with a good electrical conductivity.

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

Take particular notice of the general and regional installation and safety regulations regarding work on dangerous voltage installations (e.g. EN 50178) as well as the relevant regulations regarding the correct use of tools and personal protective equipment (PPE).



### **CAUTION**

Static discharges on surfaces or interfaces that are not generally accessible (e.g. terminal or connector pins) can cause malfunctions or defects. Therefore, when working with inverters or inverter components, ESD protective measures should be observed.

 **CAUTION**

**Transport and storage**

The level of physical shocks and vibration during transport and storage must correspond to class 2M3 according to EN 60721-3-2. It is important that the equipment is protected from water (rainfall) and excessive temperatures.

 **WARNING**

**Installation and Commissioning**

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.).

 **WARNING**

**Operation**

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**

Filtered drives can only be used on power systems with grounded starpoint.

 **CAUTION**

This equipment is suitable for use in a power system up to 10,000 symmetrical amperes (rms), for the maximum rated voltage + 10 % when protected by an appropriate standard fuse (refer to the catalogue for the type of fuse).



 **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.

 **WARNING**

**Repair**

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.



# Introduction

## 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?

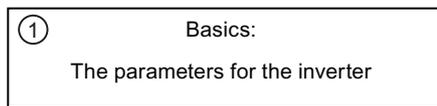
These operating instructions provide a summary of all of the information required to operate the inverter under normal, safe conditions.

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.

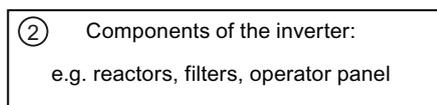
The operating instructions also contain information about special applications. Since it is assumed that readers already have a sound technical knowledge of how to configure and parameterize these applications, the relevant information is summarized accordingly. This relates, e.g. to operation with fieldbus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

## 2.2 Guide through this manual

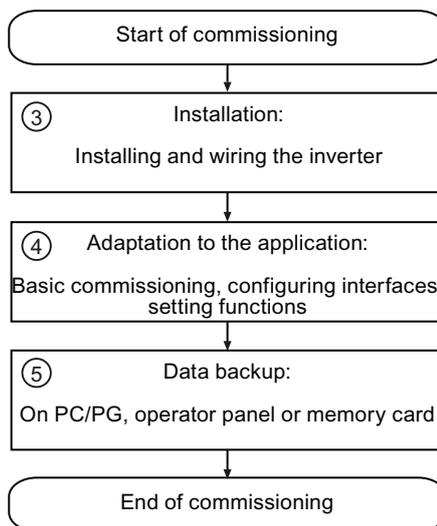
In this manual, you will find background information on your inverter, as well as a full description of the commissioning procedure:



- ① Should you be unfamiliar with assigning parameters to the inverter, background information can be found here:
- Adapting inverter to application (Page 15)
  - Frequently required parameters (Page 16)
  - Extended scope for adaptation (Page 18)

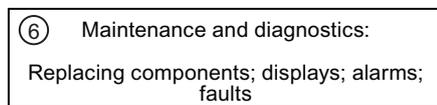


- ② Information on the inverter hardware can be found here:
- SINAMICS G120C inverter (Page 21)

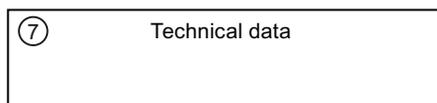


All information relating to the commissioning of your inverter is located in the following chapters:

- ③ • Installing (Page 25)
- ④ • Commissioning (Page 47)
- Adapting the terminal strip (Page 79)
  - Configuring the fieldbus (Page 91)
- ⑤ • Data backup and series commissioning (Page 71)



- ⑥ Information regarding the maintenance and diagnostics of your inverter is located in the following chapters:
- Servicing and maintaining (Page 247)
  - Alarms, faults and system messages (Page 255)



- ⑦ The most important technical data for your inverter is located in this chapter:
- Technical data (Page 273)

## 2.3 Adapting inverter to application

### 2.3.1 General basics

Inverters are used to improve and extend the starting and speed response of motors.

#### Adapting the inverter to the drive task

The inverter must match the motor that it is controlling and the drive task to be able to optimally operate and protect the motor.

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

#### Use the factory settings (where possible)

In simple applications, the inverter already functions with its factory settings.

#### Only basic commissioning is required ... for simple, standard applications

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

### 2.3.2 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. r0027 is the parameter for the inverter output current.

## 2.4 Frequently required parameters

### Commonly used parameters

Table 2- 1 Switching to commissioning mode or restore the factory setting

Parameter	Description
p0010	<b>Commissioning parameters</b> 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 2- 2 How to determine the firmware version of the Control Unit

Parameter	Description
r0018	The firmware version is displayed:

Table 2- 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 41).

Table 2- 4 This is how you parameterize the up and down ramps

Parameter	Description
p1080	<b>Minimum speed</b> 0.00 [rpm] factory setting
p1082	<b>Maximum speed</b> 1500.000 [rpm] factory setting
p1120	<b>Rampup time</b> 10.00 [s]
p1121	<b>Rampdown time</b> 10.00 [s]

Table 2- 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 2- 6 Optimizing starting behavior for V/f control for a high break loose torque and overload

Parameter	Description
p1310	<b>Voltage boost to compensate ohmic losses</b> 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: $1.732 \times \text{rated motor current (p0305)} \times \text{stator resistance (r0395)} \times \text{p1310} / 100\%$
p1311	<b>Voltage boost when accelerating</b> 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: $1.732 \times \text{rated motor current (p0305)} \times \text{stator resistance (p0350)} \times \text{p1311} / 100\%$
p1312	<b>Voltage boost when starting</b> Setting for an additional voltage boost when powering-up, however, only for the first acceleration phase.

## 2.5 Extended scope for adaptation

### 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.

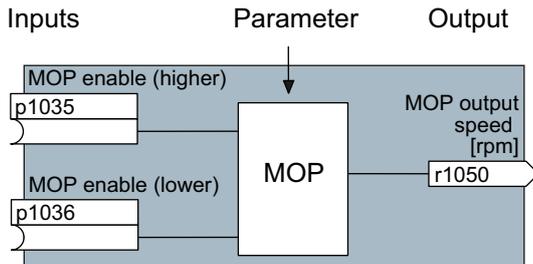


Figure 2-1 Example of a BICO block: Motorized potentiometer (MOP)

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.

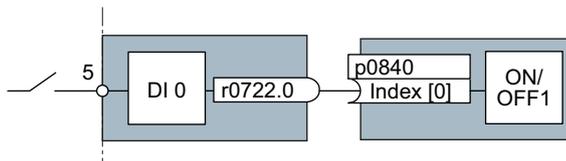


Figure 2-2 Example: Signal interconnection of two BICO blocks for digital input 0

### 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 **Binectors** and **Connectors**. 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:

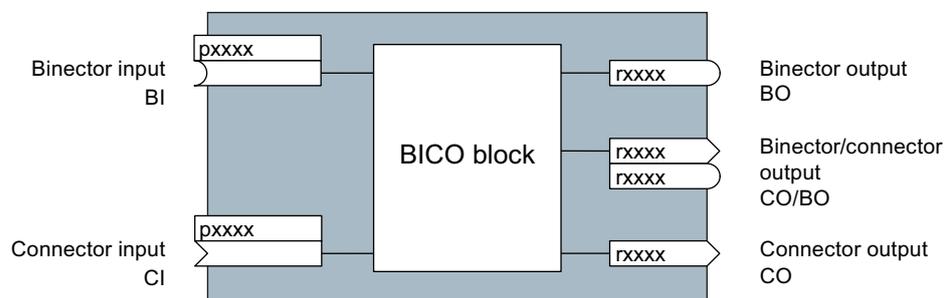


Figure 2-3 BICO symbols

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 79).

## Description

### 3.1 SINAMICS G120C inverter

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

	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	0	6SL3210-1KE11-8A	0
	0.75 kW	2.2 A	6SL3210-1KE12-3U	0	6SL3210-1KE12-3A	0
	1.1 kW	3.1 A	6SL3210-1KE13-2U	0	6SL3210-1KE13-2A	0
	1.5 kW	4.1 A	6SL3210-1KE14-3U	0	6SL3210-1KE14-3A	0
	2.2 kW	5.6 A	6SL3210-1KE15-8U	0	6SL3210-1KE15-8A	0
	3.0 kW	7.3 A	6SL3210-1KE17-5U	0	6SL3210-1KE17-5A	0
 Frame Size B	4.0 kW	8.8 A	6SL3210-1KE18-8U	0	6SL3210-1KE18-8A	0
	5.5 kW	12.5 A	6SL3210-1KE21-3U	0	6SL3210-1KE21-3A	0
 Frame Size C	7.5 kW	16.5 A	6SL3210-1KE21-7U	0	6SL3210-1KE21-7A	0
	11.0 kW	25.0 A	6SL3210-1KE22-6U	0	6SL3210-1KE22-6A	0
	15.0 kW	31.0 A	6SL3210-1KE23-2U	0	6SL3210-1KE23-2A	0
	18.5 kW	37.0 A	6SL3210-1KE23-8U	0	6SL3210-1KE23-8A	0
	USS, Modbus RTU			B		B
	PROFIBUS DP			P		P
	CANopen			C		C

### 3.2 Commissioning tools

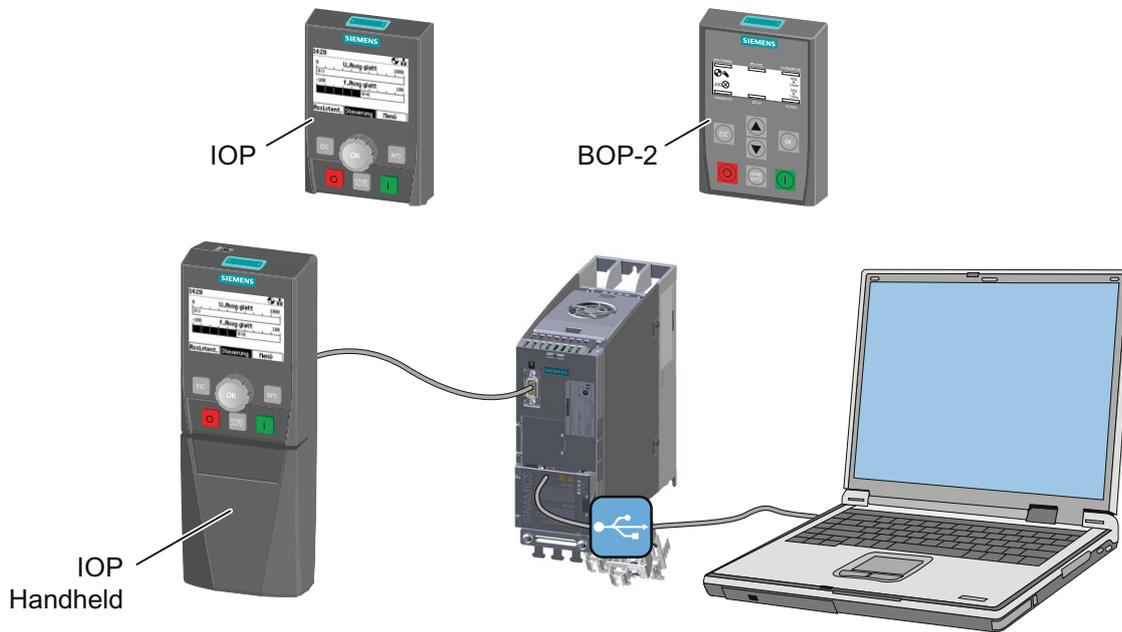


Table 3- 1 Components and tools for commissioning and data backup

Component or tool		Order number
Operator Panels for commissioning, diagnostics and controlling of inverters	BOP-2 - snapped on the inverter <ul style="list-style-type: none"> <li>Copies drive parameters</li> <li>Two-line display</li> <li>Guided commissioning</li> </ul>	6SL3255-0AA00-4CA1
	IOP - snapped on the inverter or used with the handheld <ul style="list-style-type: none"> <li>Copies drive parameters</li> <li>Plain text display</li> <li>Menu-based operation and application wizards</li> </ul>	IOP: 6SL3255-0AA00-4JA0 Handheld for IOP: 6SL3255-0AA00-4HA0
	IOP/BOP-2 Mounting Kit IP54/UL Type 12	6SL3256-0AP00-0JA0
PC tools	STARTER - commissioning tool (PC software). Connected to the inverter using an USB cable	STARTER on a DVD: 6SL3072-0AA00-0AG0 Download: STARTER ( <a href="http://support.automation.siemens.com/WW/view/en/10804985/130000">http://support.automation.siemens.com/WW/view/en/10804985/130000</a> )
	Drive ES Basic For commissioning the inverter via PROFIBUS interface. Implements STARTER	6SW1700-5JA00-4AA0

Component or tool		Order number
	PC Connection Kit - Comprising STARTER DVD and USB cable	6SL3255-0AA00-2CA0
	Optional memory card for storing and transferring the inverter settings	MMC card
		SD card
		6SL3254-0AM00-0AA0
		6ES7954-8LB00-0AA0

## Components, which you require depending on your particular application

### Line reactor

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

If the line impedance is smaller than 1 %, you have to install a line reactor in order to ensure the optimal lifetime of your inverter.

### Braking resistor

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

Inverter		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 Interfaces

The SINAMICS G120C Inverter has a number of interfaces allowing the Inverter to be adaptable for the most common drive applications.

	G120C USS/MB	G120C DP	G120C CAN
Fieldbus interface	USS/Modbus RTU	PROFIBUS DP	CanOpen
Integrated fail-safe function	STO		
Digital inputs	6		
Fail-safe digital inputs *)	1		
Analog inputs	1		
Digital outputs	2		
Analog outputs	1		

\*) A fail-safe digital input is created by combining two "standard" digital inputs

# Installing

## 4.1 Procedure for installing the inverter

### Prerequisites for installing the inverter

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

- Are the components, tools and small parts required for installation available?
- Are the ambient conditions permissible? See Technical data (Page 273).

### Installation sequence

1. Mount the inverter.
2. If required, mount the line reactor.
3. If required, mount the braking resistor.
4. Connect the following components:
  - Inverter - motor
  - Inverter - line reactor - line
  - Inverter - 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 inverter.

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

## 4.2 Mounting the inverter

### Mounting orientation

Mount the inverter in a cabinet panel or directly on the cabinet wall.

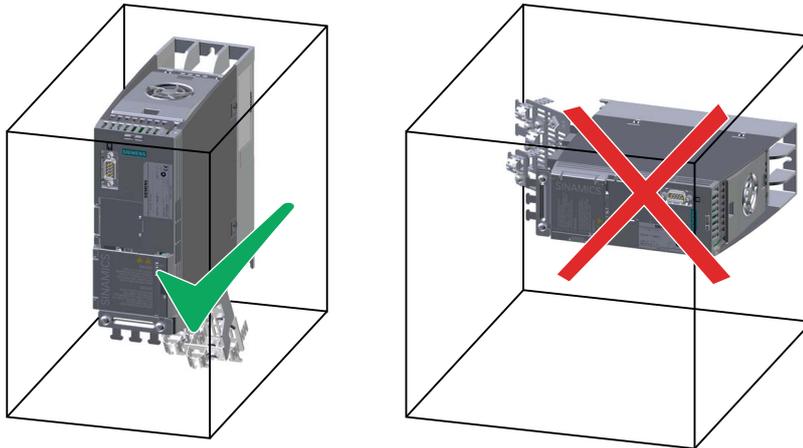


Figure 4-1 The Inverter must not be installed horizontally.

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 inverter are not covered and that the flow of cooling air is not obstructed.

Dimensions, drill patterns and minimum distances

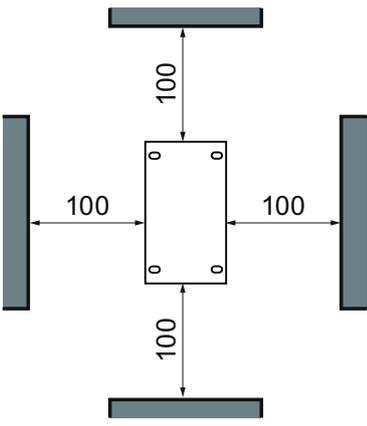
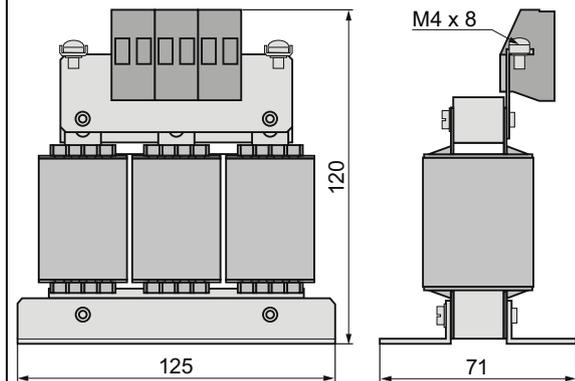
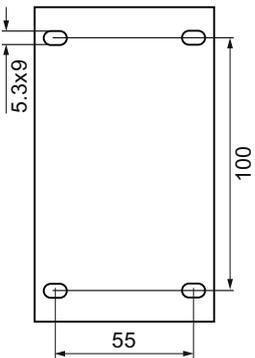
Frame Size A, 0.55 kW ... 4.0 kW		
Distances to other equipment [mm]	Dimensions [mm]	Drill pattern [mm]
		<p>Fixings:                      3 x M4 bolts                      3 x M4 nuts                      3 x M4 washers                      Tightening torque: 2.5 Nm</p>

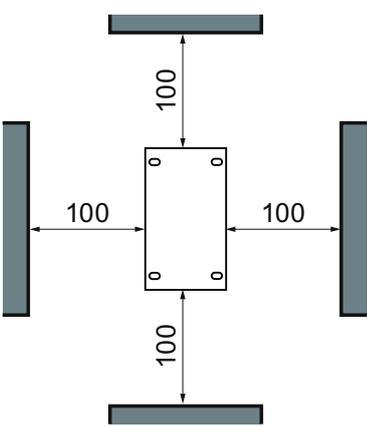
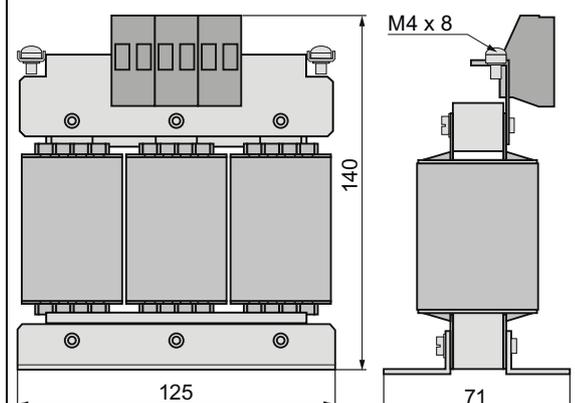
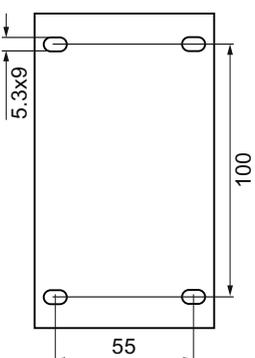
Frame Size B, 5.5 kW ... 7.5 kW		
Distances to other equipment [mm]	Dimensions [mm]	Drill pattern [mm]
		<p>Fixings:                      4 x M4 bolts                      4 x M4 nuts                      4 x M4 washers                      Tightening torque: 2.5 Nm</p>

Frame Size C, 11 kW ... 18.5 kW		
Distances to other equipment [mm]	Dimensions [mm]	Drill pattern [mm]
<p>Air</p> <p>80</p> <p>100</p>	<p>With IOP 224</p> <p>295</p> <p>140</p> <p>80</p> <p>203</p>	<p>118</p> <p>7</p> <p>283</p> <p>Fixings: 4 x M5 bolts 4 x M5 nuts 4 x M5 washers Tightening torque: 2.5 Nm</p>

## 4.3 Mounting the line reactor

### Dimensions and drill patterns

Frame Size A, 0.55 kW ... 1.1 kW		
Distances to other equipment [mm]	Dimensions [mm]	Drill pattern [mm]
		 <p>Fixings:                      4 x M5 bolts                      4 x M5 nuts                      4 x M5 washers                      Tightening torque: 6 Nm</p>

Frame Size A, 1.5 kW ... 4.0 kW		
Distances to other equipment [mm]	Dimensions [mm]	Drill pattern [mm]
		 <p>Fixings:                      4 x M5 bolts                      4 x M5 nuts                      4 x M5 washers                      Tightening torque: 6 Nm</p>

4.3 Mounting the line reactor

Frame Size B, 5.5 kW ... 7.5 kW		
Distances to other equipment [mm]	Dimensions [mm]	Drill pattern [mm]
		<p>Fixings:                      4 x M5 bolts                      4 x M5 nuts                      4 x M5 washers                      Tightening torque: 6 Nm</p>

Frame Size C, 11 kW ... 18.5 kW		
Distances to other equipment [mm]	Dimensions [mm]	Drill pattern [mm]
		<p>Fixings:                      4 x M6 bolts                      4 x M6 nuts                      4 x M6 washers                      Tightening torque: 10 Nm</p>

## 4.4 Connecting the inverter

### 4.4.1 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 inverter. In the next figures three phase systems are outlined. The three phase inverter must be connected to L1, L2 and L3. PE must always be connected. The inverter operates with most supply systems.

Table 4- 1 Power distribution systems

TN-S Power System	TN-C-S Power System	TN-C Power System	TT Power System	IT Power System
<p>A TN-S power system has separate neutral and protective ground conductors throughout the system.</p>	<p>In a TN-C-S power system, the neutral and protective functions are combined in a single part of the system.</p>	<p>In a TN-C power system, the neutral and protective functions are combined in a single conductor throughout the system.</p>	<p>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.</p>	<p>An IT power system has no direct connection to ground - instead the exposed parts of the electrical installation are grounded.</p>

#### Note

To ensure compliance for Class 1 protection in accordance with the EN 61140 directive, the input and output line voltage supplies must be earthed.

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**

Inverters with built-in filters or external filters must not be used with IT supplies.

If the inverter 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 inverter without a protective earth is not permitted under any circumstances.

## 4.4.2 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).

4.4 Connecting the inverter

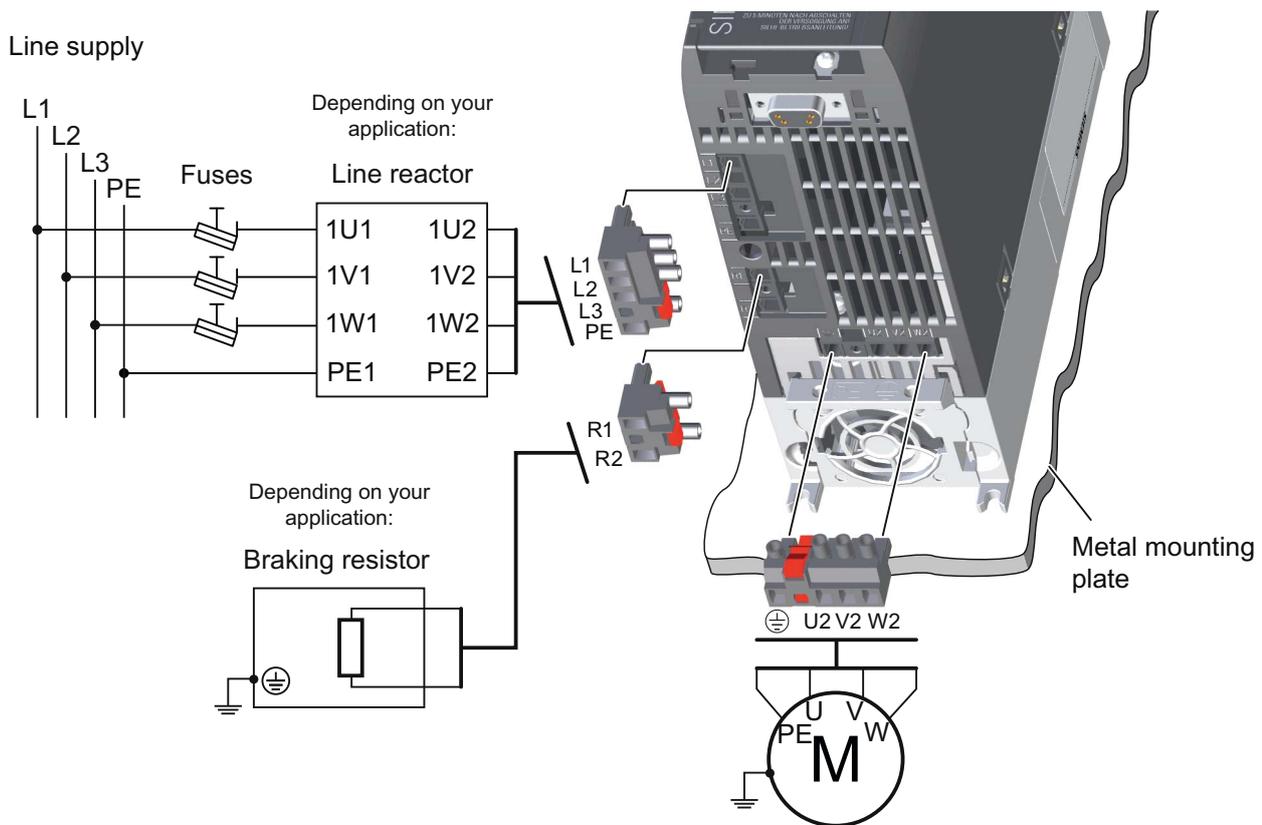


Table 4-2 Permissible cable cross section (tightening torque)

Inverter frame size (FS)	Inverter (mains supply and motor)		Line reactor			Braking resistor	
	mm <sup>2</sup>	AWG	mm <sup>2</sup>	AWG	PE	mm <sup>2</sup>	AWG
FSA, 0.55 kW ... 4.0 kW	2.5 mm <sup>2</sup> (0.5 Nm)	14 AWG (4.5 lbf in)	4 mm <sup>2</sup> (0.8 Nm)	12 AWG (7 lbf in)	PE M4 (3 Nm / 26.5 lbf in)	2.5 mm <sup>2</sup> (0.5 Nm)	14 AWG (4.5 lbf in)
FSB, 5.5 kW ... 7.5 kW	6 mm <sup>2</sup> (0.6 Nm)	10 AWG (5.5 lbf in)	10 mm <sup>2</sup> (1.8 Nm)	8 AWG (16 lbf in)	PE M5 (5 Nm / 44 lbf in)	2.5 mm <sup>2</sup> (0.5 Nm)	14 AWG (4.5 lbf in)
FSC, 11.0 kW ... 18.5 kW	16 mm <sup>2</sup> (1.5 Nm)	5 AWG (13.5 lbf in)	16 mm <sup>2</sup> (4 Nm)	5 AWG (35 lbf in)	PE M5 (5 Nm / 44 lbf in)	6 mm <sup>2</sup> (0.6 Nm)	10 AWG (5.5 lbf in)

Table 4-3 External components of the inverter

Inverter		Standard fuse type	UL/cUL fuse type	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)	10 A class J		
	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	11.0 kW	3NA3817 (40 A)	40 A class J	6SL3201-0BE23-8AA0	6SL3203-0CE23-8AA0
	15.0 kW	3NA3820 (50 A)	50 A class J		
	18.5 kW	3NA3822 (63 A)	60 A class J		

### Components for United States / Canadian installations (UL/cUL)

In order that the system is UL/cUL-compliant, use UL/cUL-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 inverter 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<sub>AC</sub>, 50/60 Hz, 3-phase
- Clamping voltage V<sub>PR</sub> = 2000 V, I<sub>N</sub> = 3 kA min, MCOV = 550 V<sub>AC</sub>, SCCR = 40 kA
- Suitable for Type 1 or Type 2 SPD application
- Clamping shall be provided between phases and also between phase and ground

### Connecting the motor

The following cable lengths are permissible:

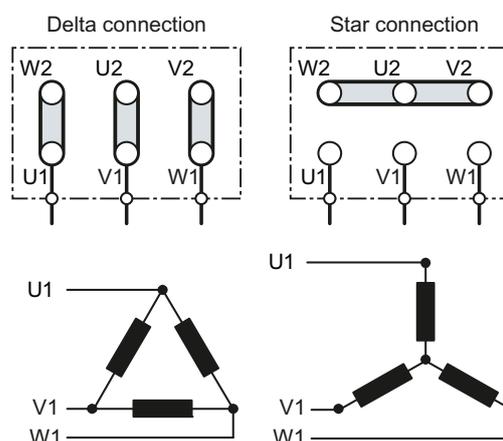
- Unshielded 100 m
- Shielded:
  - 50 m for inverter without filter
  - 25 m for inverter with filter

### 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  $\Delta/Y$ .

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  $\Delta$ .

With the 87 Hz characteristic, the motor's power output increases. The 87 Hz characteristic is mainly used with geared motors.

### 4.4.3 EMC-compliant connection

The inverters are designed for operation in industrial environments where high values of electromagnetic interference are expected. Safe, reliable and disturbance-free operation is only guaranteed if the devices are professionally installed.

Inverters with degree of protection IP20 must be installed and operated in an enclosed control cabinet.

#### Control cabinet design

- All metal parts and components of the control cabinet (side panels, rear panels, roof and base plates) must be connected to the control cabinet frame through a good electrical connection – this is best achieved using the highest possible surface area or a high number of individual screw connections
- The PE bar and the EMC shield bar must be connected to the control cabinet frame through a good electrical connection established through a large surface area.
- All of the metal enclosures of the devices and supplementary components installed in the cabinet – e.g. inverter or line filter – must be connected to the control cabinet frame through a good electrical connection through the largest possible surface area. The most favorable design is to mount these devices and supplementary components on a bare metal mounting plate with good conducting characteristics; this in turn is connected to the control cabinet frame through a good electrical connection and the largest possible surface area. It is especially important that they are connected to the PE and EMC shield bars.
- All of the connections must be implemented so that they are durable. Screw connections to painted or anodized metal components must either be established using special contact (serrated) washers that cut through the insulating surface and therefore establish a metallic conductor contact, or the insulating surface must be removed at the contact locations.
- Coils of contactors, relays, solenoid valves and motor holding brakes must be equipped with interference suppression elements in order to dampen high-frequency radiation when switching-off (RC elements or varistors with AC coils and free-wheeling diodes or varistors for DC coils). The protective circuit must be directly connected at the coil.

## Cable routing and shielding

- All inverter power cables (line supply cables, connecting cables between the braking chopper and the associated braking resistance as well as the motor cables) must be separately routed away from signal and data cables. The minimum clearance should be approx. 25 cm. As an alternative, the decoupling can be realized in the control cabinet using metal partitions (separating elements) connected to the mounting plate through a good electrical connection
- The cables from the line supply to the line filter must be routed separately away from non-filtered power cables with a high noise level (cables between the line filter and inverter, connecting cables between the braking chopper and the associated braking resistor 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
- All cables should be kept as short as possible
- Signal and data cables and the associated equipotential bonding cables must always be routed in parallel with the smallest possible clearance between them
- Shielded motor cables must be used
- The shielded motor cable should be routed separately away from the cables to the motor temperature sensors (PTC/KTY)
- Signal and data cables must be shielded.
- Especially sensitive control cables - such as setpoint and actual value cables - should be routed without any interruption with optimum shield support at both ends
- Shields should be connected at both ends to the grounded enclosures through a good electrical connection and through a large surface area
- Cable shields should be connected as close as possible to where the cable enters the cabinet
- EMC shield bars should be used for power cables; the shield support elements provided in the inverter should be used for signal and data cables
- If at all possible, cable shields should not be interrupted by intermediate terminals
- Cable shields should be retained both for power cables as well as for signal and data cables using the appropriate EMC clamps. The shield clamps must connect the shield to the EMC shield bar or the shield support element for control cables through a low inductive connection through a large surface area.

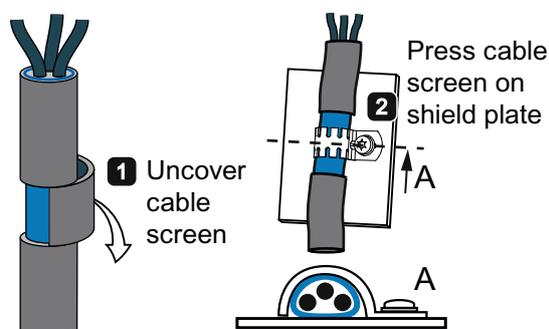


Figure 4-2 Shield support

### EMC-compliant installation of the inverter

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

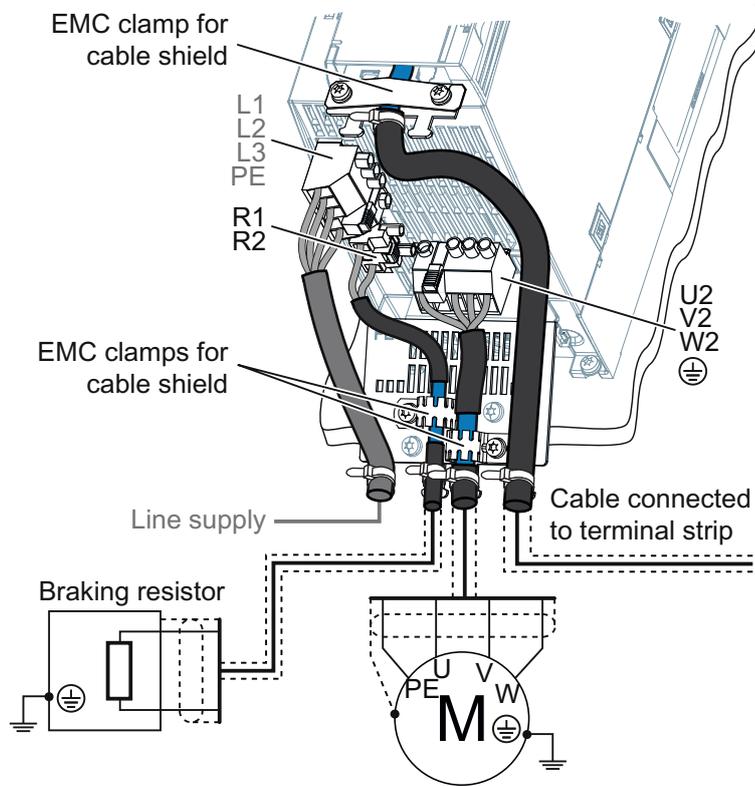


Figure 4-3 Inverter shielding

### 4.4.4 Interfaces, connectors, switches, terminal blocks and LEDs of the inverter

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

- ① Memory card slot (MMC or SD cards)
- ② Interface for operator panel (BOP-2 or IOP)
- ③ USB interface for STARTER

④ Status LEDs

	RDY
	BF
	SAFE

- ⑤ DIP switches for bus address

Bit 6 (64)	7
Bit 5 (32)	6
Bit 4 (16)	5
Bit 3 (8)	4
Bit 2 (4)	3
Bit 1 (2)	2
Bit 0 (1)	1
ON	OFF

Example:  
Address = 5

	7
	6
	5
	4
	3
	2
	1
ON	OFF

⑥ Analog input DIP switch

	Current		Voltage
--	---------	--	---------

⑦ Depending on field bus

G120C USS/MB and G120C CAN:  
Bus termination

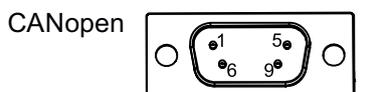
	OFF		ON
--	-----	--	----

G120C DP: no function

- ⑧ Terminal strips

- ⑨ Terminal designations

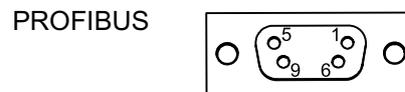
- ⑩ Field bus interface



- 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



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



- 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

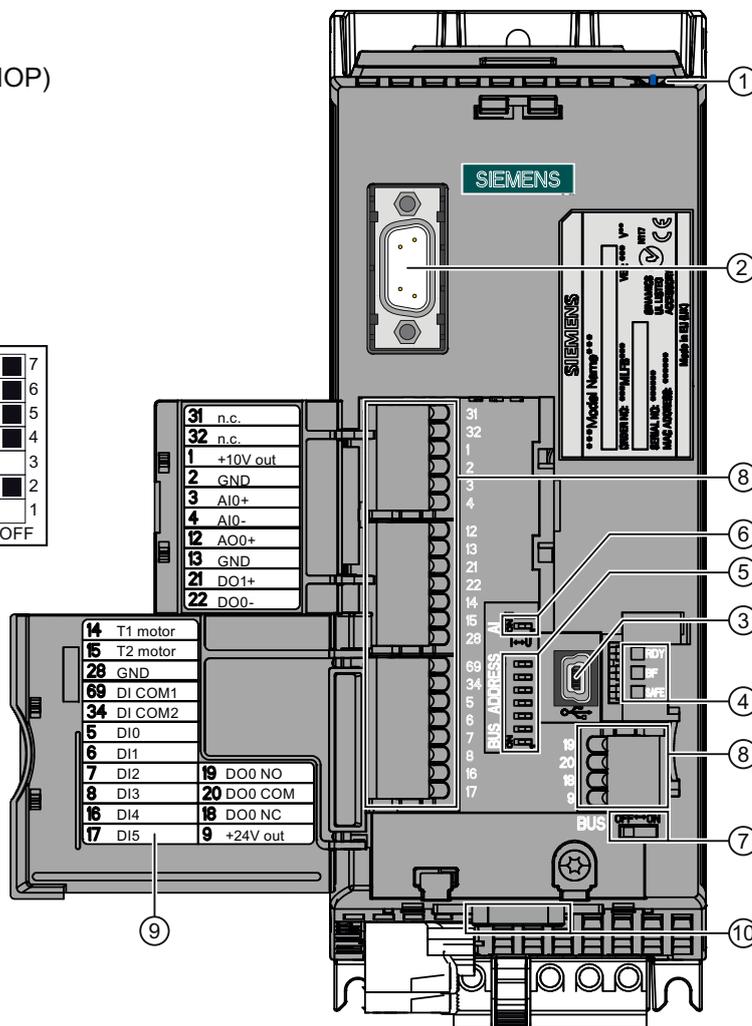


Figure 4-4 Interfaces and connectors

### 4.4.5 Terminal strips on the inverter

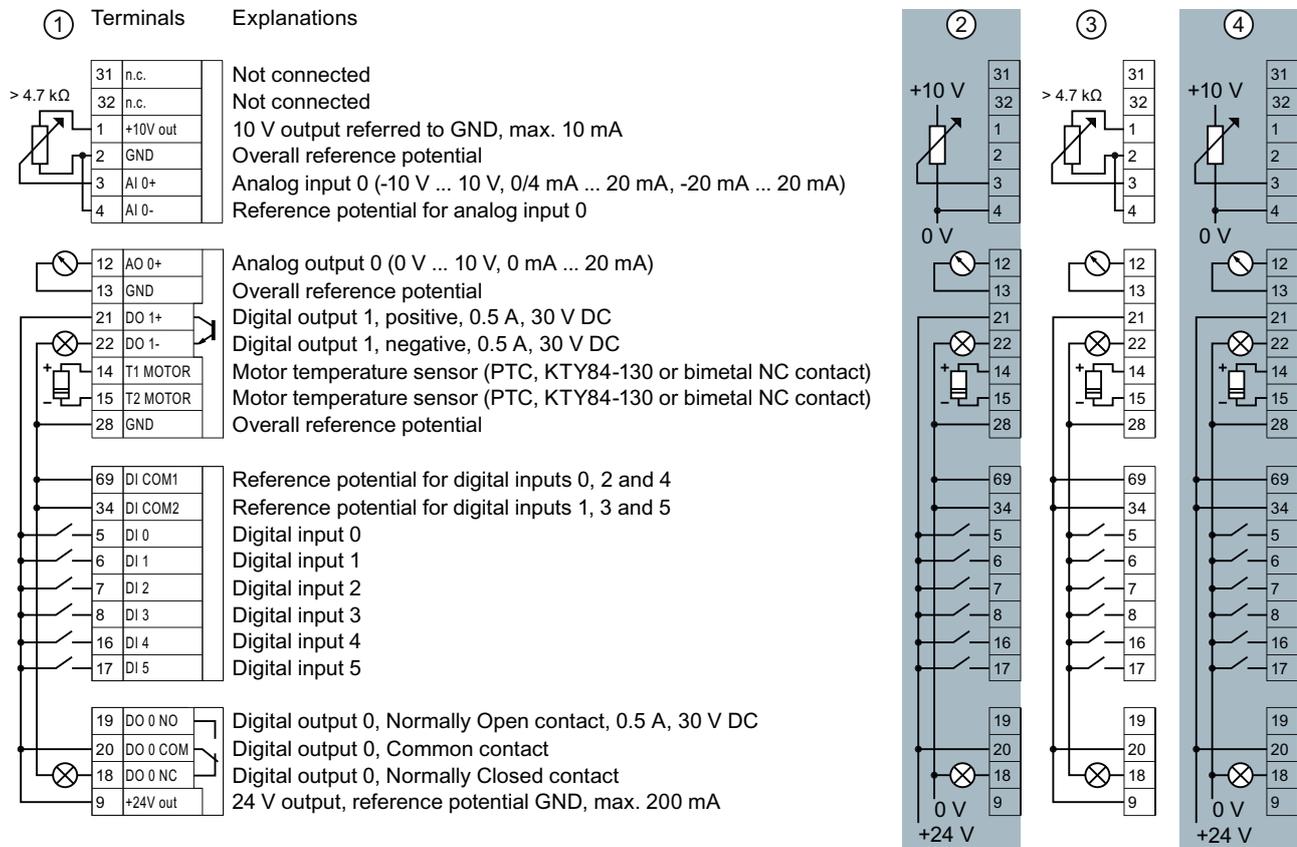


Figure 4-5 Terminal layout G120C

You can use the analog inputs AI0 and AI1 as additional digital inputs DI11 and DI12.

For a fail-safe input, use two "standard" digital inputs.

Terminals	Designation	Fail-safe input with Basic Safety
16	DI4	F-DI0
17	DI5	

Additional information on fail-safe inputs is available in the Permitted sensors (Page 228) chapter.

#### 4.4.6 Selecting the interface assignments

The inverter offers multiple predefined settings for its interfaces.

##### One of these predefined settings matches your particular application

Proceed as follows:

1. Wire the inverter corresponding to your application.
2. Carry-out the basic commissioning, see Section Commissioning (Page 47).  
In the basic commissioning, select the macro (the predefined settings of the interfaces) that matches your particular wiring.
3. When required, configure communication via fieldbus, see Configuring the fieldbus (Page 91).

##### What do you do if none of the predefined settings matches your particular application 100%?

If none of the predefined settings matches your particular application, then proceed as follows:

1. Wire the inverter corresponding to your application.
2. Carry-out the basic commissioning, see Section Commissioning (Page 47).  
In the basic commissioning, select the macro (the predefined settings of the interfaces) that comes the closest to matching your particular application.
3. Adapt the inputs and outputs to your application, see Section Adapting the terminal strip (Page 79).
4. When required, configure communication via fieldbus, see Configuring the fieldbus (Page 91).

**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				
3	AI 0+	---	Speed	12	AO 0+
4			0 V ... 10 V	13	

You have to release STO, see 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**

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  
Telegram 352

For getting the GSD file, see section: Configuring communication to the control (Page 92).

**Macro 5**  
Field bus PROFIBUS DP with safety function (STO)

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

PROFIBUS DP Telegram 352

You have to release STO, see section: Fail-safe function Safe Torque Off (STO) (Page 228).  
For getting the GSD file, see section: Configuring communication to the control (Page 92).

### Automatic / Manual - change over from field bus to jog

Factory setting with G120C DP:

**Macro 7** DI 3 = LOW  
Field bus PROFIBUS DP

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

PROFIBUS DP Telegram 1

DI 3 = HIGH  
Jog via DI 0 and DI 1

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

p1058 = Jog speed 1  
p1059 = Jog speed 2

For getting the GSD file, see section: Configuring communication to the control (Page 92).

### Motorized potentiometer

**Macro 8**  
Motorized potentiometer (MOP) with safety function (STO)

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

You have to release STO, see section: Fail-safe function Safe Torque Off (STO) (Page 228).

**Macro 9**  
Motorized potentiometer (MOP)

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

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	

You have to release STO, see section Fail-safe function Safe Torque Off (STO) (Page 228).

Process industry

Macro 14					
DI 3 = LOW					
Field bus PROFIBUS DP					
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  
Telegram 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	

For getting the GSD file, see section: Configuring communication to the control (Page 92).

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
<b>Two wire control</b>	<b>Mode 1</b>	<b>Mode 2</b>	<b>Mode 3</b>
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
<b>Three wire control</b>	<b>Mode 1</b>	<b>Mode 2</b>
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

For getting the EDS file, see section: CANopen functionality of the inverter (Page 134).

#### **4.4.7 Wiring terminal strips**

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

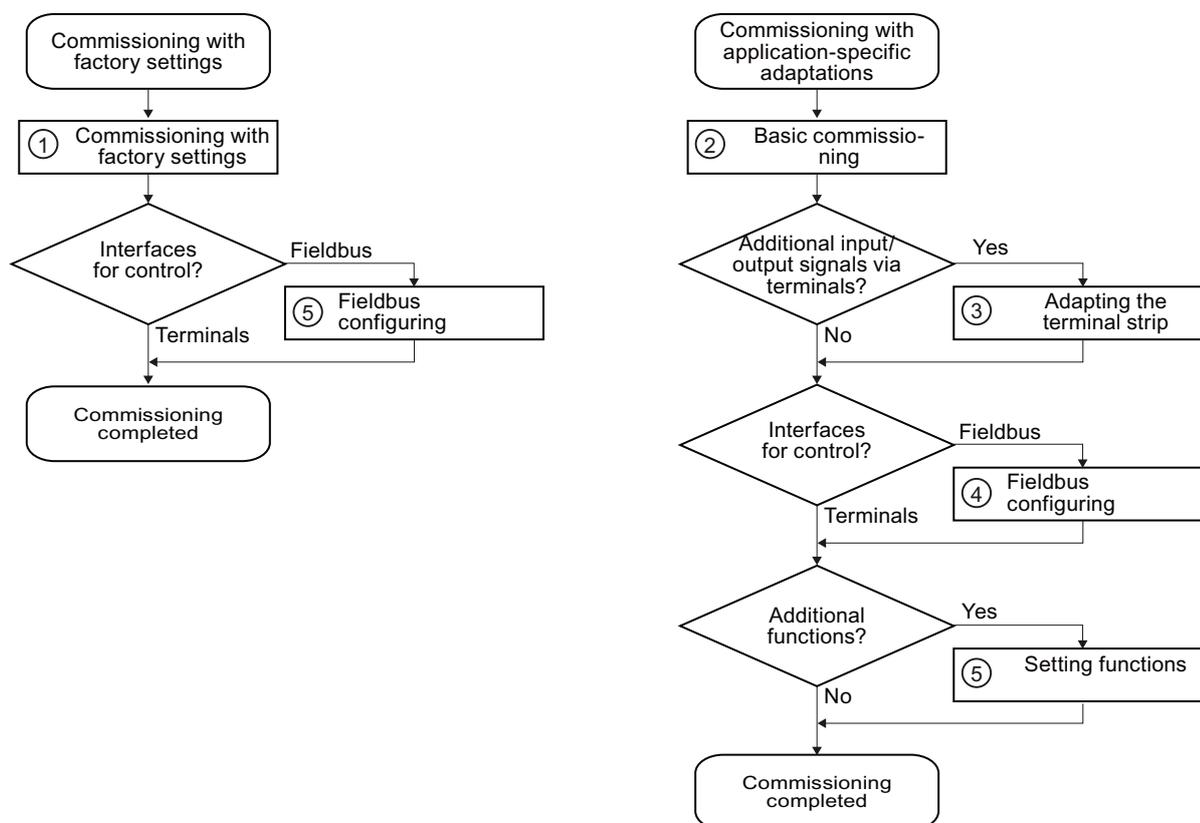
The permissible cable cross-section ranges between 0.5 mm<sup>2</sup> (21 AWG) and 1.5 mm<sup>2</sup> (16 AWG). When completely connecting-up the unit, we recommend cables with a cross-section of 1mm<sup>2</sup> (18 AWG).

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.

## Commissioning

You must commission the inverter after installation has been completed.

To do this, using Section "Commissioning with factory settings (Page 53)" you must clarify whether the motor can be operated with the inverter factory settings or an additional adaptation of the inverter is required. The two commissioning options are shown in the following diagram.



① Commissioning with factory settings (Page 53)

② Set basic commissioning with STARTER (Page 56) or BOP-2 (Page 61)

③ Adapting the terminal strip (Page 79)

④ Configuring the fieldbus (Page 91)

⑤ Functions (Page 161)

Figure 5-1 Commissioning procedure

**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.

## 5.1 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.

### Deactivating safety functions

The parameters of the safety functions can only be reset if you first deactivate the safety functions.

Table 5- 1 Procedure

STARTER	BOP-2	
1. Go online with STARTER	Set the following parameters:	
2. Call the safety functions screen form	p9761 = ...	Password for the safety functions
3. Deactivate the safety functions	p0010 = 95	Changing the safety functions
	p9601 = 0	Deactivate safety functions
	p9700 = 208	Copy parameter
	p9701 = 220	Confirm setting
	p0010 = 0	Exit change

Final steps:

1. Switch off the inverter supply voltage
2. Wait until all LEDs on the inverter go dark. Now switch on the inverter 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 5- 2 Procedure

STARTER	BOP-2
<ol style="list-style-type: none"><li>1. Go online with STARTER</li><li>2. In STARTER, click on the button .</li></ol>	<ol style="list-style-type: none"><li>1. In the "Options" menu, select the "DRVRESET" entry</li><li>2. Confirm the reset using the OK key</li></ol>

## 5.2 Preparing commissioning

### Prerequisites: before you start

Before starting commissioning, you must answer the following questions:

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

### 5.2.1 Collecting motor data

**Which motor are you using? [P0300]**

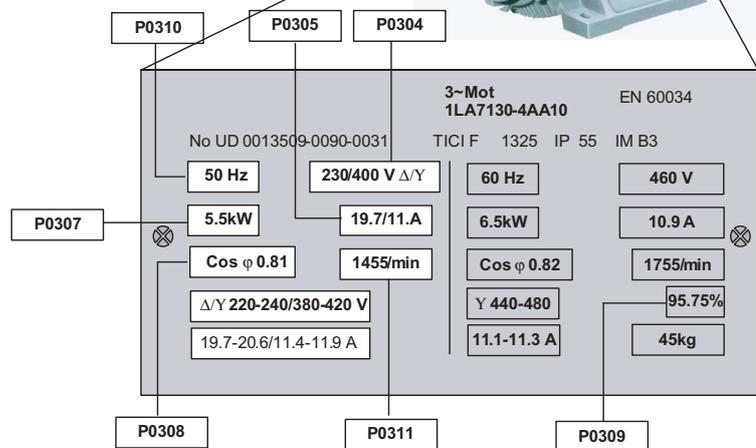
A synchronous or induction motor?

The inverters are preset in the factory for applications using 4-pole three-phase induction motors that correspond to the performance data of the inverter.



**Motor data / data on the motor rating plate**

If you use the STARTER commissioning tool and a SIEMENS motor, you only have to specify the motor Order No. In all other cases, you must read-off the data from the motor rating plate and enter into the appropriate parameters.



**NOTICE**

**Information about installation**

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.

**In which region of the world is the motor used? - Motor standard [P0100]**

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

**What is the prevailing temperature where the motor is operated? [P0625]**

- Motor ambient temperature [P0625], if it differs from the factory setting = 20° C.

## 5.2.2 Inverter factory setting

### Factory settings of additional important parameters

Parameter	Factory setting	Meaning of the factory setting	Name of the parameter and comments
p0010	0	Ready to be entered	Drive, commissioning parameter filter
p0100	0	Europe [50 Hz]	IEC/NEMA motor standard <ul style="list-style-type: none"> <li>• IEC, Europe</li> <li>• NEMA, North America</li> </ul> <b>Note:</b> This parameter cannot be changed in FW4.3.
p0300	1	Induction motor	Motor type selection (induction motors / synchronous motor)
p0304	400	[V]	Rated motor voltage (in accordance with the rating plate in V)
p0305	depends on the Power Module	[A]	Rated motor current (in accordance with the rating plate in A)
p0307	depends on the Power Module	[kW/hp]	Rated motor power (in accordance with the rating plate in kW/hp)
p0308	0	[cos phi]	Rated motor power factor (in accordance with the rating plate in cos 'phi'). If p0100 = 1, 2, then p0308 has no significance.
p0310	50	[Hz]	Rated motor frequency (in accordance with the rating plate in Hz)
p0311	1395	[rpm]	Rated motor speed (in accordance with the rating plate in rpm)
p0335	0	Non-ventilated: Shaft-mounted fan in the motor	Motor cooling type (specify the motor cooling system)
p0625	20	[°C]	Motor ambient temperature
p0640	200	[A]	Current limit (of the motor)
p0970	0	Locked	Reset drive parameters (restore to the factory settings)
P1080	0	[rpm]	Minimum speed
P1082	1500	[rpm]	Maximum speed
P1120	10	[s]	Ramp-function generator, ramp-up time
P1121	10	[s]	Ramp-function generator, ramp-down time
P1300	0	V/f control with linear characteristic	Open-loop/closed-loop control operating mode

### 5.2.3 Defining requirements for the application

#### What type of control is needed for the application? [P1300]

A distinction is made between V/f open-loop control and vector closed-loop control.

- The V/f open-loop control is the simplest operating mode for an inverter. For example, it is used for applications involving pumps, fans or motors with belt drives.
- For closed-loop vector control, the speed deviations between the setpoint and actual value are less than for V/f open-loop control; further, it is possible to specify a torque. It is suitable for applications such as winders, hoisting equipment or special conveyor drives.

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

The minimum and maximum speed with which the motor operates or is limited regardless of the speed setpoint.

- Minimum speed [P1080] - factory setting 0 [rpm]
- Maximum speed [P1082] - factory setting 1500 [rpm]

#### 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 [P1120] - factory setting 10 s
- Ramp-down time [P1121] - factory setting 10 s

## 5.3 Commissioning with factory settings

### 5.3.1 Prerequisites for using the factory settings

#### Prerequisites for using the factory settings

In simple applications, commissioning can be carried out just using the factory settings. Check which factory settings can be used and which functions need to be changed. During this check you will probably find that the factory settings only require slight adjustment:

1. The inverter and motor must match one another; compare the data on the motor rating plate with the technical data of the Power Module.
  - The rated inverter current must, as a minimum, be the same as the motor.
  - The motor power should match that of the inverter; motors can be operated in the power range from 25 % ... 100 % of the inverter power rating.
2. If you are controlling the drive using the digital and analog inputs, the inverter must be connected as shown in the wiring example. (see Wiring examples for the factory settings (Page 54) )
3. If you connect the drive to a fieldbus, you must set the bus address using the DIP switches on the front of the Control Unit.

### 5.3.2 Wiring examples for the factory settings

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

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

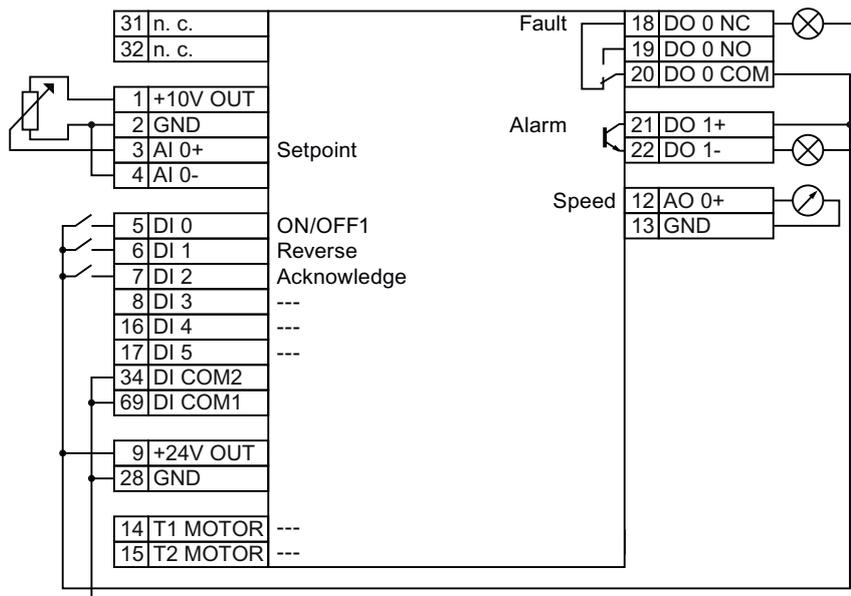


Figure 5-2 Default wiring using RS485 communications

**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 inverter with PROFIBUS interface

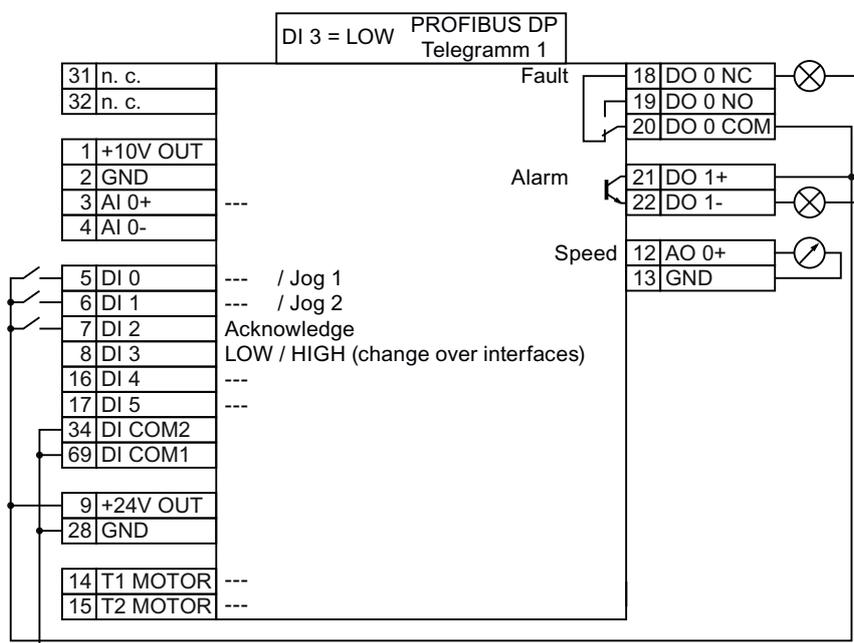


Figure 5-3 Default wiring using PROFIBUS communications

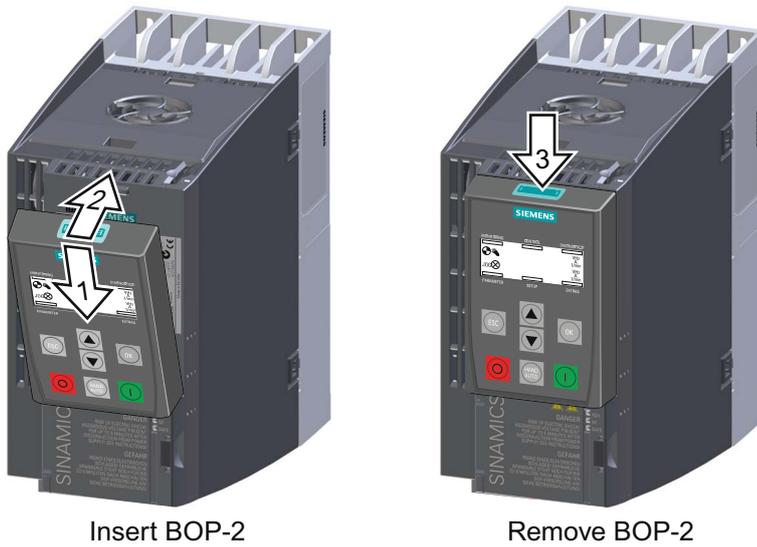
#### Note

##### Assignment of terminals following basic commissioning

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

## 5.4 Commissioning with Operator Panel BOP-2

Remove the blind cover and snap the BOP-2 on the inverter:



### 5.4.1 Display of the BOP-2

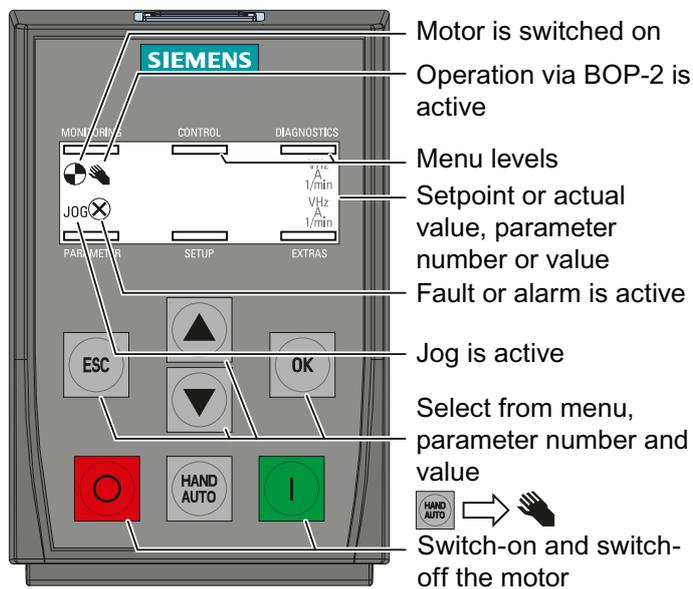
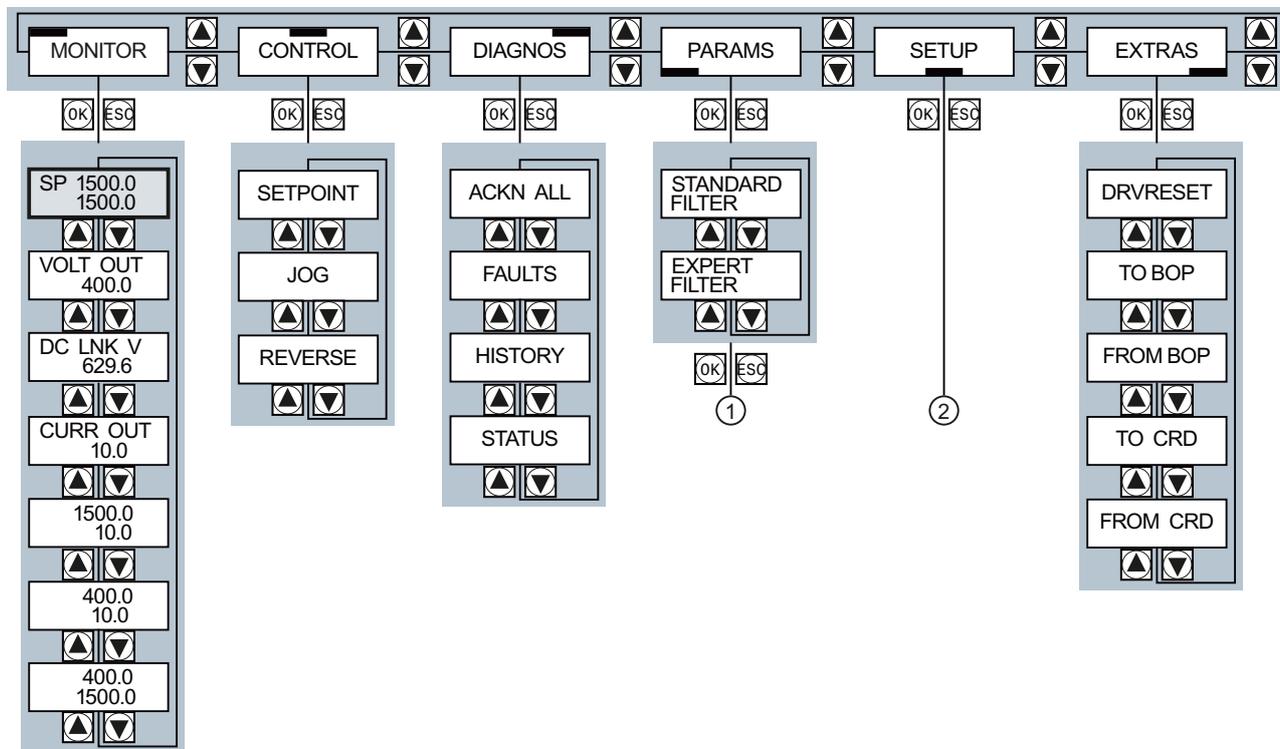


Figure 5-4 Operator control and display elements of the BOP-2

### 5.4.2 Menu structure

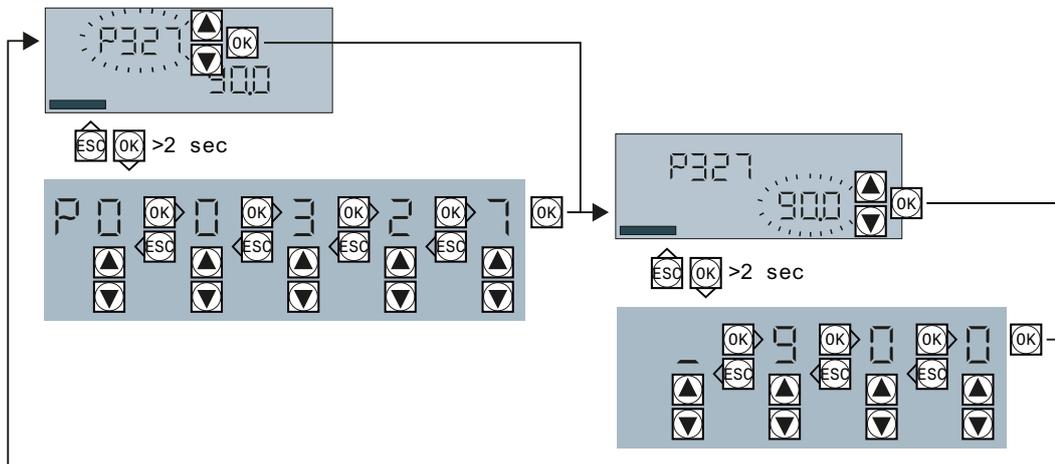


Changing parameter values:

- ① Parameter number freely selectable
- ② Basic commissioning

### 5.4.3 Freely selecting and changing parameters

Use BOP-2 to change your inverter settings, by selecting the appropriate parameter number and changing the parameter value. Parameter values can be changed in the "PARAMS" menu and the "SETUP" menu.



Select the parameter number		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.	

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

5.4.4 Basic commissioning

Menu	Remark
	Set all parameters for the "SETUP" menu. In the BOP-2, select the menu "SETUP".
	Select Reset if you wish to reset all parameters to the factory setting before the basic commissioning: NO → YES → 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)
	② Standard: IEC or NEMA
	① Voltage
	③ Current
	④ Power IEC standard (kW) ⑤ Power NEMA standard (HP)
	⑥ Rated speed
<p>Motor data on the rating plate</p>	
	We recommend the setting STIL ROT (Identify motor data at standstill and with the motor rotating). If the motor cannot rotate freely, e.g. where travel is mechanically limited, select the setting STILL (Identify motor data at standstill).
	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 41).
	Minimum motor speed.
	Motor ramp-up time.
	Motor ramp-down time.
	Confirm that the basic commissioning has been completed (Parameter p3900): NO → YES → OK

### Identifying motor data

If you select the MOT ID (p1900) during basic commissioning, alarm A07991 will be issued once basic commissioning is complete. To enable the inverter to identify the data for the connected motor, you must switch on the motor (e.g. via the BOP-2). The inverter switches off the motor after the motor data identification has been completed.

 <b>CAUTION</b>
<b>Motor data identification for dangerous loads</b>
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.

### 5.4.5 Additional settings

The Section Commissioning (Page 47) shows you what still has to be set after the basic commissioning in order to adapt the inverter to your application.

## 5.5 Commissioning with STARTER

### 5.5.1 Overview

#### 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, which is connected to the converter via the USB cable and on which STARTER V4.2 or higher has been installed.

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

#### Commissioning steps

Commissioning with STARTER is subdivided into the following steps:

1. Adapting the USB interface (Page 62)
2. Generating a STARTER project (Page 63)
3. Go online and perform the basic commissioning (Page 63)
4. Making additional settings (Page 67)

STARTER features a project Wizard that guides you step-by-step through the commissioning process.

---

#### Note

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

---

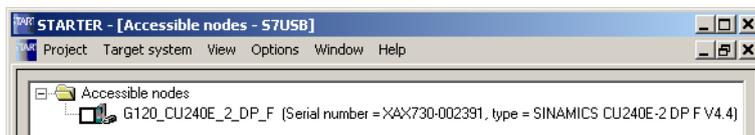
### 5.5.2 Adapting the USB interface

Switch on the converter supply voltage and 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 shows the procedure if no settings are required. In case 2, a description is provided on how you can adapt the interface.

#### 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.

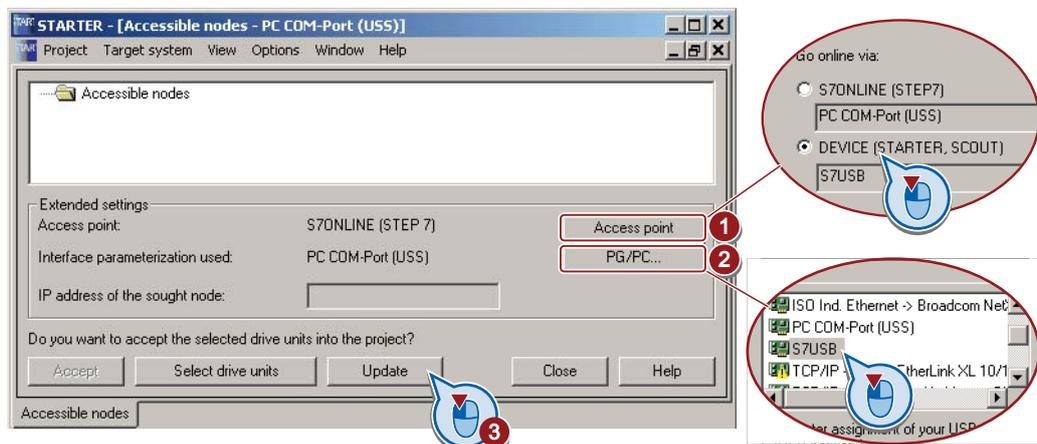


Close this screen form, without selecting the converter(s) that has/have been found. Now create your STARTER project.

#### Case 2: USB interface must be set

In this case, the message box "no other nodes found" is displayed. Close the window, and make the following settings in the "Accessible nodes" screen:

- ① Under "Access point activate "DEVICE (STARTER, Scout)"
- ② Under " PG/PC" select "S7USB"
- ③ Then click on "Update"

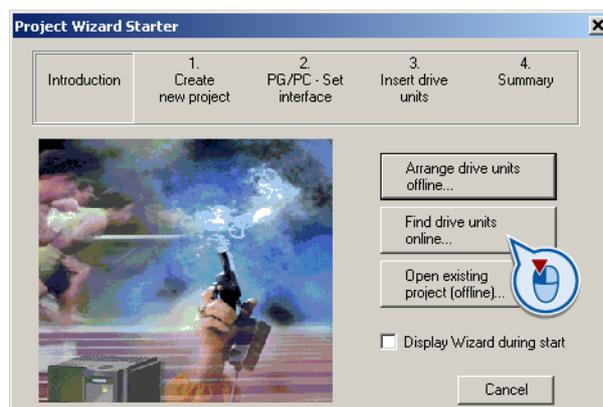


Close this screen form, without selecting the converter(s) that has/have been found. Now create your STARTER project.

### 5.5.3 Generating a STARTER project

#### Creating a STARTER project using project wizards

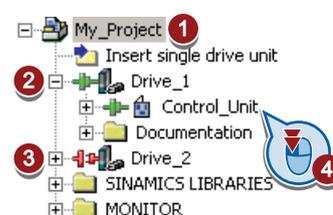
- Using "Project / New with wizard" create a new project.
- To start the wizard, click on "Search online for drive units ...".
- The wizard guides you through all of the settings that you need for your project.



### 5.5.4 Go online and perform the basic commissioning

#### Going online

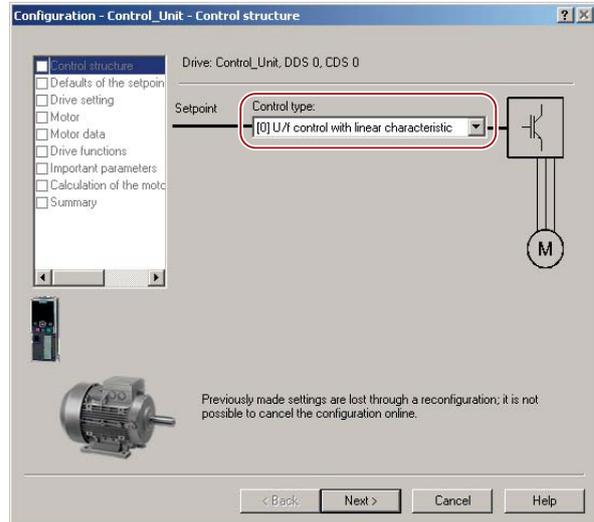
- ① Select your project and go online: .
- In the next screen form, select the device or the devices with which you want to go online. If you want to go online via the USB interface, then set the access point to "DEVICE".
- In the next screen form, download the hardware configuration that you found online into your project (PG or PC).
- STARTER shows you which converters it is accessing online and which are offline:
  - ② The converter is offline
  - ③ The converter is online
- ④ If you are online, open the screen form of the Control Unit.
- Start the wizard for the basic commissioning.



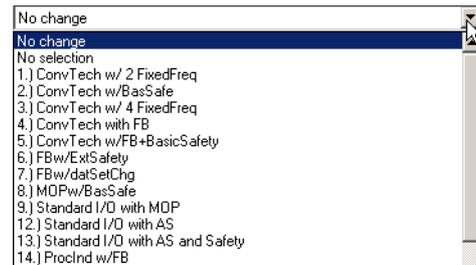
### Wizard for basic commissioning

The wizard guides you step-by-step through the basic commissioning.

- In the first step of the wizard, select the control mode. If you are not certain which control mode you require for your particular application, then select U/f control for the time being. Help on how to select the control mode is provided in Chapter Motor control (Page 183).

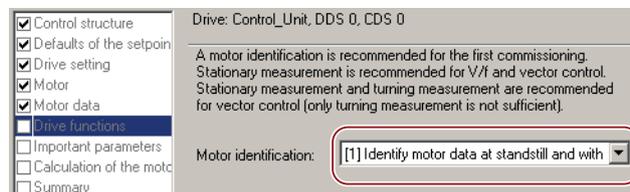


- In the next step, select the assignment of the converter interfaces (see also Section: Selecting the interface assignments (Page 41)). Remark: The possible settings of your Control Unit can deviate from those in the diagram.



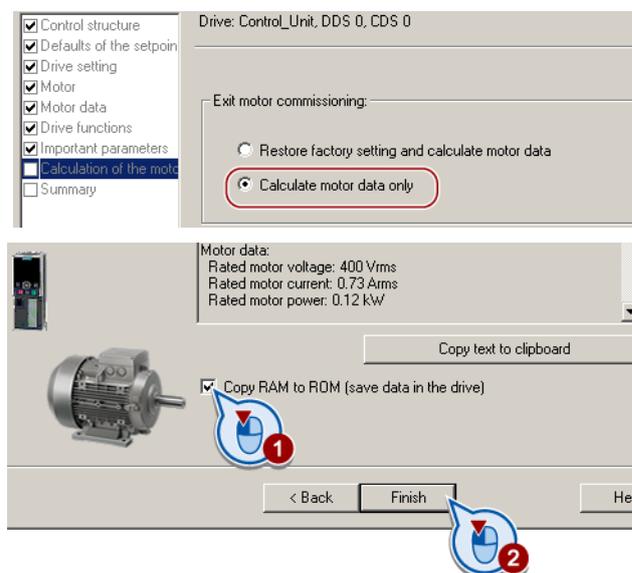
- In the next step, select the application for the converter:
  - Low overload for applications that only require a low dynamic performance, e.g.: Pumps or fans.
  - High overload for applications requiring a high dynamic performance, e.g. conveyor systems.
- In the next step, enter the motor data according to the rating plate of your motor. The motor data for SIEMENS standard motors can be called in STARTER based on their order number.

- In the next step, we recommend the setting "Identify motor data at standstill and with the motor rotating". If the motor cannot freely rotate, e.g. due to a mechanically limited travel section, then select the "Identify motor data at standstill" setting.



- In the next step, set the most important parameters that match your application, e.g. the ramp-up and ramp-down time of the motor.

- In the next step, we recommend the setting "Calculate motor data only".
- ① In the next step, set the check mark for "RAM to ROM (save data in drive)" in order to save your data in the converter so that it is not lost when the power fails.
- ② If you exit the wizard, the converter outputs alarm A07791. You must now switch-on the motor to start motor data identification.



#### Switch on motor for motor data identification

#### CAUTION

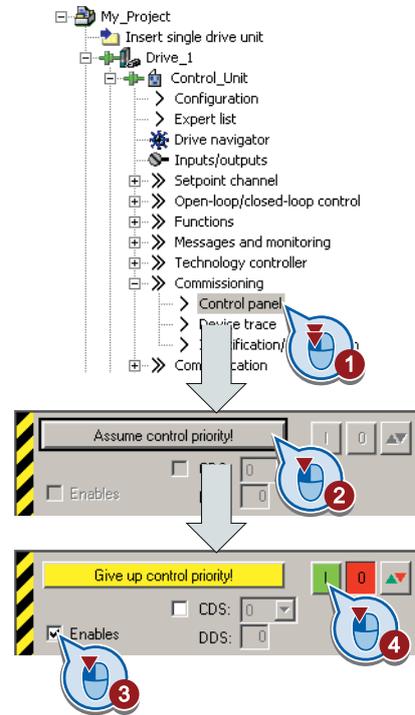
##### Motor data identification for dangerous loads

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.



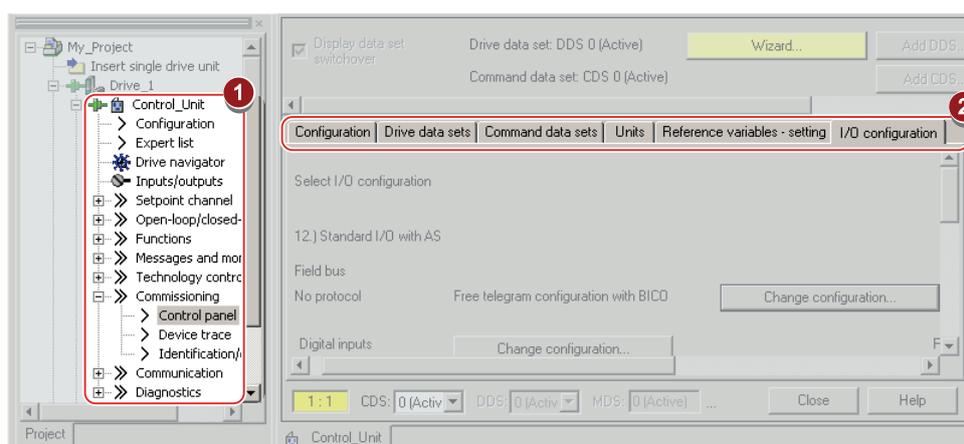
## 5.5.5 Making additional settings

After the basic commissioning, you can adapt the inverter to your application as described in the Commissioning (Page 47).

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".

## 5.5.6 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 (bit track, )

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

#### Mathematical function ()

You can define a curve using the mathematical function, e.g. 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.

---



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

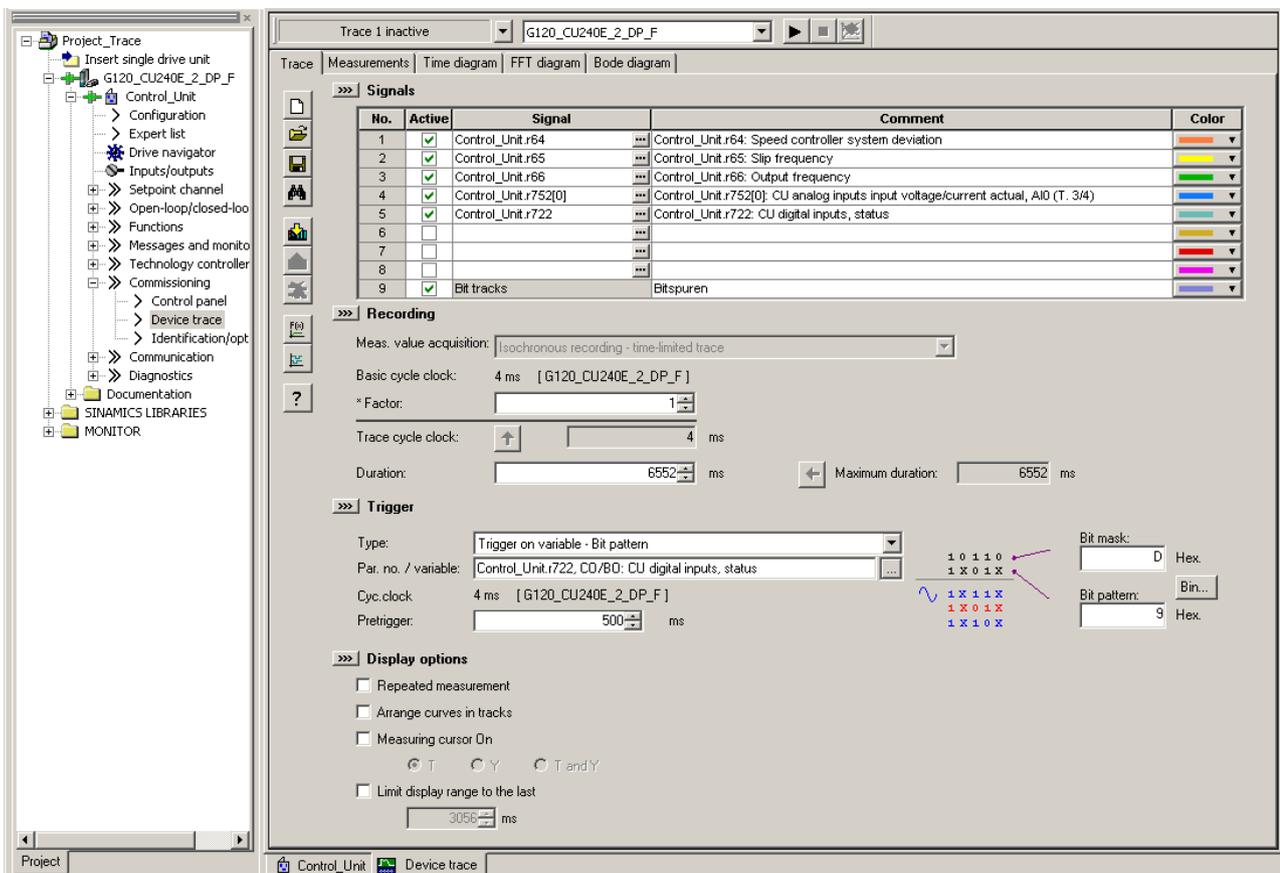


Figure 5-6 Trace dialog box

## 5.6 Data backup and series commissioning

### External data backup

After commissioning, your settings are saved in the inverter so that they are protected against power failure.

Further, we recommend that you externally save the parameter settings so that in the case of a defect, you can simply replace the Power Module or Control Unit (see also Steps for replacing the inverter (Page 248)).

You have three different options for externally backing up data (upload):

1. Memory card
2. PC/PG with STARTER
3. Operator Panel

### Series commissioning

Series commissioning means the commissioning of several identical drives in the following steps:

1. Commission the first inverter.
2. Upload the parameters of the first inverter to an external memory.
3. Download the parameters from the external memory to a second or additional inverter.

---

**Note**

The control unit to which the parameters are transferred must be of the same type and have the same or a higher firmware version as the source control unit (the same 'type' means the same MLFB).

---

For further information, refer to the following sections.

## 5.6.1 Backing up and transferring settings using memory card

### What memory cards do we recommend?

The memory card is a removable flash memory, that offers you the following options

- Automatically or manually write parameter settings from the card into the inverter (automatic or manual download)
- Automatically or manually write parameter settings from the inverter onto the card (automatic or manual upload)

We recommend that you use one of the memory cards with the following order numbers:

- MMC (order number 6SL3254-0AM00-0AA0)
- SD (order number 6ES7954-8LB00-0AA0)

### 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.)

 <b>CAUTION</b>
--

You use memory cards from other manufacturers at your own risk. Depending on the card manufacturer, not all functions are supported (e.g. download).
--

### 5.6.1.1 Saving setting on memory card

We recommend that you insert the memory card before switching on the inverter for the first time. The inverter then automatically ensures that the actual parameter setting is saved both in the inverter as well as on the card.

The following describes how you can save the inverter parameter setting on the memory card subsequently.

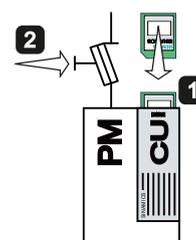
If you wish to transfer the parameter setting from the inverter on to a memory card (Upload), you have two options:

### Automatic upload

The inverter power supply has been switched off.

1. Insert an empty memory card into the inverter.
2. Then switch-on the inverter power supply again.

After it has been switched-on, the inverter copies the modified parameters to the memory card



Transfer the setting to the empty memory card

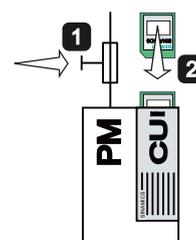
#### NOTICE

If the memory card is not empty and already contains a parameter setting, the inverter will take on the parameter setting from the memory card. The previous setting in the inverter will be deleted.

### Manual upload

If you do not wish to switch off the inverter power supply or you do not have an empty memory card available, you will need to transfer the parameter setting to the memory card as follows:

1. The inverter power supply has been switched on.
2. Insert a memory card into the inverter.



STARTER	BOP-2
<ul style="list-style-type: none"> <li>• Start the data transfer with p0971 = 1.</li> <li>• Check the value of parameter p0971. If data transfer has been completed, then the inverter sets p0971 to 0.</li> </ul>	<ul style="list-style-type: none"> <li>• Start data transfer in the menu "OPTIONS" - "TO CRD".</li> <li>• Wait until the BOP-2 signals that data transfer has been completed.</li> </ul>

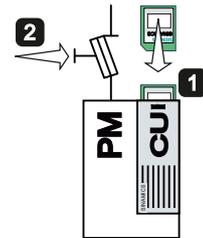
### 5.6.1.2 Transferring the setting from the memory card

If you wish to transfer the parameter setting from a memory card into the inverter (download), you have two options:

#### Automatic download

The inverter power supply has been switched off.

1. Insert the memory card into the inverter.
2. Then switch-on the inverter power supply.



If there is valid parameter data on the memory card, then the inverter accepts this automatically.

#### Note

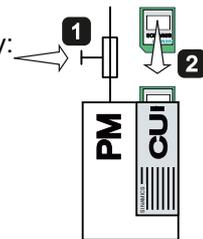
##### Inverter with enabled safety functions

After the automatic download, the inverter also accepts all of the settings of the safety functions.

#### Manual download

If you do not want to switch off the power supply, then you must transfer the parameter setting into the inverter in the following way:

1. The inverter power supply has been switched on.
2. Insert the memory card into the inverter.



STARTER	BOP-2
<ol style="list-style-type: none"> <li>1. Go online with STARTER</li> <li>2. In the expert list, set p0804 = 1.</li> <li>3. Check the value of parameter p0804. Once data transfer has been completed, then p0804 = 0 is automatically set.</li> </ol>	<ol style="list-style-type: none"> <li>1. Start data transfer in the menu "EXTRAS" - "FROM CRD".</li> <li>2. Wait until the BOP-2 signals that data transfer has been completed.</li> </ol>

**Inverter with enabled safety functions**

You must confirm the settings of the safety functions.

Table 5- 3 Procedure

STARTER	BOP-2	
1. Go online with STARTER	Set the following parameters:	
2. Call the safety functions screen form	p9761 = ...	Password for the safety functions
3. Click on the "Change settings" button	p0010 = 95	Changing the safety functions
4. Enter the password for the safety functions	p9701 = 220	Confirm the settings of the safety functions
5. Click on the "Activate settings" button.	p0010 = 0	Exit change

Final steps:

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

**5.6.1.3 Safely remove the memory card**

CAUTION
The file system on the memory card can be destroyed if the memory card is removed while the inverter 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 or BOP-2:

1. Set p9400 to 2.
2. Check the value of parameter p9400.  
If it is permissible to remove the memory card, p9400 is set to 3.
3. Remove the memory card.

## 5.6.2 Backing up and transferring settings using STARTER

### Backing up the inverter settings on PC/PG (upload)

1. Go online with STARTER: .
2. Click on the button "Load project to PG": .
3. To save data in the PG (computer), click on .

### Transferring settings from the PC/PG into the inverter (download)

1. Go online with STARTER.
2. Click on the button "Load project to target system": .
3. To save data in the converter, click on "Copy RAM to ROM" .

### Inverter with enabled safety functions

You must confirm the settings of the safety functions. Procedure:

1. In STARTER call-up the safety functions screen form
2. Click on the "Change settings" button
3. Click on the "Activate settings" button
4. Save your settings (copy RAM to ROM)
5. Switch off the inverter supply voltage
6. Wait until all LEDs on the inverter go dark. Now switch on the inverter supply voltage again. Your settings only become effective after this power-on reset.

### 5.6.3 Saving settings and transferring them using an operator panel

You start the download or upload in the "TOOLS" menu.

#### Download for inverters with enabled safety functions

You must confirm the settings of the safety functions.

Table 5- 4 Procedure

Set the following parameters	
p9761 = ...	Password for the safety functions
p0010 = 95	Changing the safety functions
p9701 = 220	Confirm the settings of the safety functions
p0010 = 0	Exit change

Final steps:

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

### 5.6.4 Other ways to back up settings

You can backup three additional settings of the parameters in memory areas of the inverter reserved for this purpose. You will find additional information in the List Manual under the following parameters:

Parameter	Description
p0970	<b>Resetting drive parameters</b> Load the back-up setting (number 10, 11 or 12). You overwrite your actual parameter setting when loading.
p0971	<b>Saving parameters</b> Backing up the setting (10, 11 or 12).

You can back-up up to 99 additional parameter settings on the memory card. You will find additional information in the List Manual under the following parameters:

Parameter	Description
p0802	<b>Data transfer with memory card as source/target</b>
p0803	<b>Data transfer with device memory as source/target</b>
p0804	<b>Start data transfer</b>



## Adapting the terminal strip

Before you adapt the inputs and outputs of the inverter, you should have completed the basic commissioning, see Chapter Commissioning (Page 47) .

In the basic commissioning, select an assignment of the inverter interfaces from several predefined configurations, see Section Wiring examples for the factory settings (Page 54).

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 18).

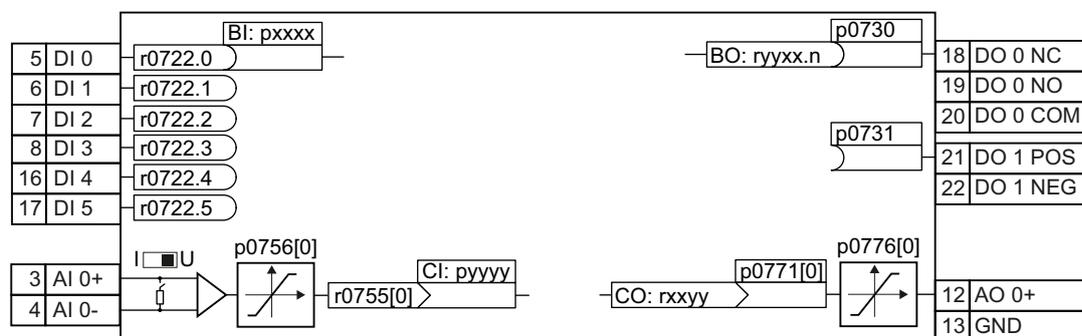


Figure 6-1 Internal connection of the inputs and outputs

## 6.1 Digital inputs

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

Table 6- 1 Binector inputs (BI) of the inverter (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 6- 2 Examples:

	Acknowledge fault with digital input 1
	Switch-on motor with digital input 2

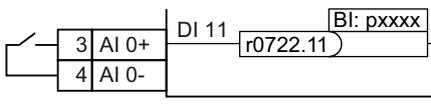
## Advanced settings

You can debounce the digital input signal using parameter p0724.

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

## Analog input as digital input

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

Terminals of the additional digital input	Changing the function of the digital input
	<p>If you use the analog input as digital input then interconnect the status parameter of the digital input with a binector input of your choice.</p>

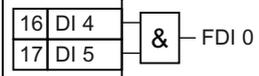
## 6.2 Fail-safe digital input

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

### Defining a fail-safe digital input

If you use the STO safety function, then you must configure the terminal strip during the basic commissioning for a fail-safe digital input, e.g. with p0015 = 2 (see Section Selecting the interface assignments (Page 41)).

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

Terminals of the fail-safe digital input	Function
	<p>You must enable STO to select the STO safety function (Basic Safety) via FDI 0.</p> <p>Further information can be found in section Fail-safe function Safe Torque Off (STO) (Page 228).</p>

## 6.3 Digital outputs

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

Table 6- 3 Binector outputs of the inverter (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 6- 4 Example:

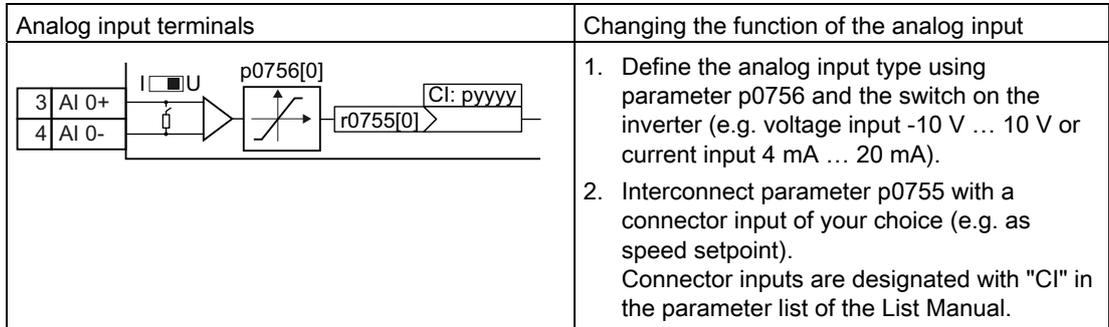
	Signal fault via digital output 1.
--	------------------------------------

### Advanced settings

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

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

## 6.4 Analog inputs

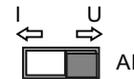


### Define the analog input type

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.

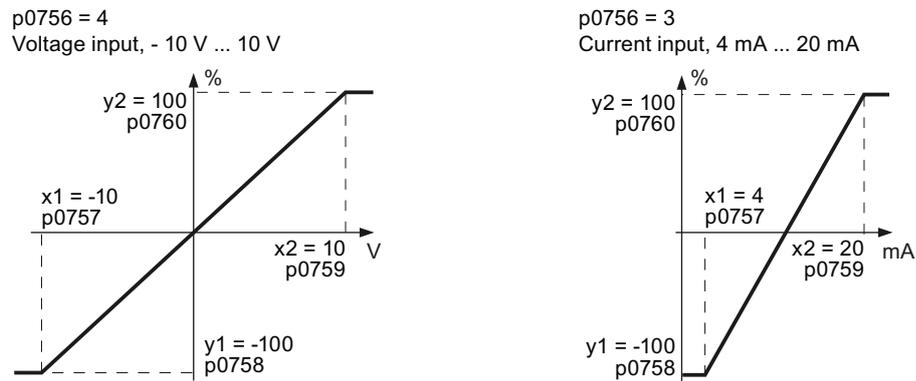


Figure 6-2 Examples for scaling characteristics

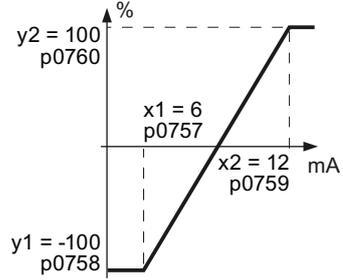
Table 6- 5 Parameters for the scaling characteristic and wire break monitoring

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.

Parameter	Description		
p0756[0] = 3	<b>Analog input type</b> Define analog input 0 as current input with wire break monitoring.	Set DIP switch for AI 0 to current input ("I"):	
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:			
p0761[0] = 6.0	<b>Analog inputs wire break monitoring, response threshold</b>	Current input, 6 mA ... 12 mA	
p0757[0] = 6.0	<b>Analog inputs, characteristic (x<sub>1</sub>, y<sub>1</sub>)</b>		
p0758[0] = -100.0	6 mA corresponds to -100 %		
p0759[0] = 12.0	<b>Analog inputs, characteristic (x<sub>2</sub>, y<sub>2</sub>)</b>		
p0760[0] = 100.0	12 mA corresponds to 100 %		

**Define the significance of the analog input**

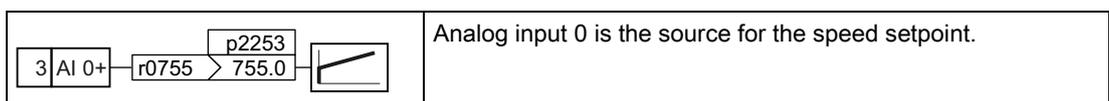
You define the analog input function by interconnecting a connector input of your choice with parameter p0755. Parameter p0755 is assigned to the particular analog input via its index, e.g. parameter p0755[0] is assigned to analog input 0.

Table 6- 6 Connector inputs (CI) of the inverter (selection)

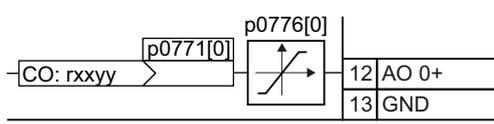
CI	Significance	CI	Significance
p1070	Main setpoint	p1522	Torque limit, upper
p1075	Supplementary setpoint	p2253	Technology controller setpoint 1
p1503	Torque setpoint	p2264	Technology controller actual value
p1511	Supplementary torque 1		

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

Table 6- 7 Example:



## 6.5 Analog outputs

Analog output terminals	Changing the function of the analog output
	<ol style="list-style-type: none"> <li>1. Define the analog output type using parameter p0776 (e.g. voltage output -10 V ... 10 V or current output 4 mA ... 20 mA).</li> <li>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".</li> </ol>

### 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 inverter automatically selects the appropriate scaling of the analog output. The linear scaling characteristic is defined using two points (p0777, p0778) and (p0779, p0780).



Figure 6-3 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 6- 8 Parameters for the scaling characteristic

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

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

**Example:**

The inverter 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	<b>Analog output, type</b> Define analog output 0 as current output.	
After changing p0776 to the value 2, the inverter 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	<b>Analog output, characteristic (x<sub>1</sub>, y<sub>1</sub>)</b>	Current output, 6 mA ... 12 mA 
p0778[0] = 6.0	0.0 % corresponds to 6 mA	
p0779[0] = 100.0	<b>Analog output, characteristic (x<sub>2</sub>, y<sub>2</sub>)</b>	
p0780[0] = 12.0	100 % corresponds to 12 mA	

**Defining the analog output function**

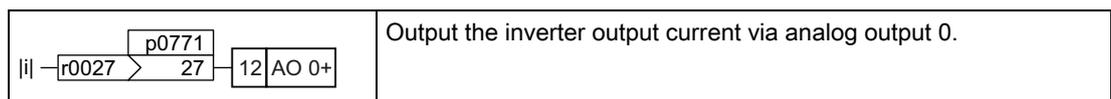
You define the analog output function by interconnecting parameter p0771 with a connector output of your choice. Parameter p0771 is assigned to the particular analog input via its index, e.g. parameter p0771[0] is assigned to analog output 0.

Table 6- 9 Connector outputs (CO) of the inverter (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 6- 10 Example:



For more information, see the parameter list and the function block diagrams 9572 ff 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

Before you connect the inverter to the field bus, you should have completed the basic commissioning, see Chapter Commissioning (Page 47)

### Fieldbus interfaces of the inverter

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

Fieldbus	Profile	Interface
PROFIBUS DP (Page 92)	PROFIdrive PROFIsafe	SUB D connector (female)
USS (Page 110)	-	RS485 connector
Modbus RTU (Page 123)	-	RS485 connector
CANopen (Page 133)	-	SUB D connector (male)

## 7.1 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. The significance of this numerical value depends on the category of the signal that you are transferring.

Signal category	4000 hex corresponds to the value of the following parameters
Speeds, frequencies	p2000
Voltage	p2001
Current	p2002
Torque	p2003
Power	p2004
Temperature	p2006

#### Control and status words

Control and status words always comprise two bytes. Depending on the control type, the two bytes are differently interpreted as higher or lower significance. An example for transferring control and status words with a SIMATIC control is provided in Chapter STEP 7 programming examples (Page 296).

## 7.2 Communication via PROFIBUS

### 7.2.1 Connect the frequency inverter to PROFIBUS

#### Permissible cable lengths, routing and shielding the PROFIBUS cable

Information can be found in the Internet  
(<http://support.automation.siemens.com/WW/view/en/1971286>).

#### Recommended PROFIBUS connectors

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

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

### 7.2.2 Configuring communication to the control

The GSD is a description file for a PROFIBUS slave. You must import the GSD of the converter into the PROFIBUS master - i.e. into your control system - in order to configure communication between the control system and converter.

You have two options for obtaining the GSD of your converter:

1. You can find the SINAMICS converter GSD on the Internet  
(<http://support.automation.siemens.com/WW/view/en/22339653/133100>).
2. The GSD is saved in the converter. The GSD is written to the memory card if you insert the memory card in the converter and set p0804 to 12. Using the memory card, you can then transfer the GSD to your PG/your PC.

In Section Application examples (Page 291) you will find an example showing how you can connect the converter with its GSD to a SIMATIC control via PROFIBUS.

### 7.2.3 Setting the address

You can set the inverter's PROFIBUS address using either DIP switches on the Control Unit or parameter p0918.

Valid PROFIBUS addresses: 1 ... 125

Invalid PROFIBUS addresses: 0, 126, 127

If you have specified a valid address using DIP switches, this address will always be the one that takes effect and p0918 cannot be changed.

If you set all DIP switches to "OFF" (0) or "ON" (1), then p0918 defines the address.

The positions and settings of the DIP switches are described in Section: Interfaces, connectors, switches, terminal blocks and LEDs of the inverter (Page 39).

<b>CAUTION</b>
A bus address that has been changed is only effective after the inverter has been switched off and back on again.

## 7.2.4 Basic settings for communication

Table 7- 1 The most important parameters

Parameter	Description												
p0015	<b>Macro drive device</b> Select the I/O configuration via PROFIBUS DP (e.g. p0015 = 7)												
p0922	<b>PROFIdrive telegram selection</b> (factory setting for inverters with PROFIBUS interface: standard telegram 1, PZD-2/2) Set the send and receive telegram, see Cyclic communication (Page 94)												
	<table border="0"> <tr> <td>1:</td> <td>Standard telegram 1, PZD-2/2</td> </tr> <tr> <td>20:</td> <td>Standard telegram 20, PZD-2/6</td> </tr> <tr> <td>352:</td> <td>SIEMENS telegram 352, PZD-6/6</td> </tr> <tr> <td>353:</td> <td>SIEMENS telegram 353, PZD-2/2, PKW-4/4</td> </tr> <tr> <td>354:</td> <td>SIEMENS telegram 354, PZD-6/6, PKW-4/4</td> </tr> <tr> <td>999:</td> <td>Free telegram configuration with BICO</td> </tr> </table>	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:	Free telegram configuration with BICO
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:	Free telegram configuration with BICO												

Using parameter p0922, you automatically interconnect the corresponding signals of the inverter to the telegram.

This BICO interconnection can only be changed, if you set p0922 to 999. In this case, select your required telegram using p2079 and then adapt the BICO interconnection of the signals.

Table 7- 2 Advanced settings

Parameter	Description
p2079	<b>PROFIdrive PZD telegram selection extended</b> Contrary to p0922, using p2079, a telegram can be set and subsequently extended. For p0922 < 999, the following applies: p2079 has the same value and is locked. All of the interconnections and extensions contained in the telegram are locked. For p0922 = 999, the following applies: p2079 can be freely set. If p2079 is also set to 999, then all interconnections can be set. For p0922 = 999 and p2079 < 999, the following applies: The interconnections contained in the telegram are locked. However, the telegram can be extended.

For further information, please refer to the List Manual.

### 7.2.5 Cyclic communication

The PROFIdrive profile defines different telegram types. Telegrams contain the data for cyclic communication with a defined meaning and sequence. The inverter has the telegram types listed in the table below.

Table 7- 3 Inverter telegram types

Telegram type (p0922)	Process data (PZD) - control and status words, setpoints and actual values							
	PZD01 STW1 ZSW1	PZD02 HSW HIW	PZD03	PZD04	PZD05	PZD06	PZD07	PZD08
<b>Telegram 1</b> Speed control PZD 2/2	STW1	NSOLL_A	← The inverter receives this data from the control					
	ZSW1	NIST_A	⇒ The inverter sends this data to the control					
<b>Telegram 20</b> Speed control, VIK/NAMUR PZD 2/6	STW1	NSOLL_A						
	ZSW1	NIST_A_ GLATT	IAIST_ GLATT	MIST_ GLATT	PIST_ GLATT	MELD_ NAMUR		
<b>Telegram 352</b> Speed control, PCS7 PZD 6/6	STW1	NSOLL_A	PCS7 process data					
	ZSW1	NIST_A_ GLATT	IAIST_ GLATT	MIST_ GLATT	WARN_ CODE	FAULT_ CODE		
<b>Telegram 353</b> Speed control, PKW 4/4 and PZD 2/2	STW1	NSOLL_A						
	ZSW1	NIST_A_ GLATT						
<b>Telegram 354</b> Speed control, PKW 4/4 and PZD 6/6	STW1	NSOLL_A	PCS7 process data					
	ZSW1	NIST_A_ GLATT	IAIST_ GLATT	MIST_ GLATT	WARN_ CODE	FAULT_ CODE		
<b>Telegram 999</b> Free interconnection via BICO PZD n/m (n,m = 1 ... 8)	STW1	Telegram length on receipt can be configured up to max. 8 words						
	ZSW1	Telegram length on transmission can be configured up to max. 8 words						

Table 7- 4 Explanation of the abbreviations

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

Table 7- 5 Telegram status in the inverter

Process data item	Control ⇒ inverter		Inverter ⇒ control	
	Status of the received word	Bits 0...15 in the received word	Defining the word to be sent	Status of the sent word
PZD01	r2050[0]	r2090.0 ... r2090.15	p2051[0]	r2053[0]
PZD02	r2050[1]	r2091.0 ... r2091.15	p2051[1]	r2053[1]
PZD03	r2050[2]	r2092.0 ... r2092.15	p2051[2]	r2053[2]
PZD04	r2050[3]	r2093.0 ... r2093.15	p2051[3]	r2053[3]
PZD05	r2050[4]	-	p2051[4]	r2053[4]
PZD06	r2050[5]	-	p2051[5]	r2053[5]
PZD07	r2050[6]	-	p2051[6]	r2053[6]
PZD08	r2050[7]	-	p2051[7]	r2053[7]

### Select telegram

Select the communication telegram using parameters p0922 and p2079. The following dependencies apply:

- **P0922 < 999:**  
For p0922 < 999, the inverter sets p2079 to the same value as p0922. With this setting, the inverter defines the length and the content of the telegram. The inverter does not permit any changes to the telegram.
- **p0922 = 999, p2079 < 999:**  
For p0922 = 999, select a telegram via p2079. Also with this setting, the inverter defines the length and the content of the telegram. The inverter does not permit any changes to the telegram content. However, you can extend the telegram.
- **p0922 = p2079 = 999:**  
For p0922 = p2079 = 999, enter the length and the content of the telegram. With this setting, you can define the telegram length via the central PROFIdrive configuration in the master. You define the telegram contents via the signal interconnections of the BICO technology. Using p2038, you can define the assignment of the control word according to SINAMICS or VIK/NAMUR.

You will find more details on the interconnection of command and setpoint sources, depending on the selected protocol, in the List Manual in function block diagrams 2420 to 2472.

#### 7.2.5.1 Control and status word 1

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

**Control word 1 (STW1)**

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

Table 7- 6 Control word 1 and interconnection with parameters in the inverter

Bit	Value	Significance		Comments	P No.
		Telegram 20	All other telegrams		
0	0	OFF1		Motor brakes with the ramp-down time p1121 at standstill ( $f < f_{min}$ ) the motor is switched off.	p0840[0] = r2090.0
	1	ON		With a positive edge, the inverter goes into the "ready" state, with additionally bit 3 = 1, the inverter switches on the motor.	
1	0	OFF2		Switch off motor immediately, motor coasts to a standstill.	p0844[0] = r2090.1
	1	No OFF2		---	
2	0	Quick stop (OFF3)		Quick stop: Motor brakes with the OFF3 ramp-down time p1135 down to standstill.	p0848[0] = r2090.2
	1	No quick stop (OFF3)		---	
3	0	Disable operation		Immediately switch-off motor (cancel pulses).	p0852[0] = r2090.3
	1	Enable operation		Switch-on motor (pulses can be enabled).	
4	0	Lock ramp-function generator		The ramp-function generator output is set to 0 (quickest possible deceleration).	p1140[0] = r2090.4
	1	Operating condition		Ramp-function generator can be enabled	
5	0	Stop ramp-function generator		The output of the ramp-function generator is "frozen".	p1141[0] = r2090.5
	1	Ramp-function generator enable			
6	0	Inhibit setpoint		Motor brakes with the ramp-down time p1121.	p1142[0] = r2090.6
	1	Enable setpoint		Motor accelerates with the ramp-up time p1120 to the setpoint.	
7	1	Acknowledging faults		Fault is acknowledged with a positive edge. If the ON command is still active, the inverter switches to "closing lockout" state.	p2103[0] = r2090.7
8		Not used			
9		Not used			
10	0	PLC has no master control		Process data invalid, "sign of life" expected.	p0854[0] = r2090.10
	1	Master control by PLC		Control via fieldbus, process data valid.	
11	1	--- <sup>1)</sup>	Direction reversal	Setpoint is inverted in the inverter.	p1113[0] = r2090.11
12		Not used			
13	1	--- <sup>1)</sup>	MOP up	The setpoint stored in the motorized potentiometer is increased.	p1035[0] = r2090.13
14	1	--- <sup>1)</sup>	MOP down	The setpoint stored in the motorized potentiometer is decreased.	p1036[0] = r2090.14
15	1	CDS bit 0	Not used	Changes over between settings for different operation interfaces (command data sets).	p0810 = r2090.15

<sup>1)</sup> 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 to 10 in accordance with PROFIdrive profile and VIK/NAMUR, bits 11 to 15 for SINAMICS G120 only).

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

Bit	Value	Significance		Comments	P No.
		Telegram 20	All other telegrams		
0	1	Ready for switching on		Power supply switched on; electronics initialized; pulses locked.	p2080[0] = r0899.0
1	1	Ready for operation		Motor is switched on (ON1 command present), no active fault, motor can start as soon as "enable operation" command is issued. See control word 1, bit 0.	p2080[1] = r0899.1
2	1	Operation enabled		Motor follows setpoint. See control word 1, bit 3.	p2080[2] = r0899.2
3	1	Fault present		The inverter has a fault.	p2080[3] = r2139.3
4	1	OFF2 inactive		Coast to standstill not activated (no OFF2)	p2080[4] = r0899.4
5	1	OFF3 inactive		No fast stop active	p2080[5] = r0899.5
6	1	Closing lockout active		The motor is only switched on after a further ON1 command	p2080[6] = r0899.6
7	1	Alarm active		Motor remains switched on; acknowledgement is not required; see r2110.	p2080[7] = r2139.7
8	1	Speed deviation within tolerance range		Setpoint/actual value deviation within tolerance range.	p2080[8] = r2197.7
9	1	Control requested		The automation system is requested to assume 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	--- <sup>1)</sup>	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 forwards		Internal inverter actual value > 0	p2080[14] = r2197.3
	0	Motor rotates backwards		Internal inverter actual value < 0	
15	1	CDS display	No alarm, thermal power unit overload		p2080[15] = r0836.0 / r2135.15

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

### 7.2.5.2 Data structure of the parameter channel

#### Parameter channel

You can write and read parameter values via the parameter channel, e.g. in order to monitor process data. The parameter channel always comprises four words.

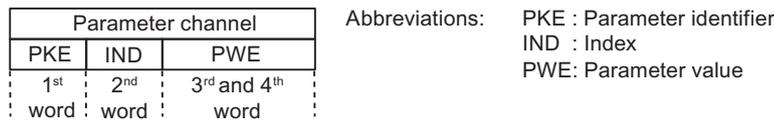


Figure 7-1 Structure of the parameter channel

#### Parameter identifier (PKE), 1st word

The parameter identifier (PKE) contains 16 bits.

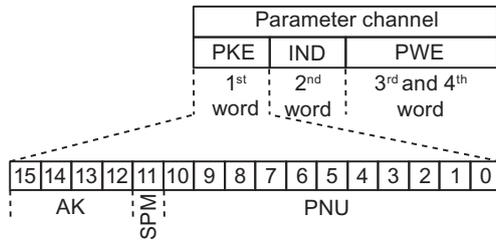


Figure 7-2 PKE - 1st word in parameter channel

- Bits 12 to 15 (AK) contain the request or response identifier.
- Bit 11 (SPM) is reserved and is always 0.
- Bits 0 to 10 (PNU) contain parameter numbers 1 ... 1999. For parameter numbers ≥ 2000 an offset must be added that is defined in the 2nd word of the parameter channel (IND).

The meaning of the request identifier for request telegrams (control → inverter) is explained in the following table.

Table 7- 8 Request identifier (control → inverter)

Request identifier	Description	Response identifier	
		positive	negative
0	No request	0	7 / 8
1	Request parameter value	1 / 2	↑
2	Change parameter value (word)	1	
3	Change parameter value (double word)	2	
4	Request descriptive element <sup>1)</sup>	3	
6	Request parameter value (field) <sup>1)</sup>	4 / 5	
7	Change parameter value (field, word) <sup>1)</sup>	4	
8	Change parameter value (field, double word) <sup>1)</sup>	5	
9	Request number of field elements	6	
11	Change parameter value (field, double word) and save in EEPROM <sup>2)</sup>	5	
12	Change parameter value (field, word) and save in EEPROM <sup>2)</sup>	4	
13	Change parameter value (double word) and save in EEPROM	2	↓
14	Change parameter value (word) and save in EEPROM	1	7 / 8
1) The required element of the parameter description is specified in IND (2nd word).			
2) The required element of the indexed parameter is specified in IND (2nd word).			

The meaning of the response identifier for response telegrams (inverter → control) is explained in the following table. The request identifier determines which response identifiers are possible.

Table 7- 9 Response identifier (inverter → control)

Response identifier	Description
0	No response
1	Transfer parameter value (word)
2	Transfer parameter value (double word)
3	Transfer descriptive element <sup>1)</sup>
4	Transfer parameter value (field, word) <sup>2)</sup>
5	Transfer parameter value (field, double word) <sup>2)</sup>
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 description is specified in IND (2nd word).	
2) The required element of the indexed parameter is specified in IND (2nd word).	

If the response identifier is 7 (request cannot be processed), one of the error numbers listed in the following table will be saved in parameter value 2 (PWE2).

Table 7- 10 Error numbers for the response "Request cannot be processed"

No.	Description	Comments
0	Impermissible parameter number (PNU)	Parameter does not exist
1	Parameter value cannot be changed	The parameter can only be read
2	Minimum/maximum not achieved or exceeded	–
3	Wrong subindex	–
4	No field	An individual parameter was addressed with a field request and subindex > 0
5	Wrong parameter type / wrong data type	Confusion of word and double word
6	Setting is not permitted (only resetting)	–
7	The descriptive element cannot be changed	Description cannot be changed
11	Not in the "master control" mode	Change request without "master control" mode (see P0927)
12	Keyword missing	–
17	Request cannot be processed on account of the operating state	The current inverter status is not compatible with the received request
20	Illegal value	Modification access with a value which is within the value limits but which is illegal for other permanent reasons (parameter with defined individual values)
101	Parameter number is currently deactivated	Dependent on the operating state of the inverter
102	Channel width is insufficient	Communication channel is too small for response
104	Illegal parameter value	The parameter can only assume certain values.
106	Request not included / task is not supported	After request ID 5, 10, 15
107	No write access with enabled controller	The operating state of the inverter prevents a parameter change
200/201	Changed minimum/maximum not achieved or exceeded	The maximum or minimum can be limited further during operation.
204	The available access authorization does not cover parameter changes.	–

## Parameter index (IND)

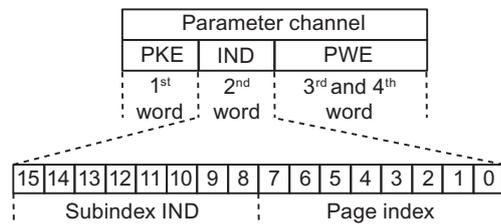


Figure 7-3 Structure of the parameter index (IND)

- For indexed parameters, select the index of the parameter by transferring the appropriate value between 0 and 254 to the subindex within a job.
- The page index is used to switch over the parameter numbers. Use this byte to add an offset to the parameter number that is transferred in the 1st word of the parameter channel (PKE).

## Page index: Offset of parameter number

The parameter numbers are assigned to several parameter ranges. The following table shows which value you must transfer to the page index to achieve a particular parameter number.

Table 7- 11 Page index setting dependent on parameter range

Parameter range	Page index								Hex value
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
0000 ... 1999	0	0	0	0	0	0	0	0	0x00
2000 ... 3999	1	0	0	0	0	0	0	0	0x80
6000 ... 7999	1	0	0	1	0	0	0	0	0x90
8000 ... 9999	0	0	1	0	0	0	0	0	0x20
10000 ... 11999	1	0	1	0	0	0	0	0	0xA0
20000 ... 21999	0	1	0	1	0	0	0	0	0x50
30000 ... 31999	1	1	1	1	0	0	0	0	0xF0

## Parameter value (PWE)

The parameter value (PWE) is transferred as a double word (32 bits). Only one parameter value may be transferred per telegram.

A 32 bit parameter value includes PWE1 (H word, 3rd word) and PWE2 (L word, 4th word).

A 16 bit parameter value is transferred in PWE2 (L word, 4th word). In this case, PWE1 (H word, 3rd word) must be set to 0.

**Example of read request for parameter P7841[2]**

To obtain the value of the indexed parameter P7841, you must fill the telegram of the parameter channel with the following data:

- Request parameter value (field): Bits 15 ... 12 in the PKE word:  
Request identifier = 6
- Parameter number without offset: Bits 10 ... 0 in the PKE word:  
Because you can only code parameter numbers from 1 ... 1999 in the PKE, you must deduct as large an offset as possible, a number divisible by 2000, from the parameter number, and transfer the result of this calculation to the PKE word.  
In our example, this means: 7841 - 6000 = 1841
- Coding the offset of the parameter number in the page index byte of the IND word:  
In this example: When offset = 6000, this corresponds to a page index value of 0x90.
- Index of parameter in the subindex byte of the IND word:  
In this example: Index = 2
- 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.

Table 7- 12 Request to read parameter P7841[2]

PKE (1st word)			IND (2nd word)		PWE (3rd and 4th words)	
AK		PNU (10 bits)	Subindex (H byte)	Page index (L byte)	PWE1 (H word)	PWE2 (L word)
0x6	0	0x731 (decimal: 1841)	0x02	0x90	0x0000	0x0000

**Rules for editing requests and responses**

- You can only request one parameter per transmitted telegram
- Each received telegram contains only one response
- The request must be repeated until the right response is received
- The response is assigned to a request by means of the following identifiers:
  - Suitable response identifier
  - Suitable parameter number
  - Suitable parameter index IND, if required
  - Suitable parameter value PWE, if necessary
- The complete request must be sent in a telegram. Request telegrams cannot be subdivided. The same applies to responses.

### 7.2.5.3 Slave-to-slave communication

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

For slave-to-slave communication, in the control system you must define which inverter 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 inverters that operate as subscriber, you must define how the data transferred using slave-to-slave communication is processed. Using parameter r2077, in the inverter, you can read-out the PROFIBUS addresses of the inverters 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 8 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 inverters in STEP 7 is provided in Section: Configuring slave-to-slave communication in STEP 7 (Page 302).

## 7.2.6 Acyclic communication

### 7.2.6.1 Acyclic communication

As from performance level DP-V1, PROFIBUS communications offer acyclic data communications apart from cyclic communications. You can parameterize and troubleshoot (diagnostics) the inverter via acyclic data transfer. Acyclic data is transferred in parallel with cyclic data transfer but with a lower priority.

The inverter supports the following data transfer types:

- 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 (Human Machine Interface)

You can find a STEP 7 program example for acyclic data transfer in Section Application examples (Page 291).

### 7.2.6.2 Reading and changing parameters via data set 47

#### Reading parameter values

Table 7- 13 Request to read parameters

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

Table 7- 14 Converter response to a read request

Data block	Byte n	Bytes n + 1	n
Header	Reference (identical to a read request)	01 hex: Converter has executed the read request. 81 hex: Converter was not able to completely execute the read request.	0
	01 hex	Number of parameters (m) (identical to the read request)	2
Values, parameter 1	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	Number of index values or - for a negative response - number of error values	4
	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.		6
	...		...
Values, parameter 2	...		
...	...		
Values, parameter m	...		

### Changing parameter values

Table 7- 15 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 7- 16 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 7- 17 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"- <b>error value 1</b> You can find the error values in the table at the end of this section.		6
	Only if "number of error values" = 02 hex: <b>Error value 2</b> Error value 1 defines whether the converter sends error value 2 and what it means.		8
Values, parameter 2	...		
...	...		...
Values, parameter m	...		

## Diagnostics

Table 7- 18 Error value in the parameter response

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

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

## 7.3 Communication via RS485

### 7.3.1 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 inverter (Page 39). This connector has short-circuit proof, isolated pins.

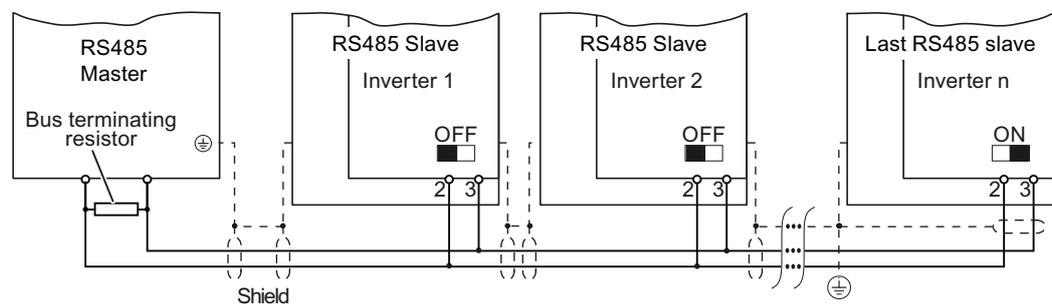


Figure 7-4 Communication network via RS485

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 inverter (Page 39).

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.

## 7.3.2 Communication via USS

### 7.3.2.1 Setting the address

You can set the inverter's USS address using either DIP switches on the Control Unit or parameter p2021.

Valid USS addresses: 1 ... 30  
 Invalid USS addresses: 0, 31 ... 127

If you have specified a valid address using DIP switches, this address will always be the one that takes effect and p2021 cannot be changed.

If you set all DIP switches to "OFF" (0) or "ON" (1), then p2021 defines the address.

The positions and settings of the DIP switches are described in Section Interfaces, connectors, switches, terminal blocks and LEDs of the inverter (Page 39).

**CAUTION**

A bus address that has been changed is only effective after the inverter has been switched off and back on again.

### 7.3.2.2 Structure of a USS telegram

A USS telegram comprises a sequence of characters, which are sent in a defined sequence. Every character within the telegram comprises 11 bits. The sequence of characters of a USS telegram is shown in the following diagram.

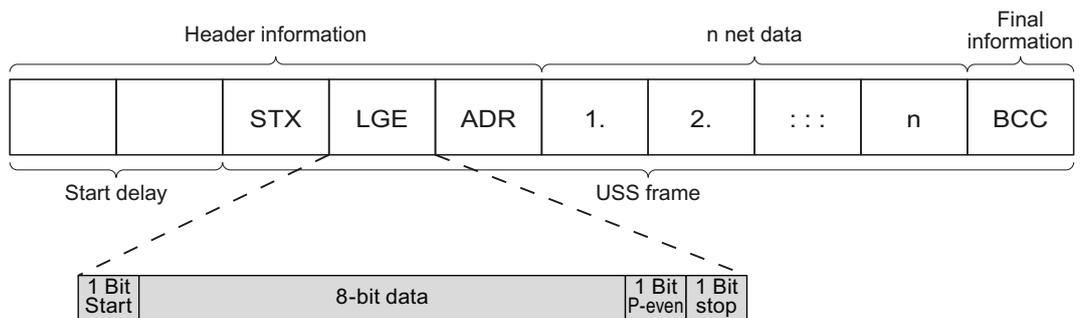


Figure 7-5 Structure of a USS telegram

## Description

Telegrams with both a variable and fixed length can be used. This can be selected using parameters p2022 and p2023 to define the length of the PZD and the PKW within the net data.

STX	1 byte	
LGE	1 byte	
ADR	1 byte	
Net data	PKW	8 bytes (4 words: PKE + IND + PWE1 + PWE2)
(example)	PZD	4 bytes (2 words: PZD1 + PZD2)
BCC	1 byte	

## Start delay

The start delay must be maintained before a new master telegram is started.

## STX

The STX block is an ASCII character (0x02) and indicates the beginning of a message.

## LGE

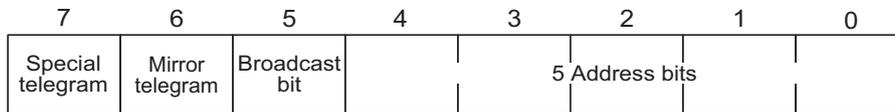
LGE specifies the number of bytes that following in the telegram. It is defined as the sum of the following bytes

- Net data
- ADR
- BCC

The actual overall telegram length is two bytes longer because STX and LGE are not counted in LGE.

### ADR

The ADR range contains the address of the slave node (e.g. of the inverter). The individual bits in the address byte are addressed as follows:



- Bit 5 broadcast bit  
Bit 5 = 0: normal data exchange. Bit 5 = 1: Address (bits 0 ... 4) is not evaluated (is not supported in SINAMICS G120!).
- Bit 6 mirror telegram  
Bit 6 = 0: normal data exchange. Bit 6 = 1: The slave returns the telegram unchanged to the master. Is used to test the bus connection.
- Bit 7 special telegram  
Bit 7 = 0: normal data exchange. Bit 7 = 1 to transfer telegrams that require a net data structure different from the device profile.

### BCC

BCC (Block Check Character). It is an exclusive OR checksum (XOR) over all telegram bytes with the exception of the BCC itself.

#### 7.3.2.3 User data range of the USS telegram

The user data range of the USS protocol is used to transmit application data. This comprises the parameter channel data and the process data (PZD).

The user data occupy the bytes within the USS frame (STX, LGE, ADR, BCC). The size of the user data can be configured using parameters p2023 and p2022. The structure and sequence of the parameter channel and process data (PZD) are shown in the figure below.

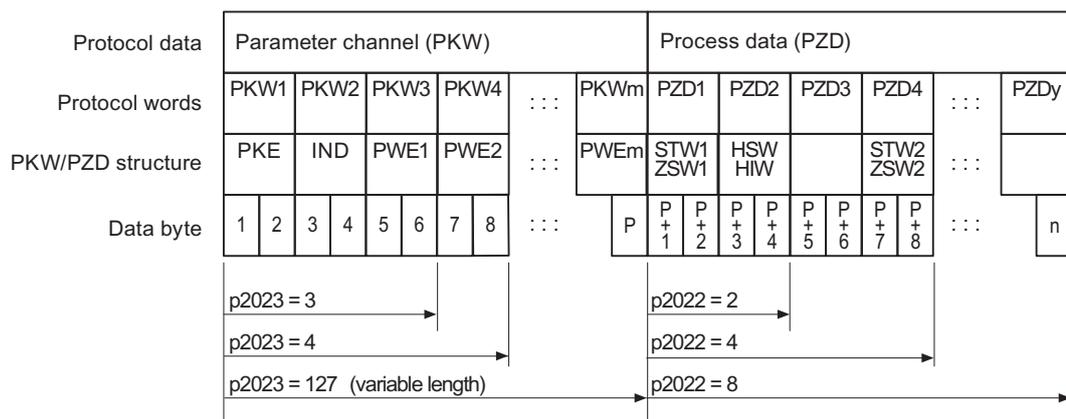


Figure 7-6 USS user data structure

The length for the parameter channel is determined by parameter p2023 and the length for the process data is specified by parameter p2022. If the parameter channel or the PZD is not required, the appropriate parameters can be set to zero ("PKW only" or "PZD only").

It is not possible to transfer "PKW only" and "PZD only" alternatively. If both channels are required, they must be transferred together.

### 7.3.2.4 Data structure of the USS parameter channel

The USS protocol defines for inverters the user data structure via which a master accesses the slave inverter. The parameter channel is used to read and write parameters in the inverter.

#### Parameter channel

You can use the parameter channel with a fixed length of 3 or 4 data words or with a variable length.

The first data word always contains the parameter identifier (PKE) and the second contains the parameter index.

The third, fourth and subsequent data words contain parameter values, texts and descriptions.

#### Parameter identifier (PKE), 1st word

The parameter identifier (PKE) is always a 16-bit value.

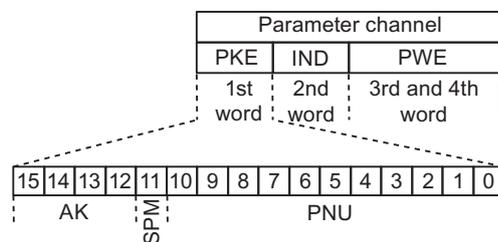


Figure 7-7 PKE structure

- Bits 12 to 15 (AK) contain the request or response identifier.
- Bit 11 (SPM) is reserved and always = 0.
- Bits 0 to 10 (PNU) contain parameter numbers 1 ... 1999. For parameter numbers  $\geq 2000$ , you must add an offset in the 2nd word of the parameter channel (IND).

The following table includes the request ID for telegrams between the master → inverter.

Table 7- 19 Request identifier (master → inverter)

Request identifier	Description	Response identifier	
		Positive	Negative
0	No request	0	7
1	Request parameter value	1 / 2	7
2	Change parameter value (word)	1	7
3	Change parameter value (double word)	2	7
4	Request descriptive element <sup>1)</sup>	3	7
6	Request parameter value <sup>1) 2)</sup>	4 / 5	7
7	Change parameter value (word) <sup>1) 2)</sup>	4	7
8	Change parameter value (double word) <sup>1) 2)</sup>	5	7

1) The required element of the parameter description is specified in IND (2nd word).  
 2) Identifier 1 is identical to identifier 6, ID 2 is identical to 7, and 3 is identical to 8. We recommend that you use identifiers 6, 7, and 8.

The following table includes the response ID for telegrams between the inverter → master. The response ID depends on the request ID.

Table 7- 20 Response identifier (inverter → master)

Response identifier	Description
0	No response
1	Transfer parameter value (word)
2	Transfer parameter value (double word)
3	Transfer descriptive element <sup>1)</sup>
4	Transfer parameter value (field, word) <sup>2)</sup>
5	Transfer parameter value (field, double word) <sup>2)</sup>
6	Transfer number of field elements
7	Request cannot be processed, task cannot be executed (with error number)

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

If the response ID = 7, then the inverter sends one of the error numbers listed in the following table in parameter value 2 (PWE2).

Table 7- 21 Error numbers for the response "Request cannot be processed"

No.	Description	Comments
0	Impermissible parameter number (PNU)	Parameter does not exist
1	Parameter value cannot be changed	The parameter can only be read
2	Minimum/maximum not achieved or exceeded	–
3	Wrong subindex	–
4	No field	An individual parameter was addressed with a field request and subindex > 0
5	Wrong parameter type / wrong data type	Confusion of word and double word
6	Setting is not permitted (only resetting)	Index is outside the parameter field[]
7	The descriptive element cannot be changed	Description cannot be changed
11	Not in the "master control" mode	Change request without "master control" state
12	Keyword missing	–
17	Request cannot be processed on account of the operating state	The actual inverter operating state is not compatible with the received request
20	Illegal value	Modification access with a value which is within the value limits but which is illegal for other permanent reasons (parameter with defined individual values)
101	Parameter number is currently deactivated	Dependent on the operating state of the inverter
102	Channel width is insufficient	Communication channel is too small for response
104	Illegal parameter value	The parameter can only assume certain values.
106	Request not included / task is not supported	After request identifier 5,11,12,13,14,15
107	No write access with enabled controller	The operating state of the inverter prevents a parameter change
200/201	Changed minimum/maximum not achieved or exceeded	The maximum or minimum can be limited further during operation.
204	The available access authorization does not cover parameter changes.	–

### Parameter index (IND)

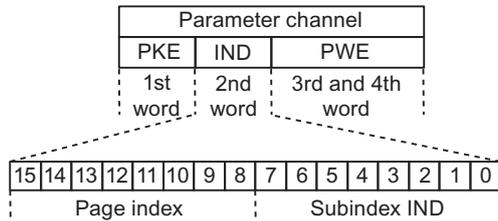


Figure 7-8 Structure of the parameter index (IND)

- For indexed parameters, select the index of the parameter by transferring the appropriate value between 0 and 254 to the subindex within a job.
- The page index is used to switch over the parameter numbers. Use this byte to add an offset to the parameter number that is transferred in the 1st word of the parameter channel (PKE).

### Page index: Offset of parameter number

The parameter numbers are assigned to several parameter ranges. The following table shows which value you must transfer to the page index to achieve a particular parameter number.

Table 7- 22 Page index setting dependent on parameter range

Parameter range	Page index								Hex value
	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	
0000 ... 1999	0	0	0	0	0	0	0	0	0x00
2000 ... 3999	1	0	0	0	0	0	0	0	0x80
6000 ... 7999	1	0	0	1	0	0	0	0	0x90
8000 ... 9999	0	0	1	0	0	0	0	0	0x20
10000 ... 11999	1	0	1	0	0	0	0	0	0xA0
20000 ... 21999	0	1	0	1	0	0	0	0	0x50
30000 ... 31999	1	1	1	1	0	0	0	0	0xF0

## Parameter value (PWE)

You can vary the number of PWEs using parameter p2023.

Parameter channel with fixed length	Parameter channel with variable length
<p>P2023 = 4</p> <p>A parameter channel with fixed length should contain 4 words as this setting is sufficient for all parameters (including double words).</p>	<p>P2023 = 127</p> <p>For a variable length of parameter channel, the master will only send the number of PWEs necessary for the task in the parameter channel. The response telegram is also no longer than necessary.</p>
<p>P2023 = 3</p> <p>You can select this setting if you only want to read or write 16-bit data or alarm signals.</p> <ul style="list-style-type: none"> <li>• 16-bit data: e.g. p0210 supply voltage</li> <li>• 32-bit data: Indexed parameter, e.g. p0640[0...n] Bit parameter, e.g. 722.0...12</li> </ul>	
<p>The master must always transmit the permanently set number of words in the parameter channel. Otherwise the slave will not respond to the telegram.</p> <p>When the slave responds it must always respond with the defined number of words.</p>	

### Note

8-bit values are transmitted as 16-bit values; the higher-order byte is zero. The fields of 8-bit values require one PWE per index.

## Rules for editing requests/responses

- You can only request one parameter for each telegram sent.
- Each received telegram contains only one response.
- The master must repeat a request until it receives a suitable response.
- Request and response are assigned to one another using the following identifiers:
  - Suitable response identifier
  - Suitable parameter number
  - Suitable parameter index IND, if required
  - Suitable parameter value PWE, if necessary
- The master must send the complete request in one telegram. Request telegrams cannot be split up. The same applies to responses.

7.3.2.5 USS read request

**Example: Reading out alarm messages from the inverter.**

The parameter channel comprises four words (p2023 = 4). In order to obtain the values of the indexed parameter r2122, you must fill the telegram of the parameter channel with the following data:

- Request parameter value (field): Bits 15 ... 12 in the PKE word:  
Request identifier = 6
- Parameter number without offset: Bits 10 ... 0 in the PKE word:  
Because you can only code parameter numbers from 1 ... 1999 in the PKE, you must deduct as large an offset as possible, a number divisible by 2000, from the parameter number, and transfer the result of this calculation to the PKE word.  
In our example, this means: 2122 - 2000 = 122 = 7AH
- Offset of the parameter number in the byte page index of the word IND:  
for this example: When offset = 2000, this corresponds to a page index value of 0x80
- Index of the parameter in the byte subindex of the word IND:  
If you wish to read-out the last alarm, then you must enter index 0, for the third from last, index 2 (example). You can find a detailed description on the history of the alarm messages in the Section Alarms (Page 258) .
- 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.

Table 7- 23 Request to read parameter r2122[2]

PKE (1st word)			IND (2nd word)		PWE (3rd and 4th words)		
AK		PNU	Page index (H byte)	Subindex (L byte)	PWE1(H word)	PWE2(L word)	
						Drive Object	
15 ... 12	11	10 ... 0	15 ... 8	7 ... 0	15 ... 0	15 ... 10	9 ... 0
0x6	0	0x7A (dec: 122)	0x80	0x02	0x0000	0x0000	0x0000

### 7.3.2.6 USS write job

#### Example: Define digital input 2 as source for ON/OFF in CDS1

In this case, parameter p0840[1] (source, ON/OFF) must be assigned the value 722.2 (digital input 2).

The parameter channel comprises four words (p2023 = 4). To change the value of the indexed parameter P0840, you must fill the telegram of the parameter channel with the following data:

- Change parameter value (field): Enter bit 15 ... 12 in PKE (1st word):  
Request identifier = 7
- Parameter number without offset: Enter bit 10 ... 0 in PKE (1st word):  
As the parameter is < 1999, it can be directly entered without an offset - converted into hex - in the example 840 = 348H.
- Enter the offset of the parameter number in byte page index of word IND (2nd word):  
in this example = 0.
- Enter the index of parameter in the byte subindex of word IND (2nd word):  
for this example = 1 (CDS1)
- Enter a new parameter value in PWE1 (Word3):  
in the example 722 = 2D2H.
- Drive Object: Enter bit 10 ... 15 in PWE2 (4th word):  
for SINAMICS G120, always 63 = 3FH
- Index of the parameter: Enter bit 0 ... 9 in PWE2 (word4):  
in example 2.

Table 7- 24 Request to change p0840[1]

PKE (1st word)			IND (2nd word)		PWE (3rd and 4th words)		
AK		PNU	Page index (H byte)	Subindex (L byte)	PWE1(H word)	PWE2(L word)	
15 ... 12	11	10 ... 0	15 ... 8	7 ... 0	15 ... 0	Drive Object	9 ... 0
0x7	0	0x348 (dec: 840)	0x0000	0x01	0x2D2 (dec: 722)	3F (fixed) (dec: 63)	0x0002

### 7.3.2.7 USS process data channel (PZD)

#### Description

Process data (PZD) is exchanged between the master and slave in this telegram range. Depending on the direction of transfer, the process data channel contains request data for the slave or response data to the master. The request contains control words and setpoints for the slaves, while the response contains status words and actual values for the master.

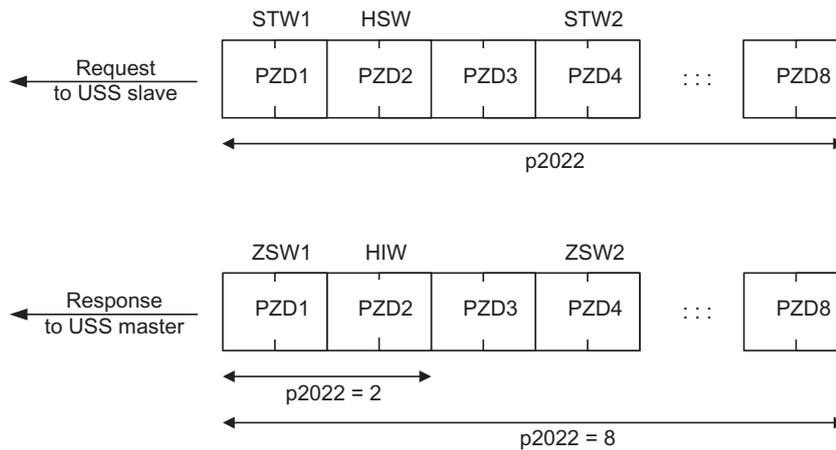


Figure 7-9 Process data channel

The number of PZD words in a USS telegram is defined by parameter p2022. The first two words are:

- Control 1 (STW1, r0054) and main setpoint (HSW)
- Status word 1 (ZSW1, r0052) and main actual value (HIW)

If P2022 is greater than or the same as 4, the additional control word (STW2, r0055) is transferred as the fourth PZD word (default setting).

You define the sources of the PZD using parameter p2051.

For further information, please refer to the Parameter Manual.

### 7.3.2.8 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 7- 25 Character runtime

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

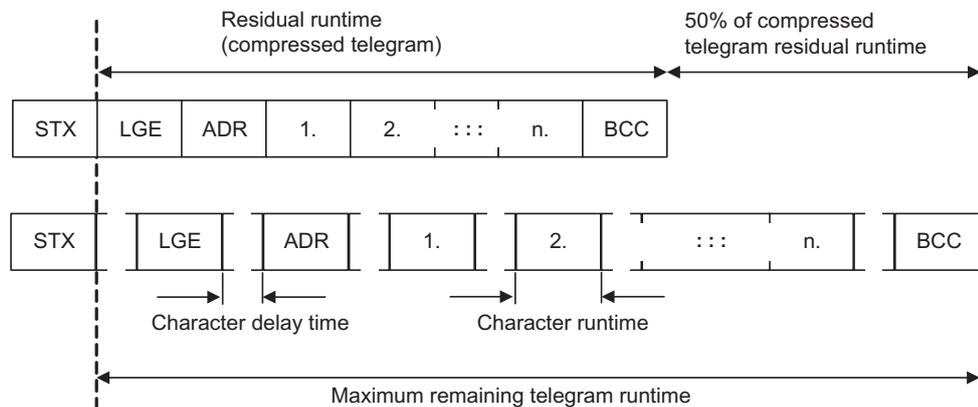


Figure 7-10 Telegram runtime as the sum of the residual runtime and character delay times

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  $> 2 \times$  character runtime.

The slave only responds after the response delay has expired.

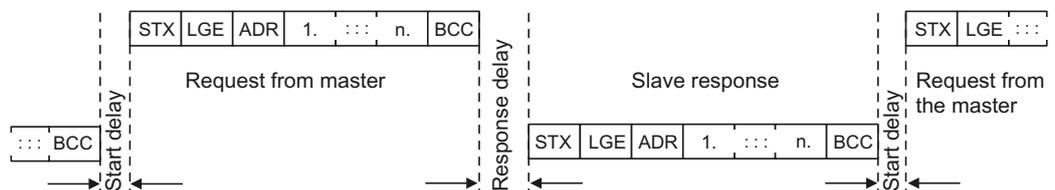


Figure 7-11 Start delay and response delay

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 7- 26 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.

### 7.3.3 Communication over Modbus RTU

#### 7.3.3.1 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.



##### 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 k $\Omega$  resistors are provided to polarize the receive and send cables.

 <b>CAUTION</b>
<b>It is not permitted to change over the units!</b>
The "Unit changover (Page 196)" function is not permissible with this bus system!

### 7.3.3.2 Setting the address

You can set the inverter's Modbus RTU address using either DIP switches on the Control Unit or parameter p2021.

Valid Modbus RTU addresses: 1 ... 247

Invalid Modbus RTU addresses: 0

If you have specified a valid address using DIP switches, this address will always be the one that takes effect and p2021 cannot be changed.

If you set all DIP switches to "OFF" (0) or "ON" (1), then p2021 defines the address.

The positions and settings of the DIP switches are described in Section Interfaces, connectors, switches, terminal blocks and LEDs of the inverter (Page 39).

**CAUTION**

A bus address that has been changed is only effective after the inverter has been switched off and back on again.

### 7.3.3.3 Basic settings for communication

Parameter	Description
P0015 = 21	<b>Macro drive unit</b> Selecting the I/O configuration
p2030 = 2	<b>Fieldbus protocol selection</b> 2: Modbus
p2020	<b>Fieldbus baud rate</b> Baud rates from 4800 bit/s to 187500 bit/s can be set for communication, factory setting = 19200 bit/s.
p2024	<b>Modbus timing</b> (see Section "Baud rates and mapping tables (Page 126)") <ul style="list-style-type: none"> <li>• <b>Index 0: Maximum slave telegram processing time:</b> The time after which the slave must have sent a response to the master.</li> <li>• <b>Index 1: Character delay time:</b> Character delay time: Maximum permissible delay time between the individual characters in the Modbus frame. (Modbus standard processing time for 1.5 bytes).</li> <li>• <b>Index2: Inter-telegram delay:</b> Maximum permissible delay time between Modbus telegrams. (Modbus standard processing time for 3.5 bytes).</li> </ul>
p2029	<b>Fieldbus fault statistics</b> Displays receive faults on the fieldbus interface
p2040	<b>Process data monitoring time</b> Determines the time after which an alarm is generated if no process data are transferred. <b>Note:</b> This time must be adapted depending on the number of slaves and the baud rate set for the bus (factory setting = 100 ms).

### 7.3.3.4 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.

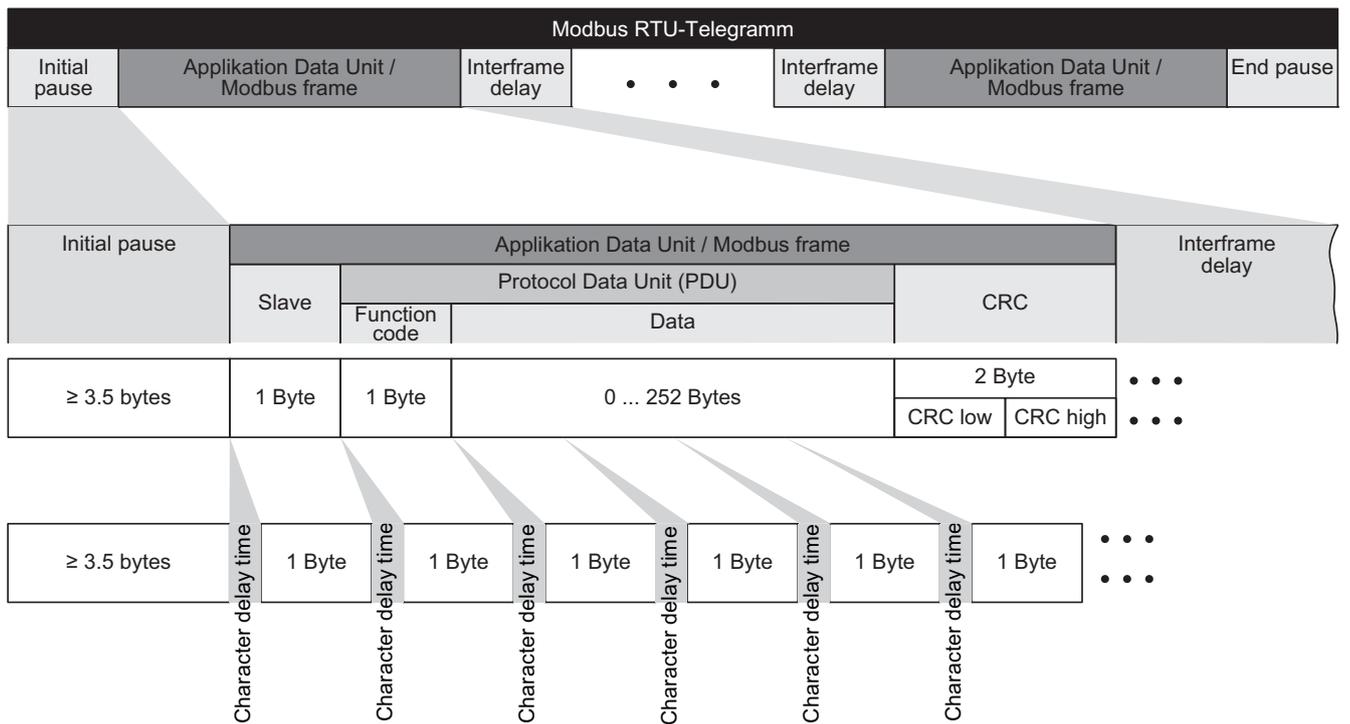


Figure 7-12 Modbus with delay times

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

### 7.3.3.5 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 7- 27 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 7- 28 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
<b>Process data</b>							
<b>Control data</b>							
40100	Control word	R/W	--	1			Process data 1
40101	Main setpoint	R/W	--	1			Process data 2
<b>Status data</b>							
40110	Status word	R	--	1			Process data 1
40111	Main actual value	R	--	1			Process data 2
<b>Parameter data</b>							
<b>Digital outputs</b>							
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
<b>Analog outputs</b>							
40220	AO 0	R	%	100	-100.0 ... 100.0		r0774.0
40221	AO 1	R	%	100	-100.0 ... 100.0		r0774.1
<b>Digital inputs</b>							
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
<b>Analog inputs</b>							
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
<b>Converter identification</b>						
40300	Powerstack number	R	--	1	0 ... 32767	r0200
40301	Converter firmware	R	--	0.0001	0.00 ... 327.67	r0018
<b>Converter data</b>						
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
<b>Converter diagnostics</b>						
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
<b>Fault diagnostics</b>						
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	--
<b>Technology controller</b>						
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
<b>Technology controller adjustment</b>						
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
<b>PID diagnostics</b>						
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

### 7.3.3.6 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 7- 29 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 7- 30 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 7- 31 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 7- 32 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"

### 7.3.3.7 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 7- 33 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).

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## 7.4 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 inverter (Page 39).

### 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 136) 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

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#### **Note**

In the configuration example (Page 159) 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 148) and List of objects (Page 151).

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### 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>).

### 7.4.1 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 in Internet (<http://support.automation.siemens.com/WW/view/en/48351511>).

In Section Engineering example (Page 159), you can find an example of how you can integrate the converter into a CAN controller using the EDS.

### 7.4.2 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 146) or via Free PDO mapping (Page 147)

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

\*) COB-ID for RPDO and TPDO for the "Predefined Connection Set", see Page (Page 146).

## 7.4.3 Commissioning CANopen

### 7.4.3.1 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 DIP switch on the Control Unit, using parameter p8620 or in STARTER in the screen form under "Control Unit/Communication/CAN" under the CAN interface tab.

Valid node IDs: 1 ... 126  
Invalid node IDs: 0, 127

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

If you set all DIP switches to "OFF" (0) or "ON" (1), then the Node ID set in p8620 or STARTER is effective.

The positions and settings of the DIP switches are described in Section Interfaces, connectors, switches, terminal blocks and LEDs of the inverter (Page 39).

### 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.

#### 7.4.3.2 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

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##### 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.

 <b>WARNING</b>
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.

#### 7.4.3.3 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 7- 34 SDO abort codes

<b>Abort code</b>	<b>Description</b>
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)

#### 7.4.3.4 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 151).

#### 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

### 7.4.3.5 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 147) or the Predefined connection set (Page 146) 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 7- 35 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 7- 36 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:

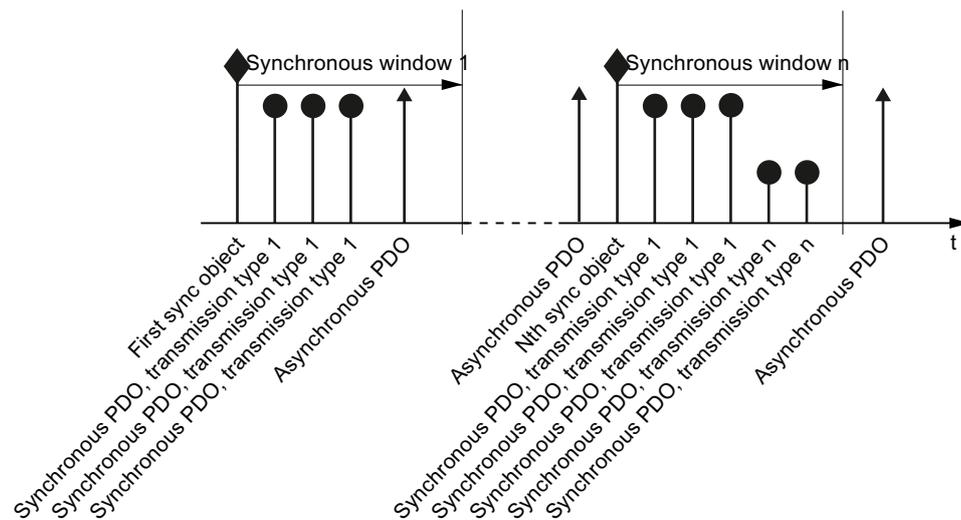


Figure 7-13 Principle of synchronous and asynchronous transmission

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

---

### 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).

### 7.4.3.6 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 142).

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

- $COB-ID_{TPDO} = 180 \text{ hex} + \text{Node-ID} + ((TPDO\text{-No.} - 1) * 100 \text{ hex})$   
Example: COB-ID of the TPDO 2, (Node ID = C hex)  
 $180 \text{ hex} + \text{C hex} + ((2 - 1) * 100 \text{ hex}) = 18\text{C hex} + 100 \text{ hex} = 28\text{C hex}$  is required
- $COB-ID_{RPDO} = 200 \text{ hex} + \text{Node-ID} + ((RPDO\text{-No.} - 1) * 100 \text{ hex})$   
Example: COB-ID of the 3rd RPDO, (Node ID = C hex)  
 $200 \text{ hex} + \text{C hex} + ((3 - 1) * 100 \text{ hex}) = 20\text{C hex} + 100 \text{ hex} = 30\text{C hex}$  is required

### 7.4.3.7 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 142).

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

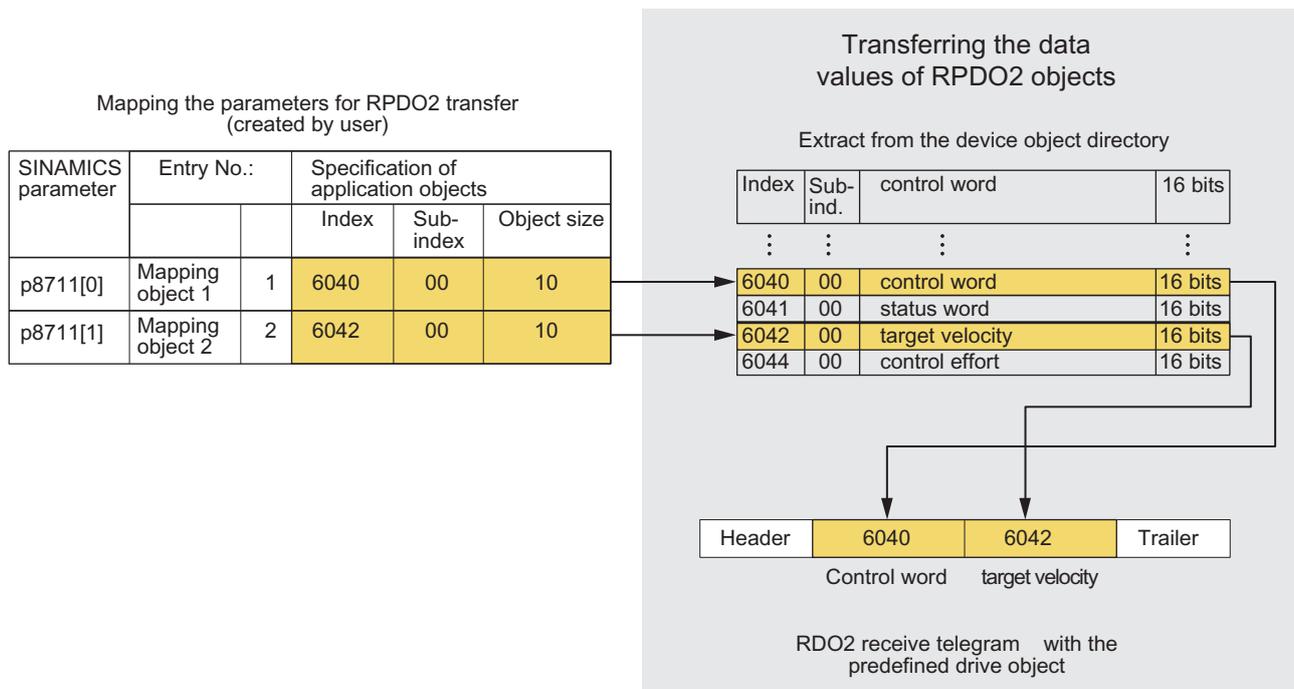


Figure 7-14 PDO mapping for control word and speed setpoint

## 7.4.4 Further CANopen functions

### 7.4.4.1 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".

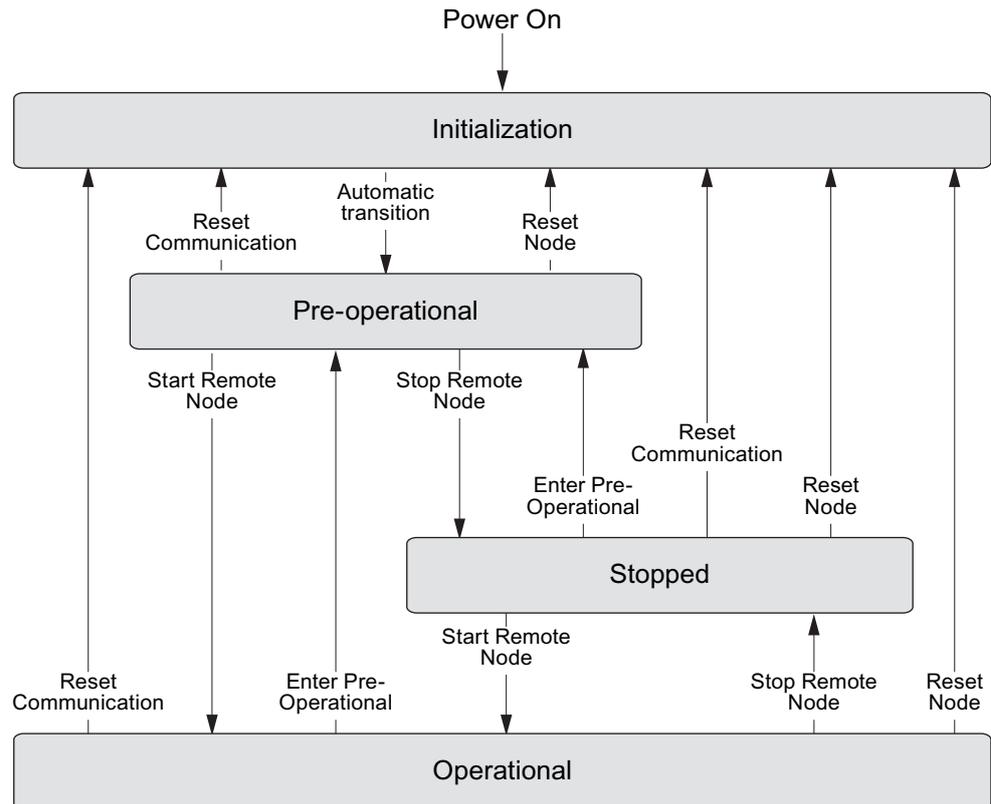


Figure 7-15 CANopen status diagram

The transition states and addressed nodes are displayed using the command specifier and the Node\_ID:

Table 7- 37 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.

## 7.4.5 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 7- 38 RPDO configuration objects - communication parameters

OD Index (hex)	Subindex (hex)	Name of the object	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
<b>1400</b>		<b>Receive PDO 1 communication parameter</b>				
	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
<b>1401</b>		<b>Receive PDO 2 communication parameter</b>				
	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
<b>1402</b>		<b>Receive PDO 3 communication parameter</b>				
	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
<b>1403</b>		<b>Receive PDO 4 communication parameter</b>				
	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
<b>1404</b>		<b>Receive PDO 5 communication parameter</b>				
	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
<b>1405</b>		<b>Receive PDO 6 communication parameter</b>				
	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
<b>1406</b>		<b>Receive PDO 7 communication parameter</b>				
	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
<b>1407</b>		<b>Receive PDO 8 communication parameter</b>				
	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 7- 39 RPDO configuration objects - mapping parameters

OD Index (hex)	SubIndex (hex)	Name of the object	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
<b>1600</b>		<b>Receive PDO 1 mapping parameter</b>				
	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
<b>1601</b>		<b>Receive PDO 2 mapping parameter</b>				
	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
<b>1602</b>		<b>Receive PDO 3 mapping parameter</b>				
	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
<b>1603</b>		<b>Receive PDO 4 mapping parameter</b>				
	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

OD Index (hex)	SubIndex (hex)	Name of the object	SINAMICS parameters	Data type	Predefined connection set	Can be read/written to
<b>1604</b>		<b>Receive PDO 5 mapping parameter</b>				
	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
<b>1605</b>		<b>Receive PDO 6 mapping parameter</b>				
	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
<b>1606</b>		<b>Receive PDO 7 mapping parameter</b>				
	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
<b>1607</b>		<b>Receive PDO 8 mapping parameter</b>				
	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 7- 40 TPDO configuration objects - communication parameters

OD Index (hex)	Subindex (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
<b>1800</b>		<b>Transmit PDO 1 communication parameter</b>				
	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
<b>1801</b>		<b>Transmit PDO 2 communication parameter</b>				
	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
<b>1802</b>		<b>Transmit PDO 3 communication parameter</b>				
	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
<b>1803</b>		<b>Transmit PDO 4 communication parameter</b>				
	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
<b>1804</b>		<b>Transmit PDO 5 communication parameter</b>				
	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

OD Index (hex)	Subindex (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
<b>1805</b>		<b>Transmit PDO 6 communication parameter</b>				
	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
<b>1806</b>		<b>Transmit PDO 7 communication parameter</b>				
	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
<b>1807</b>		<b>Transmit PDO 8 communication parameter</b>				
	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 7- 41 TPDO configuration objects - mapping parameters

OD Index (hex)	SubIndex (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
<b>1A00</b>		<b>Transmit PDO 1 mapping parameter</b>				
	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
<b>1A01</b>		<b>Transmit PDO 2 mapping parameter</b>				
	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
<b>1A02</b>		<b>Transmit PDO 3 mapping parameter</b>				
	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
<b>1A03</b>		<b>Transmit PDO 4 mapping parameter</b>				
	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

OD Index (hex)	SubIndex (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/written to
<b>1A04</b>		<b>Transmit PDO 5 mapping parameter</b>				
	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
<b>1A05</b>		<b>Transmit PDO 6 mapping parameter</b>				
	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
<b>1A06</b>		<b>Transmit PDO 7 mapping parameter</b>				
	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
<b>1A07</b>		<b>Transmit PDO 8 mapping parameter</b>				
	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

### 7.4.5.1 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  $\pm$ 100 %
  - For temperature values: 16 bit (word): 4000hex  $\pm$  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

### 7.4.5.2 Objects in drive profile DSP402

Table 7- 42 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 <sup>1)</sup>
6041		Status word	r8784	PDO/SDO	Unsigned16	–	R
6060		Modes of operation	p1300	SDO	Integer8	–	R/ <sup>2)</sup>
6061		Modes of operation display	p1300	SDO	Integer8	–	R
Profile torque mode							
6071		Target torque Set torque	p1513[0]	SDO/PDO	Integer16	–	R/W <sup>1)</sup>
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

## 7.4.6 Engineering example

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

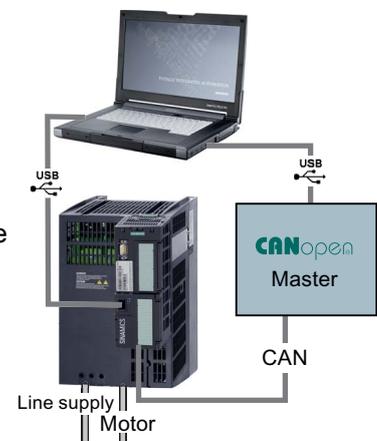
In the first step, the converter is integrated into the communication via the CAN bus using the Predefined Connection Set. In this case, the control word, the speed setpoint as well the status word and speed actual value are transferred.

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 61) 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 135) - (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 146): 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 "Predefined Connection Set" (speed setpoint/control word as well as the actual value/status word, also see Objects in drive profile DSP402 (Page 158)).

**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

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

- Commissioning (Page 47)
- If necessary: Adapting the terminal strip (Page 79)
- If necessary: Configuring the fieldbus (Page 91)

### 8.1 Overview of the inverter functions

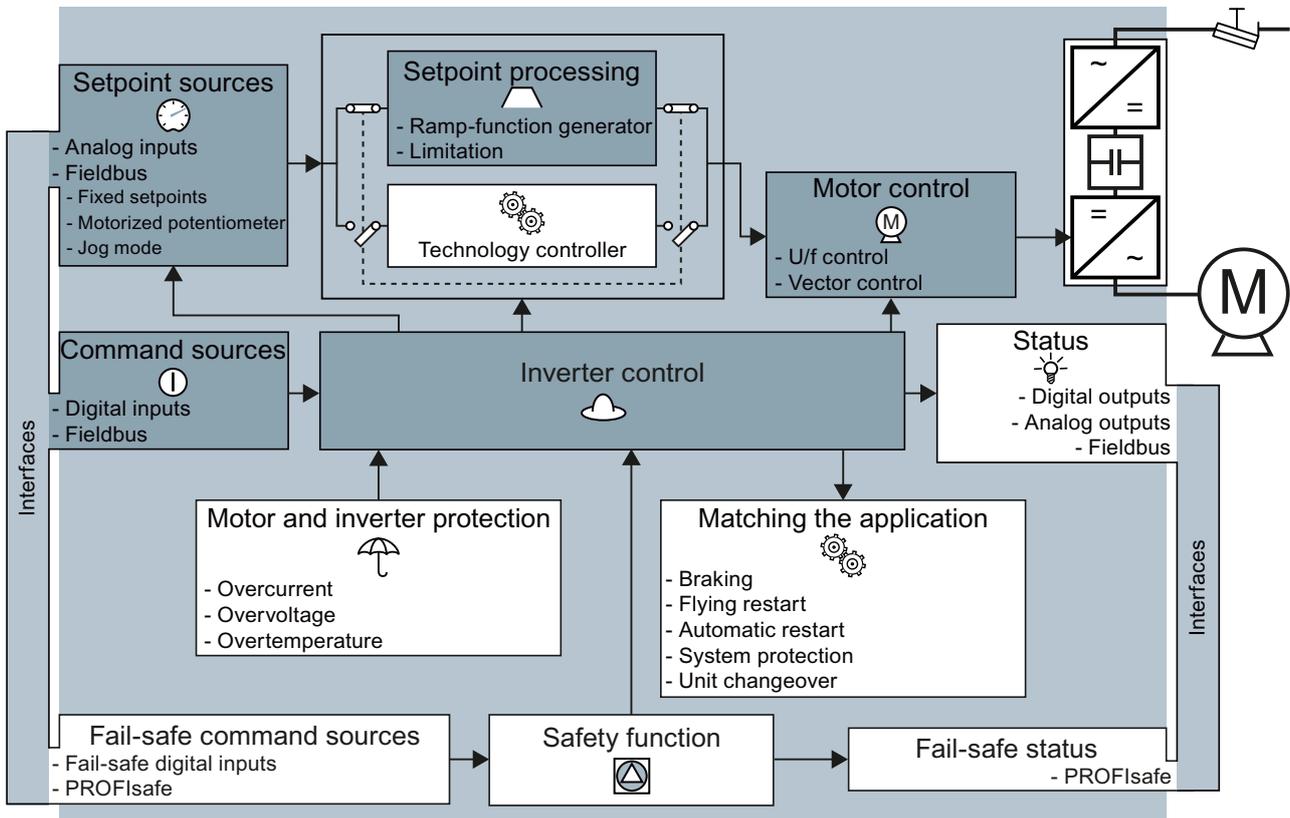


Figure 8-1 Overview of inverter functions

8.1 Overview of the inverter functions

Functions relevant to all applications	Functions required in special applications only
<p>The functions that you require in your application are shown in a dark color in the function overview above.</p> <p>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.</p>	<p>The functions whose parameters you only need to adapt when actually required are shown in white in the function overview above.</p>
 <p><b>Inverter control</b> is responsible for all of the other inverter functions. Among other things, it defines how the inverter responds to external control signals.</p> <p>Inverter control (Page 163)</p>	 <p>The <b>production functions</b> 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.</p> <p>Protection functions (Page 190)</p>
 <p>The <b>command source</b> defines where the control signals are received from to switch on the motor, e.g. via digital inputs or a fieldbus.</p> <p>Command sources (Page 171)</p>	 <p>The <b>status messages</b> 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.</p> <p>Status messages (Page 195)</p>
 <p>The <b>setpoint source</b> defines how the speed setpoint for the motor is specified, e.g. via an analog input or a fieldbus.</p> <p>Setpoint sources (Page 172)</p>	 <p>The functions <b>matching the application</b> 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.</p> <p>Application-specific functions (Page 196)</p>
 <p>The <b>setpoint processing</b> uses a ramp-function generator to prevent speed steps occurring and to limit the speed to a permissible maximum value.</p> <p>Setpoint calculation (Page 181)</p>	 <p>The <b>safety functions</b> are used in applications that must fulfill special requirements in terms of functional safety.</p> <p>Fail-safe function Safe Torque Off (STO) (Page 228)</p>
 <p>The <b>motor closed-loop control</b> ensures that the motor follows the speed setpoint.</p>	

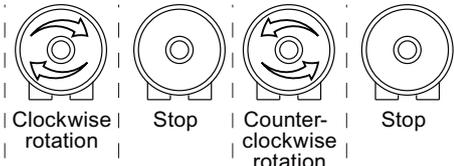
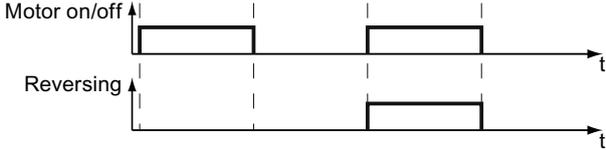
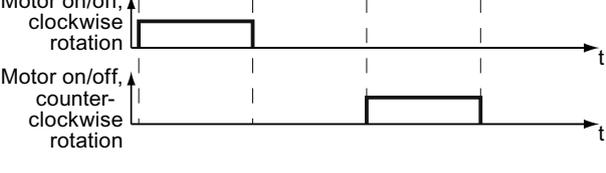
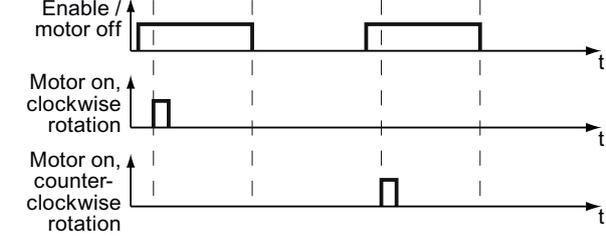
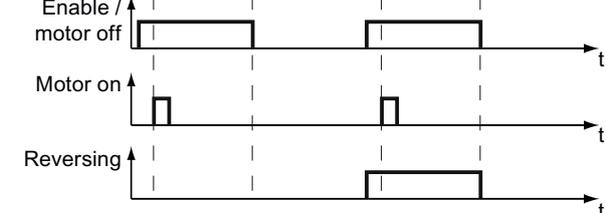
## 8.2 Inverter control



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 8- 1 Two-wire control and three-wire control

Behavior of the motor	Control commands	Typical application
 <p>Clockwise rotation   Stop   Counter-clockwise rotation   Stop</p>		
 <p>Motor on/off Reversing</p>	<p><b>Two-wire control, method 1</b></p> <ol style="list-style-type: none"> <li>1. Switch the motor on and off (ON/OFF1).</li> <li>2. Reverse the motor direction of rotation.</li> </ol>	<p>Local control in conveyor systems.</p>
 <p>Motor on/off, clockwise rotation Motor on/off, counter-clockwise rotation</p>	<p><b>Two-wire control, method 2 and two-wire control, method 3</b></p> <ol style="list-style-type: none"> <li>1. Switch the motor on and off (ON/OFF1), clockwise rotation.</li> <li>2. Switch the motor on and off (ON/OFF1), counter-clockwise rotation.</li> </ol>	<p>Traction drives with control via joystick</p>
 <p>Enable / motor off Motor on, clockwise rotation Motor on, counter-clockwise rotation</p>	<p><b>Three-wire control, method 1</b></p> <ol style="list-style-type: none"> <li>1. Issue enable for switching on motor and switch off motor (OFF1).</li> <li>2. Switch on motor (ON), clockwise rotation.</li> <li>3. Switch on motor (ON), counter-clockwise rotation.</li> </ol>	<p>Traction drives with control via joystick</p>
 <p>Enable / motor off Motor on Reversing</p>	<p><b>Three-wire control, method 2</b></p> <ol style="list-style-type: none"> <li>1. Issue enable for switching on motor and switch off motor (OFF1).</li> <li>2. Switch on motor (ON).</li> <li>3. Reverse the motor direction of rotation.</li> </ol>	<p>-</p>

### 8.2.1 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.

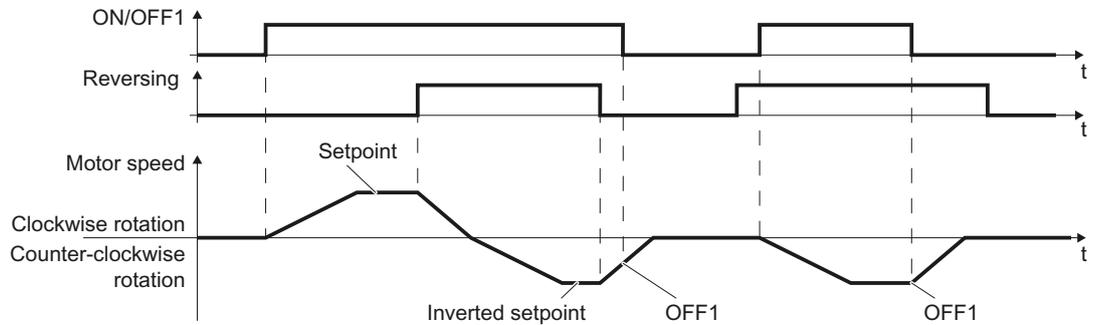


Figure 8-2 Two-wire control, method 1

Table 8-2 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 8-3 Parameter

Parameter	Description					
p0015 = 12	<b>Macro drive unit</b> (factory setting for inverters without PROFIBUS interface)					
	Controlling the motor using the digital inputs of the inverter:	<table border="1"> <tr> <td>DI 0</td> <td>DI 1</td> </tr> <tr> <td>ON/OFF1</td> <td>Reversing</td> </tr> </table>	DI 0	DI 1	ON/OFF1	Reversing
DI 0	DI 1					
ON/OFF1	Reversing					
<b>Advanced setting</b> Interconnecting control commands with digital inputs of your choice (DI x).						
p0840[0 ... n] = 722.x	<b>BI: ON/OFF1</b> (ON/OFF1)					
p1113[0 ... n] = 722.x	<b>BI: Setpoint inversion</b> (reversing)					
<b>Example</b>						
p0840 = 722.3	DI 3: ON/OFF1. Also see Section Digital inputs (Page 80).					

### 8.2.2 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.

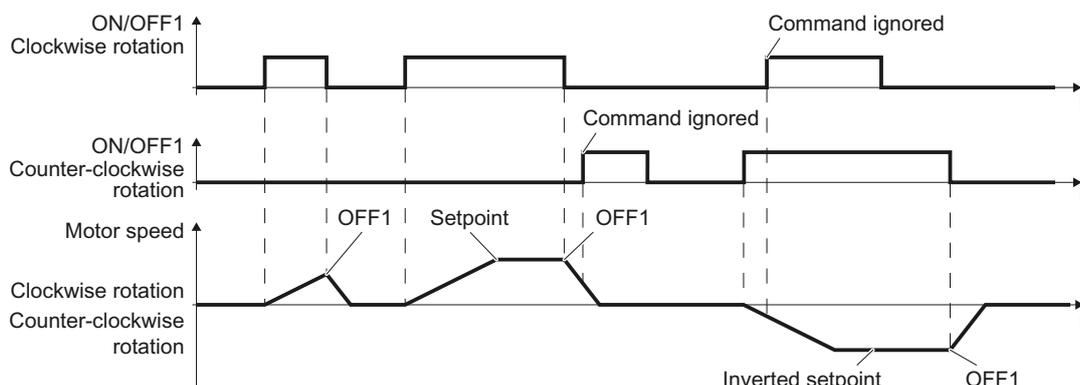


Figure 8-3 Two-wire control, method 2

Table 8-4 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 8-5 Parameter

Parameter	Description		
p0015 = 17	<b>Macro drive unit</b>		
	Controlling the motor using the digital inputs of the inverter:	DI 0	DI 1
		ON/OFF1 clockwise rotation	ON/OFF1 , counter-clockwise rotation
<b>Advanced setting</b> Interconnecting control commands with digital inputs of your choice (DI x).			
p3330[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 1</b> (ON/OFF1 clockwise rotation)		
p3331[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 2</b> (ON/OFF1 , counter-clockwise rotation)		
<b>Example</b>			
p3331 = 722.0	DI 0: ON/OFF1 Counter-clockwise rotation Also see Section Digital inputs (Page 80).		

### 8.2.3 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.

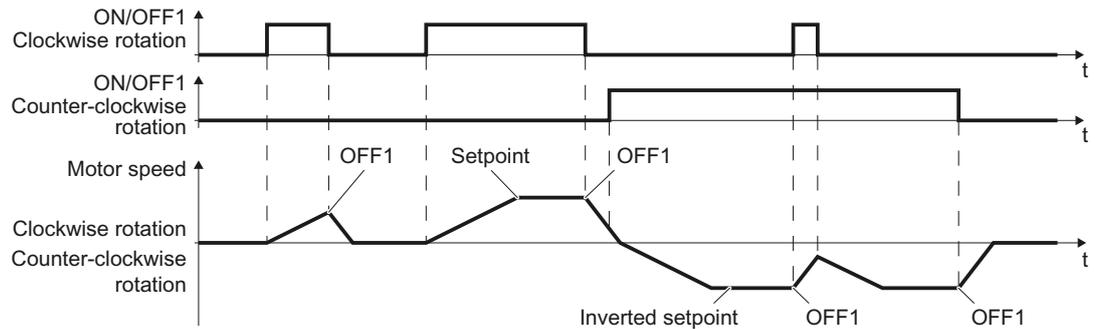


Figure 8-4 Two-wire control, method 3

Table 8-6 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 8-7 Parameter

Parameter	Description		
p0015 = 18	<b>Macro drive unit</b>		
	Controlling the motor using the digital inputs of the inverter:	DI 0 ON/OFF1 clockwise rotation	DI 1 ON/OFF1 , counter-clockwise rotation
<b>Advanced setting</b> Interconnecting control commands with digital inputs of your choice (DI x).			
p3330[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 1</b> (ON/OFF1 clockwise rotation)		
p3331[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 2</b> (ON/OFF1 , counter-clockwise rotation)		
<b>Example</b>			
p3331[0 ... n] = 722.2	DI 2: ON/OFF1 Counter-clockwise rotation Also see Section Digital inputs (Page 80).		

### 8.2.4 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).

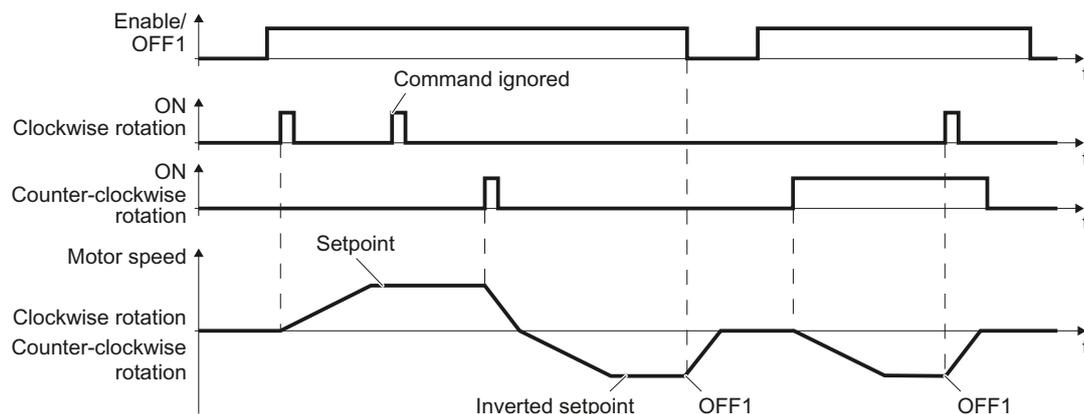


Figure 8-5 Three-wire control, method 1

Table 8- 8 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 8- 9 Parameter

Parameter	Description			
p0015 = 19	<b>Macro drive unit</b>			
	Controlling the motor using the digital inputs of the inverter:	DI 0	DI 1	DI 2
		Enable/OFF1	ON clockwise rotation	ON , counter-clockwise rotation
<b>Advanced setting</b> Interconnecting control commands with digital inputs of your choice (DI x).				
p3330[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 1</b> (enable/OFF1)			
p3331[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 2</b> (ON clockwise rotation)			
p3332[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 3</b> (ON , counter-clockwise rotation)			
<b>Example</b>				
p3332 = 722.0	DI 0: ON Counter-clockwise rotation. Also see Section Digital inputs (Page 80).			

### 8.2.5 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).

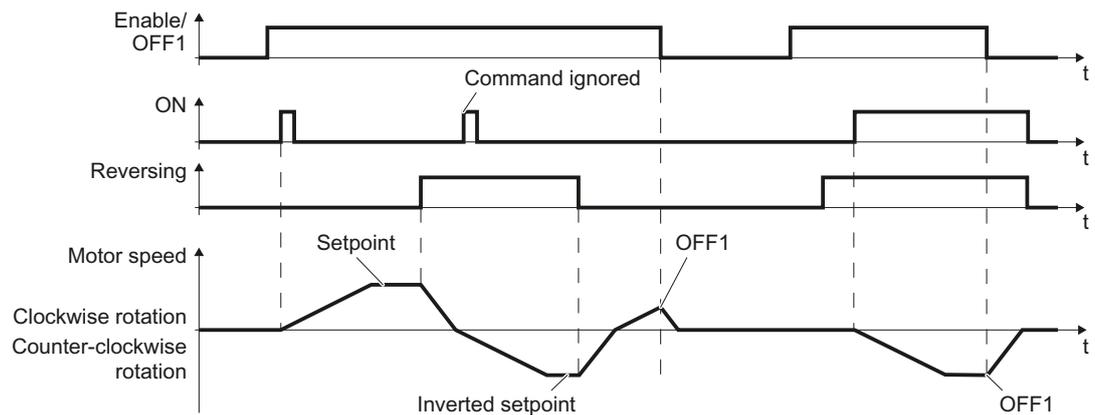


Figure 8-6 Three-wire control, method 2

Table 8- 10 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 8- 11 Parameter

Parameter	Description			
p0015 = 20	<b>Macro drive unit</b>			
	Controlling the motor using the digital inputs of the inverter:	DI 0	DI 1	DI 2
		Enable/OFF1	ON	Reversing
<b>Advanced setting</b>				
Interconnecting control commands with digital inputs of your choice (DI x).				
p3330[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 1 (enable/OFF1)</b>			
p3331[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 2 (ON)</b>			
p3332[0 ... n] = 722.x	<b>BI: 2-3-WIRE Control Command 3 (reversing)</b>			
<b>Example</b>				
p3331 = 722.0	DI 0: ON. Also see Section Digital inputs (Page 80).			

### 8.2.6 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

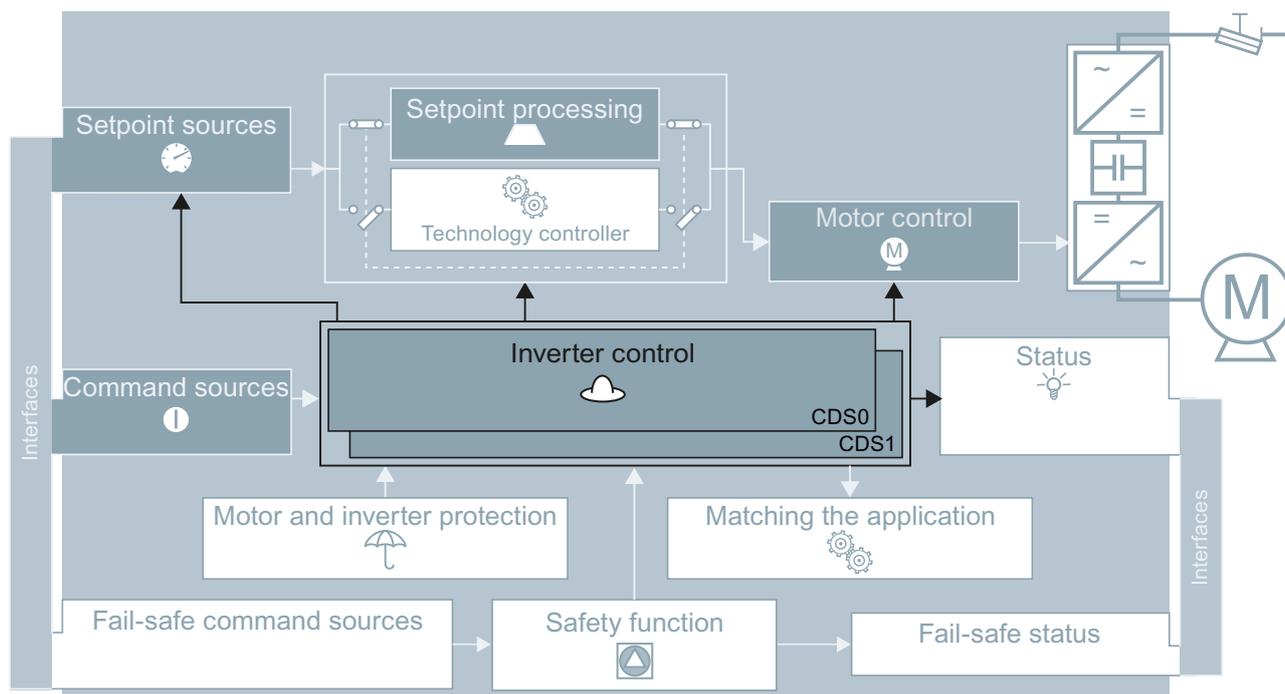


Figure 8-7 Control data set switchover in the inverter

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.

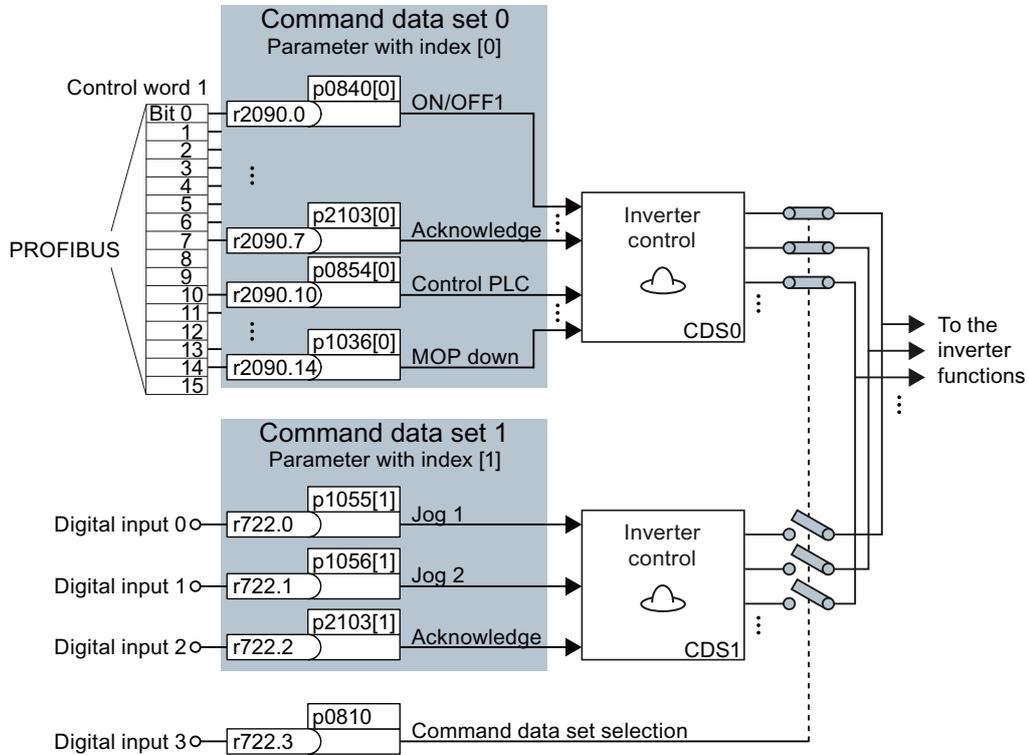


Figure 8-8 Example for the various command data sets

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 41).

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.

## 8.3 Command sources



The command source is the interface via which the inverter receives its control commands. When commissioning, you define this using macro 15 (p0015).

---

**Note**

The "Get master control" or "Manual/Auto changeover" function can also be used to specify commands and setpoints via STARTER or the Operator Panel.

---

### Change command source

If you subsequently change the command source using macro 15, then you must carry out commissioning again.

You also have the option to adapt the pre-assignment - which you selected using macro 15 - to the requirements of your particular system. You can obtain detailed information about this in the Sections Adapting the terminal strip (Page 79) and Configuring the fieldbus (Page 91).

## 8.4 Setpoint sources



The setpoint source is the interface via which the inverter receives its setpoint. The following options are available:

- Motorized potentiometer simulated in the inverter.
- Inverter analog input.
- Setpoints saved in the inverter:
  - Fixed setpoints
  - Jog
- Inverter fieldbus interface.

Depending on the parameterization, the setpoint in the inverter has one of the following meanings:

- Speed setpoint for the motor.
- Torque setpoint for the motor.
- Setpoint for a process variable.  
The inverter receives a setpoint for a process variable, e.g. the level of liquid in a container, and calculates its speed setpoint using the internal technology controller.

### 8.4.1 Analog input as setpoint source

If you use an analog input as setpoint source, then you must adapt this analog input to the type of connected signal ( $\pm 10$  V, 4 ... 20 mA, ...). Additional information is available in Section Analog inputs (Page 84).

#### Procedure

You have two options for interconnecting the setpoint source with an analog input:

1. Using p0015, select a configuration that is suitable for your application.  
Please refer to the section titled Selecting the interface assignments (Page 41) to find out which configurations are available for your inverter.
2. Interconnect main setpoint p1070 with an analog input of your choice.

Table 8- 12 Analog inputs as setpoint source

Parameter	Setpoint source
r0755[0]	Analog input 0
r0755[1]	Analog input 1

Example: You interconnect analog input 0 as the setpoint source with p1070 = 755[0].

## 8.4.2 Motorized potentiometer as setpoint source

The 'motorized potentiometer' (MOP) function simulates an electromechanical potentiometer for entering setpoints. You can continuously adjust the motorized potentiometer (MOP) using the control signals "raise" and "lower". The control signals are received via the digital inputs of the inverter or from the operator panel that has been inserted.

### Typical applications

- Entering the speed setpoint during the commissioning phase.
- Manual operation of the motor should the higher-level control fail.
- Entering the speed setpoint after changeover from automatic operation to manual operation.
- Applications with largely constant setpoint and without higher-level control.

### Principle of operation

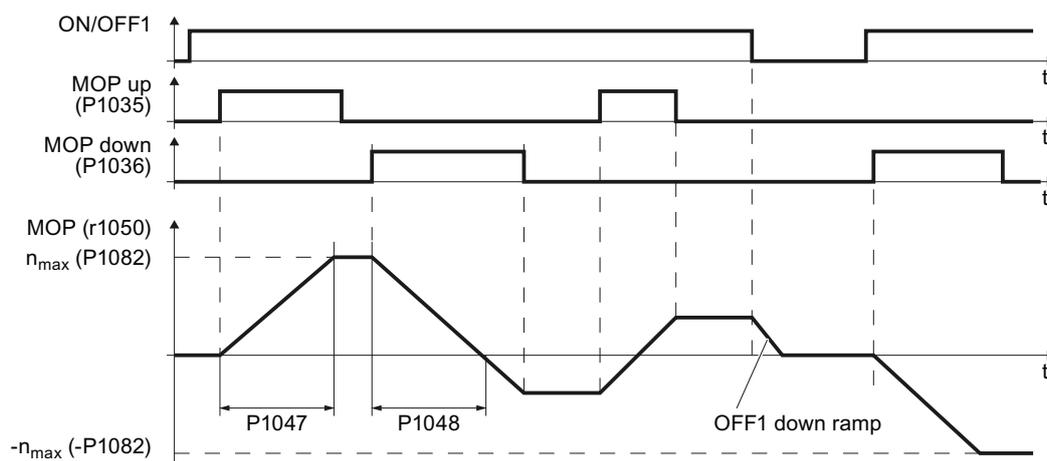


Figure 8-9 Function chart of motorized potentiometer

### Motorized potentiometer parameters

Table 8- 13 Basic setup of motorized potentiometer

Parameter	Description
p1047	<b>MOP ramp-up time</b> (factory setting 10 s)
p1048	<b>MOP ramp-down time</b> (factory setting 10 s)
p1040	<b>Start value of MOP</b> (factory setting 0 rpm) Determines the start value [rpm] that becomes effective when the motor is switched on

Table 8- 14 Extended setup of motorized potentiometer

Parameter	Description
p1030	<p><b>Configuration of the MOP, parameter value with four independently adjustable bits 00 to 03</b> (factory setting 00110 bin)</p> <p><b>Bit 00:</b> 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</p> <p><b>Bit 01:</b> 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</p> <p><b>Bit 02:</b> Configure initial rounding                      0: No initial rounding                      1: With initial rounding. The initial rounding is a sensitive way of specifying small setpoint changes (progressive reaction when keys are pressed).</p> <p><b>Bit 03:</b> 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)</p> <p><b>Bit 04:</b> Ramp-function generator always active                      0: Setpoint is only calculated with enabled pulses                      1: Setpoint is calculated independent of the pulse enable (this setting is required if the energy-saving mode has been selected).</p>
p1035	<p><b>Signal source to increase setpoint</b> (factory setting 0)                      Automatically pre-assigned during commissioning, e.g. with the button on the Operator Panel</p>
p1036	<p><b>Signal source to reduce setpoint</b> (factory setting 0)                      Automatically pre-assigned during commissioning, e.g. with the button on the operator panel</p>
p1037	<p><b>Maximum setpoint</b> (factory setting 0 rpm)                      Automatically pre-assigned during commissioning</p>
p1038	<p><b>Minimum setpoint</b> (factory setting 0 rpm)                      Automatically pre-assigned during commissioning</p>
p1039	<p><b>Signal source to invert minimum and maximum setpoints</b> (factory setting 0)</p>
p1044	<p><b>Signal source for set value</b> (factory setting 0)</p>

For more information about the motorized potentiometer, see the List Manual (function diagram 3020 and the parameter list).

### Interconnecting the motorized potentiometer with the setpoint source

You have two options for interconnecting the motorized potentiometer with the setpoint source:

1. Using p0015, select a configuration that is suitable for your application.  
Please refer to the section titled Selecting the interface assignments (Page 41) to find out which configurations are available for your inverter.
2. Interconnect the main setpoint with the motorized potentiometer by setting p1070 to 1050.

### Example of parameterization of the motorized potentiometer

Table 8- 15 Implementing a motorized potentiometer using digital inputs

Parameter	Description
p0015 = 9	<b>Macro drive unit:</b> Configure inverter on MOP as the setpoint source <ul style="list-style-type: none"> <li>• The motor is switched on and off via digital input 0.</li> <li>• The MOP setpoint is increased via digital input 1.</li> <li>• The MOP setpoint is decreased via digital input 2.</li> </ul>
p1040 = 10	<b>MOP start value</b> Each time the motor is switched on a setpoint corresponding to 10 rpm is specified
p1047 = 5	<b>MOP ramp-up time:</b> The MOP setpoint is increased from zero to maximum (p1082) in 5 seconds
p1048 = 5	<b>MOP ramp-down time:</b> The MOP setpoint is reduced from maximum (p1082) to zero in 5 seconds

### 8.4.3 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 of this simplified specification of speed setpoint are:

- Conveyor belt with two different speeds.
- Grinding machine with different speeds corresponding to the diameter of the grinding wheel.

If you use the technology controller in the inverter, then you can enter process variables that remain constant over time using a fixed setpoint, e.g.:

- Closed-loop control of a constant flow with a pump.
- Closed-loop control of a constant temperature using a fan.

#### Procedure

You can set up to 16 various fixed setpoints and select these either via digital inputs or the fieldbus. The fixed setpoints are defined using parameters p1001 to p1004 and can be assigned to the corresponding command sources (e.g. the digital inputs) using parameters p1020 to p1023.

The various fixed setpoints can be selected in two ways:

1. Direct selection:  
Precisely one fixed speed setpoint is assigned to each selection signal (e.g. a digital input). As several selection signals are selected, the associated fixed speed setpoints are added together to form a total setpoint.  
Direct selection is particularly well suited to controlling the motor using the inverter's digital inputs.
2. Binary selection:  
Precisely one fixed speed setpoint is assigned to each possible combination of selection signals.  
Binary selection should preferably be used with a central control and when linking the inverter to a fieldbus.

Table 8- 16 Parameters for direct selection of fixed setpoints

Parameter	Description
p1016 = 1	Direct selection of fixed setpoints (factory setting)
p1001	<b>Fixed setpoint 1</b> Factory setting: 0 rpm)
p1002	<b>Fixed setpoint 2</b> Factory setting: 0 rpm)
p1003	<b>Fixed setpoint 3</b> Factory setting: 0 rpm)
p1004	<b>Fixed setpoint 4</b> Factory setting: 0 rpm)
p1020	<b>Signal source for selection of fixed setpoint 1</b> (factory setting: 722.3, i.e. selection via digital input 3)
p1021	<b>Signal source for selection of fixed setpoint 2</b> (factory setting: 722.4, i.e. selection via digital input 4)
p1022	<b>Signal source for selection of fixed setpoint 3</b> (factory setting: 722.5, i.e. selection via digital input 5)
p1023	<b>Signal source for selection of fixed setpoint 4</b> (factory setting: 0, i.e. selection is locked)

Table 8- 17 Function diagram of direct selection of fixed setpoints

Fixed setpoint selected by	BICO interconnection of selection signals (example)	The resultant fixed setpoint corresponds to the parameter values of ...
Digital input 3 (DI 3)	p1020 = 722.3	p1001
Digital input 4 (DI 4)	p1021 = 722.4	p1002
Digital input 5 (DI 5)	p1022 = 722.5	p1003
Digital input 6 (DI 6)	p1023 = 722.6	p1004
DI 3 and DI 4		p1001 + p1002
DI 3 and DI 5		p1001 + p1003
DI 3, DI 4 and DI 5		p1001 + p1002 + p1003
DI 3, DI 4, DI 5 and DI 6		p1001 + p1002 + p1003 + p1004

You will find further information about the fixed setpoints and *binary* selection in function block diagrams 3010 and 3011 in the List Manual.

**Example: Selecting two fixed speed setpoints using digital input 2 and digital input 3**

The motor is to run at two different speeds:

- The motor is switched on with digital input 0
- When digital input 2 is selected, the motor is to run at a speed of 300 rpm.
- When digital input 3 is selected, the motor is to accelerate to a speed of 2000 rpm.
- When digital input 1 is selected, the motor should go into reverse

Table 8- 18 Parameter settings for the example

Parameter	Description
p0015 = 12	<b>Macro drive unit:</b> Configure inverter with terminal strip as the command and setpoint source. <ul style="list-style-type: none"> <li>• The motor is switched on and off via digital input 0.</li> <li>• The setpoint source is analog input 0.</li> </ul>
p1001 = 300.000	Defines the fixed setpoint 1 in [rpm]
p1002 = 2000.000	Defines the fixed setpoint 2 in [rpm]
p1016 = 1	Direct selection of fixed setpoints
p1020 = 722.2	Interconnection of fixed setpoint 2 with DI 2. r0722.2 = parameter that displays the status of digital input 2.
p1021 = 722.3	Interconnection of fixed setpoint 3 with status of DI 3. r0722.3 = parameter that displays the status of digital input 3.
p1070 = 1024	Interconnect main setpoint with fixed speed setpoint

### 8.4.4 Running the motor in jog mode (JOG function)

Using the "jog" function (JOG function), you can switch the motor on and off using a control command or the operator panel. The speed to which the motor accelerates for "Jog" can be set.

The motor must be switched-off before you issue the "jog" control command. "Jog" has no effect when the motor is switched on.

The "Jog" function is typically used to manually switch-on a motor after switching over from automatic to manual operation.

#### Setting jogging

The "Jog" function has two different speed setpoints, e.g. for motor counter-clockwise rotation and clockwise rotation.

With an operator panel, you can always select the "Jog" function. If you wish to use additional digital inputs as control commands, you must interconnect the particular signal source with a digital input.

Table 8- 19 Parameters for the "Jog" function

Parameter	Description
p1055	<b>Signal source for jogging 1 - jog bit 0</b> (factory setting: 0) If you wish to jog via a digital input, then set p1055 = 722.x
p1056	<b>Signal source for jogging 2 - jog bit 1</b> (factory setting: 0) If you wish to jog via a digital input, then set p1056 = 722.x
p1058	<b>Jogging 1 speed setpoint</b> (factory setting, 150 rpm)
p1059	<b>Jogging 2 speed setpoint</b> (factory setting, 150 rpm)

### 8.4.5 Specifying the motor speed via the fieldbus

If you enter the setpoint via a fieldbus, you must connect the inverter to a higher-level control. For additional information, see chapter Configuring the fieldbus (Page 91).

#### Interconnecting the fieldbus with the setpoint source

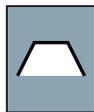
You have two options for using the fieldbus as the setpoint source:

1. Using p0015, select a configuration that is suitable for your application.  
Please refer to the section titled Selecting the interface assignments (Page 41) to find out which configurations are available for your inverter.
2. Interconnect main setpoint p1070 with the fieldbus.

Table 8- 20 Fieldbus as setpoint source

Parameter	Setpoint source
r2050[x]	Receive word no. x from RS485 interface
r2090[x]	Receive word no. x from PROFIBUS interface

## 8.5 Setpoint calculation



The setpoint processing modifies the speed setpoint, e.g. it limits the setpoint to a maximum and minimum value and using the ramp-function generator prevents the motor from executing speed steps.

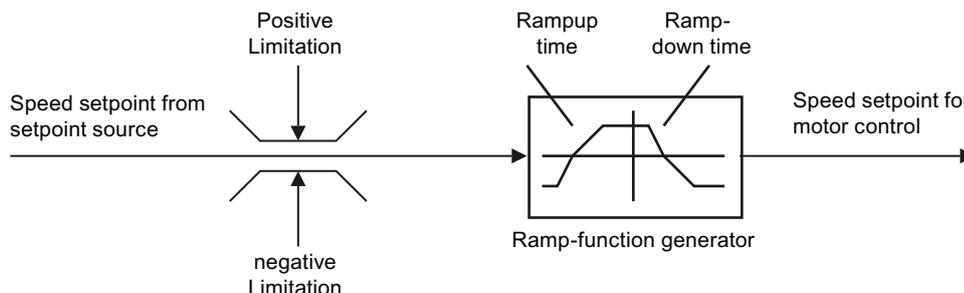


Figure 8-10 Setpoint processing in the inverter

### 8.5.1 Minimum speed and maximum speed

The speed setpoint is limited by both the minimum and maximum speed.

When the motor is switched on, it accelerates to the minimum speed regardless of the speed setpoint. The set parameter value applies to both directions of rotation. Beyond its limiting function, the minimum speed serves as a reference value for a series of monitoring functions.

The speed setpoint is limited to the maximum speed in both directions of rotation. The inverter generates a message (fault or alarm) when the maximum speed is exceeded.

The maximum speed also acts as an important reference value for various functions (e.g. the ramp-function generator).

Table 8- 21 Parameters for minimum and maximum speed

Parameter	Description
P1080	Minimum speed
P1082	Maximum speed

### 8.5.2 Ramp-function generator

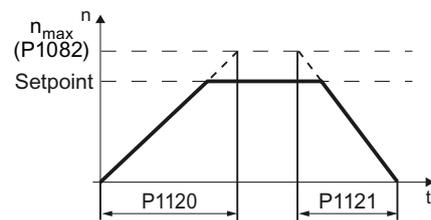
The ramp-function generator in the setpoint channel limits the speed of changes to the speed setpoint. The ramp-function generator does the following:

- 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.

#### Ramp-up/down time

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 purely 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.



#### Ramp-up time (p1120)

Duration of acceleration (in seconds) from zero speed to the maximum speed P1082

#### Ramp-down time (P1121)

Duration of deceleration (in seconds) from the maximum speed P1082 to standstill

The quick-stop function (OFF3) has a separate ramp-down time, which is set with P1135.

---

#### Note

If the ramp-up/down times are too short, the motor accelerates/decelerates with the maximum possible torque and the set times will be exceeded.

---

For more information about this function, see the List Manual (function diagram 3060 and the parameter list).

#### 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).

For more information, see the List Manual (the parameter list and function diagram 3070).

## 8.6 Motor control



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

- Open-loop control with V/f-characteristic (V/f control)
- Field-oriented control (vector control)

### Criteria for selecting either V/f control or vector control

V/f control is perfectly suitable for almost any application in which the speed of induction motors is to be changed. Examples of typical applications for V/f control include:

- Pumps
- Fans
- Compressors
- Horizontal conveyors

Commissioning vector control takes more time than when commissioning V/f control. When compared to V/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 vector control is used:

- Hoisting gear and vertical conveyors
- Winders
- Extruders

**It is not permissible to use vector 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		
	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole
Pole number of the motor						
Maximum motor speed [rpm]	9960	4980	3320	14400	7200	4800

### 8.6.1 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 ( $f = n \cdot \text{number of pole pairs} / 60$ , in particular:  $f_{\text{max}} = p1082 \cdot \text{number of pole pairs} / 60$ ). The inverter provides the two most important characteristics (linear and square-law). User-defined characteristic curves are also supported.

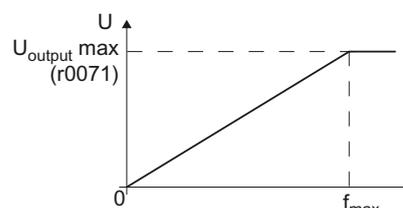
V/f control is not a high-precision method of controlling the speed of the motor. The speed setpoint and the speed of the motor shaft are always slightly different. The deviation depends on the motor load. If the connected motor is loaded with the rated torque, the motor speed is below the speed setpoint 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.

#### 8.6.1.1 V/f control with linear and square-law characteristic

##### V/f control with linear characteristic (p1300 = 0):

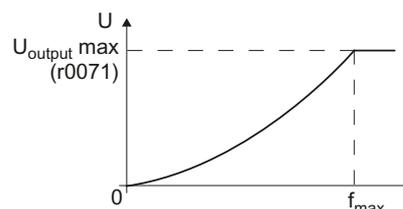
Mainly used in applications in which the motor torque must be independent of the motor speed. Examples of such applications include horizontal conveyors or compressors.



##### V/f control with parabolic characteristic (p1300 = 2)

Used in applications in which the motor torque increases with the motor speed. Examples of such applications include pumps and fans.

V/f control with square-law characteristic reduces the losses in the motor and inverter due to lower currents than when a linear characteristic is used.



#### Note

V/f control with a square-law characteristic must not be used in applications in which a high torque is required at low speeds.

**8.6.1.2 Additional characteristics for the V/f control**

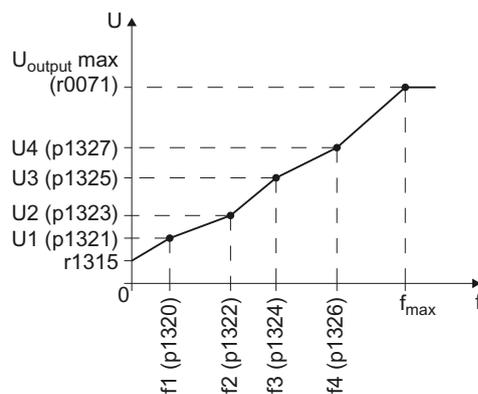
In addition to linear and square-law characteristics, there are the following additional versions of the V/f control that are suitable for special applications.

**Linear V/f characteristic with Flux Current Control (FCC) (P1300 = 1)**

Voltage losses across the stator resistance are automatically compensated. This is particularly useful for small motors since they have a relatively high stator resistance. The prerequisite is that the value of the stator resistance in P350 is parameterized as accurately as possible.

**V/f control with parameterizable characteristic (p1300 = 3)**

Variable V/f characteristic that supports the torque response of synchronous motors (SIEMOSYN motors).



**Linear V/f characteristic with ECO (p1300 = 4), quadratic V/f characteristic with ECO (p1300 = 7)**

ECO mode is suitable for applications with a low dynamic response and constant speed setpoint, and allows energy savings of up to 40%.

When the setpoint is reached and remains unchanged for 5 s, the inverter automatically reduces its output voltage to optimize the motor's operating point. ECO mode is deactivated in the event of setpoint changes or if the inverter's DC-link voltage is too high or too low.

In ECO mode set the slip compensation (P1335) to 100 %. In the event of minor fluctuations in the setpoint, you have to raise the ramp-function generator tolerance using p1148.

Note: Sudden load variations can cause the motor to stall.

### V/f control for drives requiring a precise frequency (textile industry) (p1300 = 5), V/f control for drives requiring a precise frequency and FCC (p1300 = 6)

These characteristics require the motor speed to remain constant under all circumstances. This setting has the following effects:

- When the maximum current limit is reached, the stator voltage is reduced but not the speed.
- Slip compensation is locked.

For more information about this function, see function diagram 6300 in the List Manual.

### V/f control with independent voltage setpoint

The interrelationship between the frequency and voltage is not calculated in the inverter, but is specified by the user. With BICO technology, P1330 defines the interface via which the voltage setpoint is entered (e.g. analog input → P1330 = 755).

#### 8.6.1.3 Optimizing with a high break loose torque and brief overload

The ohmic losses in the motor stator resistance and the motor cable play a more significant role the smaller the motor and the lower the motor speed. You can compensate for these losses by raising the V/f characteristic.

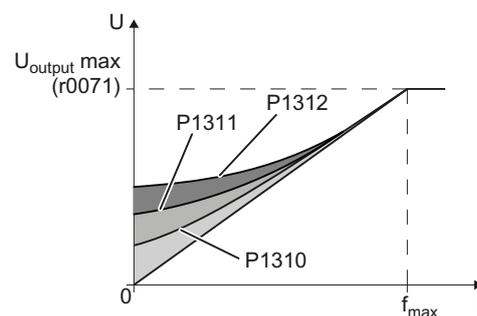
There are also applications where the motor temporarily needs more than its rated current in the lower speed range or during acceleration in order to adhere to the speed setpoint. Examples of such applications are:

- Driven machines with a high break loose torque
- Utilizing the brief overload capability of the motor when accelerating

#### Voltage increase in V/f control (boost)

Voltage losses resulting from long motor cables and the ohmic losses in the motor are compensated for using parameter p1310. An increased break loose torque when starting and accelerating is compensated using parameter p1312 and/or p1311.

The voltage boost is active for every characteristic type of the V/f control. The figure opposite shows the voltage boost using the example of a linear V/f characteristic.



**Note**

Only increase the voltage boost in small steps until satisfactory motor behavior is reached. Excessively high values in p1310 ... p1312 can cause the motor to overheat and switch off (trip) the inverter due to overcurrent .

Table 8- 22 Optimizing the starting characteristics for a linear characteristic

Parameter	Description
P1310	<b>Permanent voltage boost</b> (factory setting 50 %) 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: $1.732 \times \text{rated motor current (p0305)} \times \text{stator resistance (r0395)} \times \text{p1310} / 100 \%$ .
P1311	<b>Voltage boost on acceleration</b> The voltage boost on acceleration is independent of speed and occurs when the setpoint is increased. It disappears as soon as the setpoint is reached. Value in V: $1.732 \times \text{rated motor current (p0305)} \times \text{stator resistance (r0395)} \times \text{p1311} / 100 \%$
P1312	<b>Voltage boost at start up</b> The voltage boost at start-up results in an additional voltage boost when accelerating, but only the first time the motor accelerates after it has been switched on. The voltage boost in V is: $1.732 \times \text{rated motor current (p0305)} \times \text{stator resistance (r0395)} \times \text{p1312} / 100\%$

You will find more information about this function in the parameter list and in function diagram 6300 of the List Manual.

## 8.6.2 Vector control

Using a motor model, the vector 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.

Vector control is possible without directly measuring the motor speed. This closed-loop control is also known as sensorless vector control.

### 8.6.2.1 Commissioning vector control

Vector control only functions error-free if, during the basic commissioning, the motor data were correctly parameterized and a motor data identification was performed with the motor in the cold state.

You can find the basic commissioning in the following sections:

- Commissioning with Operator Panel BOP-2 (Page 56)
- Commissioning with STARTER (Page 61)

### Optimizing vector control

- Carry out the automatic speed controller optimization using (p1960 = 1)

Table 8- 23 The most important vector control parameters

Parameter	Description
P1300 = 20	<b>Control type:</b> Vector control without speed encoder
p0300 ... p0360	<b>Motor data</b> is transferred from the rating plate during basic commissioning and calculated with the motor data identification
p1452 ... p1496	<b>Speed controller parameters</b>
p1511	<b>Additional torque</b>
p1520	<b>Upper torque limit</b>
p1521	<b>Lower torque limit</b>
p1530	<b>Motoring power limit</b>
p1531	<b>Regenerative power limit</b>

Additional information about this function is provided in the parameter list and in function diagrams 6030 onwards in the List Manual.

You will find more information On the internet:

(<http://support.automation.siemens.com/WW/view/en/7494205>):

## 8.7 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.

### 8.7.1 Inverter temperature monitoring

The inverter temperature is essentially determined by the resistive losses of the output current and the switching losses which occur when pulsing the Power Module. The inverter temperature falls when either the output current or the pulse frequency of the Power Module is reduced.

#### I2t monitoring (A07805 - F30005)

The Power Module's I2t monitoring controls the inverter utilization by means of a current reference value. The utilization is specified in r0036 [%].

#### Monitoring the chip temperature of the power unit (A05006 - F30024)

The temperature difference between the power chip (IGBT) and heat sink is monitored using A05006 and F30024. The measured values are specified in r0037[1] [°C].

#### Heat sink monitoring (A05000 - F30004)

The power unit heat sink temperature is monitored using A05000 and F30004. The values are specified in r0037[0] [°C].

#### Inverter response

Parameter	Description
P0290	<p><b>Power unit overload response</b>                      (factory setting for SINAMICS G120 inverters with Power Module PM260: 0;                      factory setting for all of the inverters: 2)</p> <p>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</p>
P0292	<p><b>Power unit temperature warning threshold</b> (factory setting: Heat sink [0] 5°C, power semiconductor [1] 15°C)                      The value is set as a difference to the shutdown temperature.</p>

## 8.7.2 Motor temperature monitoring using a temperature sensor

You can use one of the following sensors to protect the motor against overtemperature:

- PTC sensor
- KTY 84 sensor
- ThermoClick sensor

The motor's temperature sensor is connected to the Control Unit.

### Temperature measurement via PTC

The PTC sensor is connected to terminals 14 and 15.

- **Overtemperature:** The threshold value to switch over to an alarm or fault is 1650  $\Omega$ . After the PTC responds, alarm A07910 or shutdown with fault F07011 is initiated corresponding to the setting in p0610.
- **Short-circuit monitoring:** Resistance values < 20  $\Omega$  indicate a temperature sensor short-circuit

### Temperature measurement using KTY 84

The device is connected to terminals 14 (anode) and 15 (cathode) in the forward direction of the diode. The measured temperature is limited to between -48 °C and +248°C and is made available for further evaluation.

- When the alarm threshold is reached (set via p0604; factory setting: 130 °C), alarm A7910 is triggered. Response -> p0610)
- Fault F07011 is output (depending on the setting in p0610) if
  - the fault threshold temperature (settable in p0605) is reached
  - the alarm threshold temperature (settable in p0604) is reached and is still present after the delay time as expired.

### Wire-break and short-circuit monitoring via KTY 84

- Wire break: Resistance value > 2120  $\Omega$
- Short circuit: Resistance value < 50  $\Omega$

As soon as a resistance outside this range is measured, A07015 "Alarm temperature sensor fault" is activated and after the delay time expires, F07016 "Motor temperature sensor fault" is output.

### Temperature monitoring via ThermoClick sensor

The ThermoClick sensor responds at values  $\geq 100 \Omega$ . After the ThermoClick sensors has responded, either alarm A07910 or shutdown with fault F07011 is initiated corresponding to the setting in p0610.

**Parameters to set the motor temperature monitoring with sensor**

Table 8- 24 Parameters for detecting the motor temperature via a temperature sensor

Parameter	Description		
P0335	<b>Specify the motor cooling</b> 0: Self-ventilated - with fan on the motor shaft (IC410* or IC411*) - (factory setting) 1: Forced ventilation - with a separately driven fan (IC416*) 2: Self-ventilated and inner cooling* (open-circuit air cooled) 3: Forced ventilated and inner cooling* (open-circuit air cooled)		
P0601	<b>Motor temperature sensor type</b> 0: No sensor (factory setting) 1: PTC thermistor (→ P0604) 2: KTY84 (→ P0604) 4: ThermoClick sensor	Terminal no.	
		14	PTC+ KTY anode ThermoClick
		15	PTC- KTY cathode ThermoClick
P0604	<b>Motor temperature alarm threshold</b> (factory setting 130 °C) The alarm threshold is the value at which the inverter is either shut down or $I_{max}$ is reduced (P0610)		
P0605	<b>Motor temperature fault threshold</b> (Factory setting: 145 °C)		
P0610	<b>Motor overtemperature response</b> Determines the response when the motor temperature reaches the alarm threshold. 0: No motor response, only an alarm 1: Alarm and reduction of $I_{max}$ (factory setting) reduces the output speed 2: Fault message and shutdown (F07011)		
P0640	<b>Current limit</b> (input in A)		

\*According to EN 60034-6

### 8.7.3 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 8- 25  $I_{max}$  controller parameters

Parameter	Description
P0305	<b>Rated motor current</b>
P0640	<b>Motor current limit</b>
P1340	<b>Proportional gain of the <math>I_{max}</math> controller for speed reduction</b>
P1341	<b>Integral time of the <math>I_{max}</math> controller for speed reduction</b>
r0056.13	<b>Status: <math>I_{max}</math> controller active</b>
r1343	<b>Speed output of <math>I_{max}</math> controller</b> 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.

### 8.7.4 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 inverter and causes  $V_{DC}$  in the inverter to increase.

Above a critical DC link voltage both the inverter as well as the motor will be damaged. Before the voltage can reach critical levels, however, the inverter switches the motor off with the fault message "DC link overvoltage".

#### Protecting the motor and inverter 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 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 inverter braking methods can be found in Section Braking functions of the inverter (Page 202).

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 8- 26  $V_{DCmax}$  controller parameters

Parameter for U/f control	Parameter for vector control	Description
p1280 = 1	p1240 = 1	<b><math>V_{DC}</math> controller or <math>V_{DC}</math> monitoring configuration</b> (factory setting: 1)1: Enable $V_{DCmax}$ controller
r1282	r1242	<b><math>V_{DCmax}</math> controller switch-on level</b> Shows the value of the DC-link voltage above which the $V_{DCmax}$ controller is active
p1283	p1243	<b><math>V_{DCmax}</math> controller dynamic factor</b> (factory setting: 100 %) scaling of the control parameters P1290, P1291 and P1292
p1294	p1254	<b><math>V_{DCmax}</math> controller automatic recording ON-signal level</b> (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	<b>Unit supply voltage</b> 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).

## 8.8

### Status messages

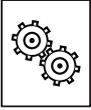


Information about the inverter state (alarms, faults, actual values) can be output via inputs and outputs and also via the communication interface.

Details on evaluating the inverter state via inputs and outputs are provided in Section Adapting the terminal strip (Page 79).

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 91).

## 8.9 Application-specific functions



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
- Logical and arithmetic functions using function blocks that can be freely interconnected

Please refer to the following sections for detailed descriptions.

### 8.9.1 Unit changeover

#### 8.9.1.1 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 198) IEC/NEMA (adaptation to the line supply)
- Changing over the unit system (Page 199)
- Changing over units for the technology controller (Page 200)

<b>NOTICE</b>
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 200).

**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

**8.9.1.2 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 8- 27 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 <sup>2</sup>	lb ft <sup>2</sup>	kgm <sup>2</sup>
p0344	Motor weight (for thermal motor type)	kg	Lb	kg
r1969	Speed_cont_opt moment of inertia determined	kgm <sup>2</sup>	lb ft <sup>2</sup>	kgm <sup>2</sup>

\*) Factory setting

### 8.9.1.3 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  $\triangleq$  p0505 = 2 and p0505 = 3  $\triangleq$  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  $\triangleq$  p0505 = 3 and p0505 = 2  $\triangleq$  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".

---

### 8.9.1.4 Changing over units for the technology controller

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**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.

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### 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.

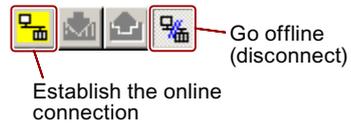
The parameters affected by changing over units of the technology controller belong to unit group 9\_1. For details, please refer to the section titled "Unit group and unit choice" in the List Manual.

### 8.9.1.5 Changing of the units with STARTER

The converter must be in the offline mode in order to change over the units.

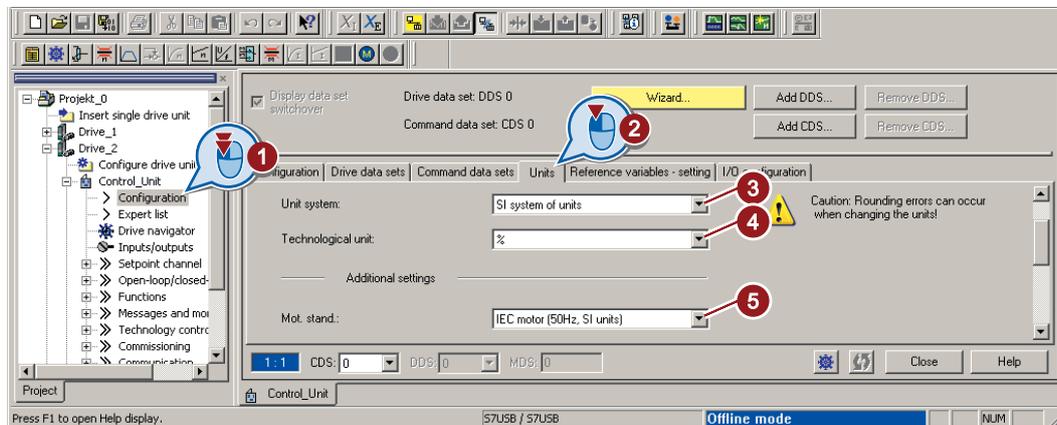
STARTER shows whether you change settings online in the converter or change offline in the PC (**Online mode** / **Offline mode**).

You switch over the mode using the adjacent buttons in the menu bar.



Procedure

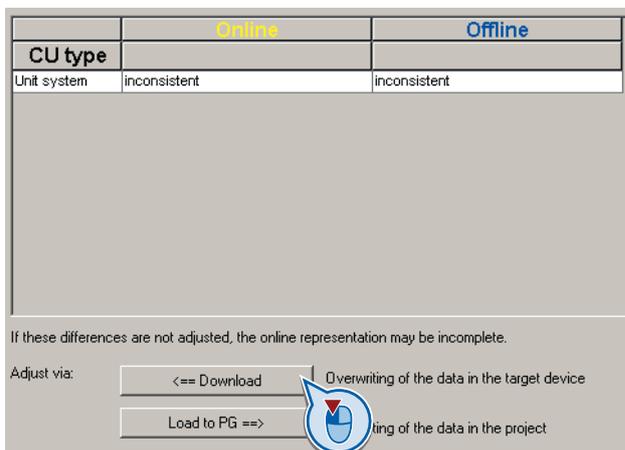
- Go to the "Units" tab in the configuration screen form to change over the units.



- ③ Changing over the unit system
- ④ Selecting process variables of the technology controller
- ⑤ adapting to the line supply

Figure 8-11 Unit changeover

- Save your settings
- 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.

## 8.9.2 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 216).
- 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.

### 8.9.2.1 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 204)
- Compound braking (Page 208)
- Dynamic braking (Page 210)

## Main features of the braking functions

### DC braking

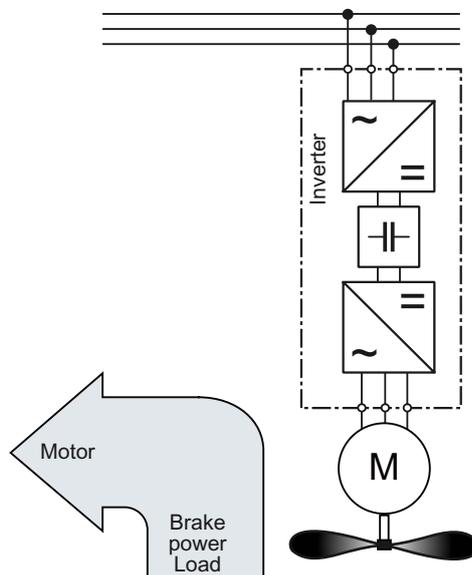
The motor converts the regenerative power into heat.

- *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.

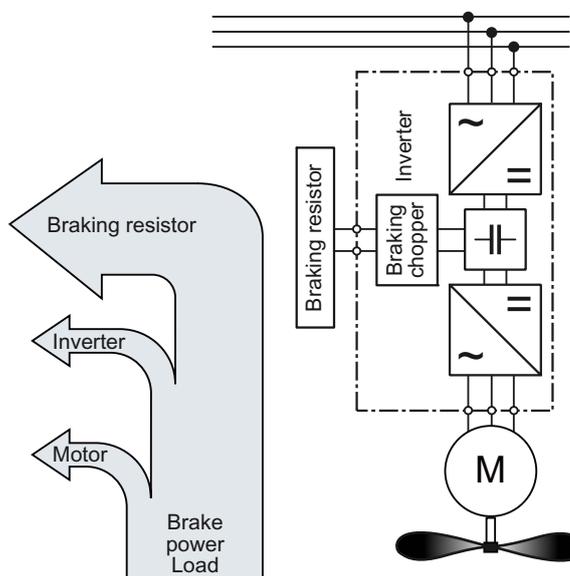
- *Advantage:* Defined braking characteristics, the motor brakes without the inverter having to convert any regenerative energy
- *Disadvantages:* significant motor temperature rise; no constant braking torque; regenerative power is dissipated as heat; does not function when the line supply fails



### 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



## Braking method depending on the application

Table 8- 28 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

### 8.9.2.2 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:

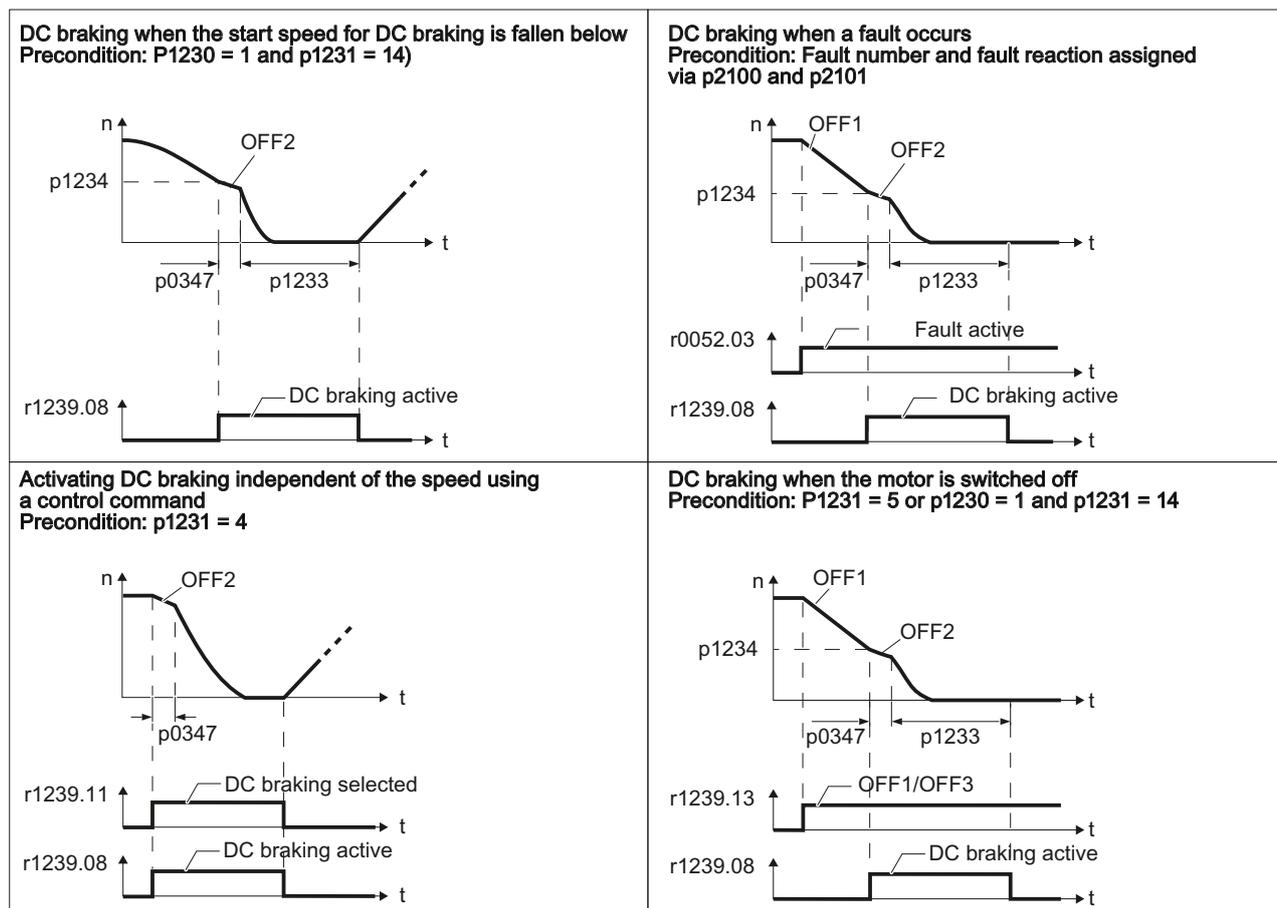
- Centrifuges
- Saws
- Grinding machines
- Conveyor belts

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" 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.

---

 <b>CAUTION</b>
--

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 8- 29 Parameters for configuring DC braking

Parameter	Description
p1230	<b>Activate DC braking (BICO parameter)</b> 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	<b>Configure DC braking</b> <ul style="list-style-type: none"> <li>• p1231 = 0, no DC braking</li> <li>• p1231 = 4, general enabling of DC braking</li> <li>• p1231 = 5, DC braking for OFF1/3, independent of p1230</li> <li>• P1231 = 14, enables DC braking for the case that the motor speed falls below the start speed for DC braking.</li> </ul>

Table 8- 30 Parameters for configuring DC braking in the event of faults

Parameter	Description
p2100	<b>Set fault number for fault reaction</b> (factory setting: 0) Enter the fault number for which DC braking should be activated, e.g.: p2100[3] = 7860 (external fault 1).
p2101 = 6	<b>Fault reaction setting</b> (factory setting: 0) Assigning the fault response: p2101[3] = 6.
<p>The fault is assigned an index of p2100. The associated fault response must be assigned the same index in p2101.</p> <p>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.</p>	

Table 8- 31 Additional parameters for setting DC braking

Parameter	Description
p1232	<b>DC braking braking current</b> (factory setting: 0 A) Setting the braking current for the DC braking.
p1233	<b>DC braking duration</b> (factory setting: 1 s)
p1234	<b>DC braking start speed</b> (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	<b>Motor de-excitation</b> 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.

8.9.2.3 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

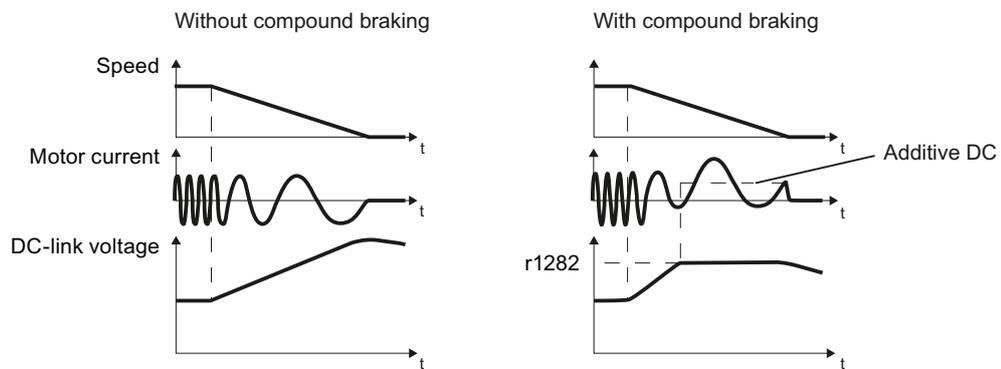


Figure 8-12 Motor brakes with and without active compound braking

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 inverter 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 8- 32 Parameters to enable and set compound braking

Parameter	Description
P3856	<p><b>Compound braking current (%)</b></p> <p>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.</p> <p>P3856 = 0 Compound braking locked</p> <p>P3856 = 1 ... 250 Current level of the DC braking current as a % of the rated motor current (P0305)</p> <p>Recommendation: <math>p3856 &lt; 100 \% \times (r0209 - r0331) / p0305 / 2</math></p>
r3859.0	<p><b>Status word, compound braking</b></p> <p>r3859.0 = 1: Compound braking is active</p>

 <b>CAUTION</b>
<p>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.</p>

### 8.9.2.4 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  $V_{DC\ link, max}$ .

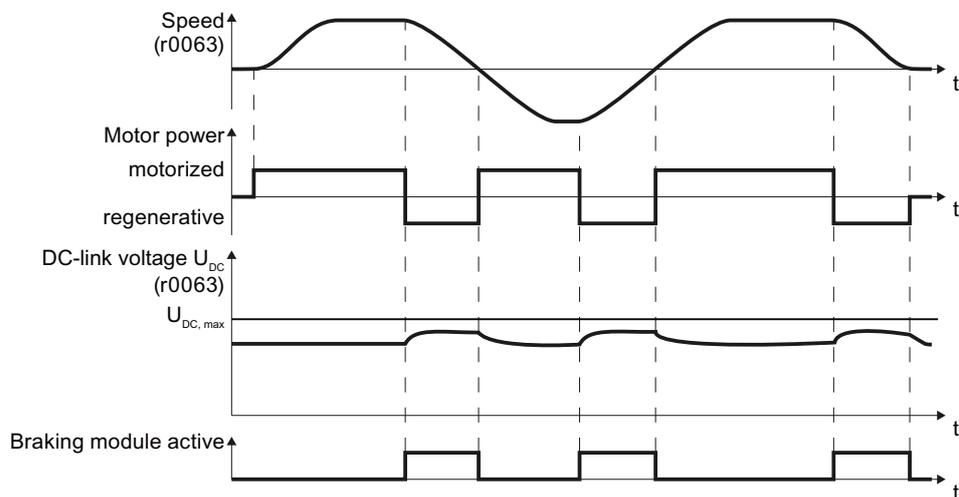


Figure 8-13 Simplified representation of dynamic braking with respect to time

#### Mounting the braking resistor

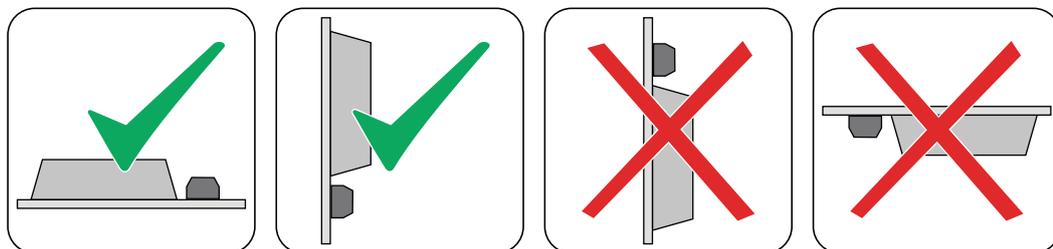
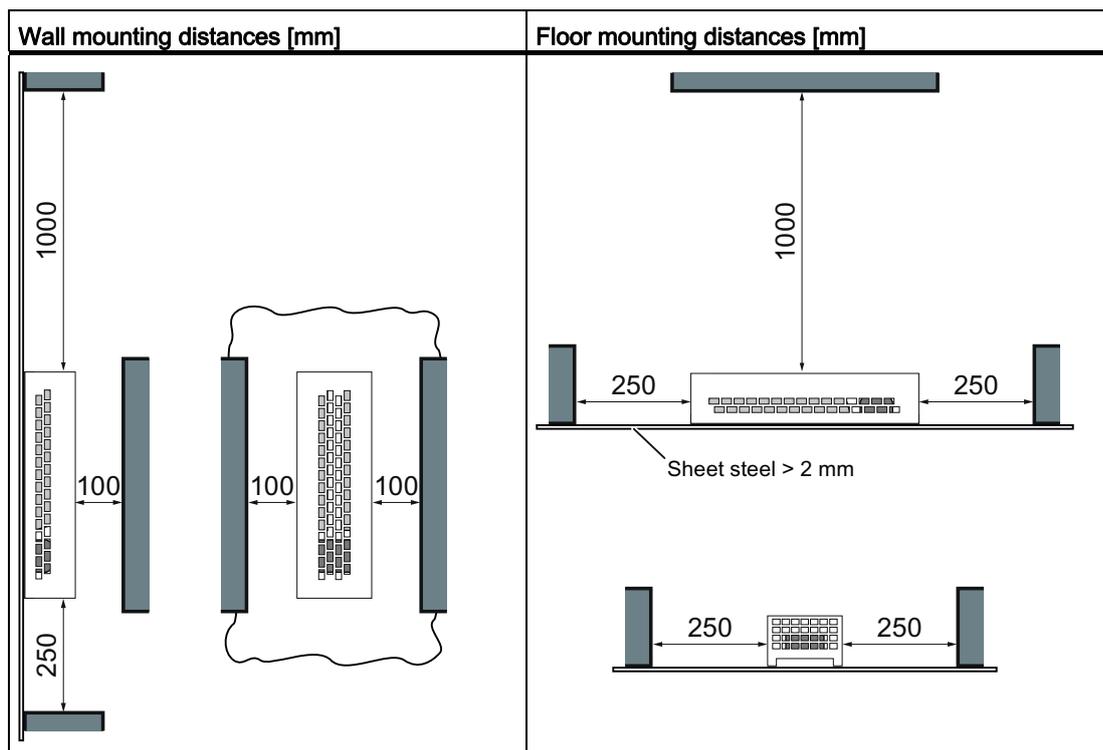


Figure 8-14 Permissible mounting orientation of the braking resistor

 <b>CAUTION</b>
The operation of the braking resistor without housing is not permitted.

### 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.

Dimensions and drill patterns

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

<b>Frame Size A, 2.2 kW ... 4.0 kW</b>	
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]	
	<p>Fixing:                      4 × M4 bolts                      4 × M4 nuts                      4 × M4 washers                      Tightening torque 3 Nm</p>

Frame Size C, 11 kW ... 18.5 kW	
Dimensions [mm]	
Drill pattern [mm]	
	<p>Fixing:                      4 × M5 bolts                      4 × M5 nuts                      4 × M5 washers                      Tightening torque 6 Nm</p>

**Connecting the braking resistor**

1. Connect the braking resistor to terminals R1 and R2 on the inverter.
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 inverter.
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 inverter. Set the function of this digital input to the OFF2 command.

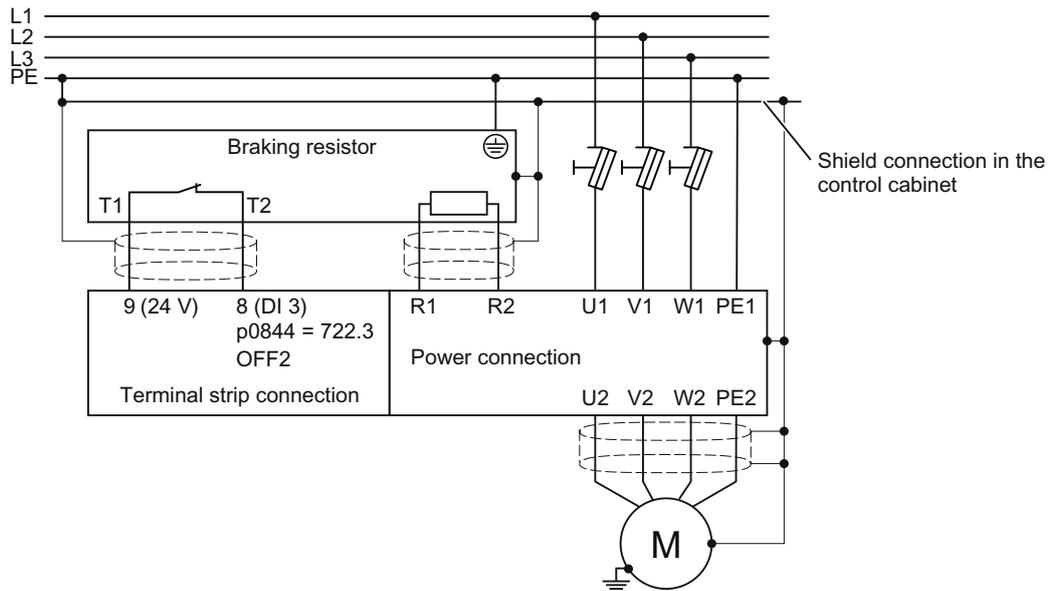


Figure 8-15 Braking resistor connections (Example: temperature monitoring via DI 3)

**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.

**Parameterizing the dynamic braking**

Deactivate the  $V_{DCmax}$  controller. The  $V_{DCmax}$  controller is described in Section Limiting the maximum DC link voltage (Page 194).

The dynamic braking does not have to be parameterized any further.

### 8.9.2.5 Motor holding brake

The motor holding brake prevents the motor turning when it is switched off. The inverter has internal logic to control a motor holding brake.

The motor holding brake control inside the inverter is suitable for the following typical applications:

- Horizontal, inclined and vertical conveyors
- Pumps
- Fans

#### 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 inverter using digital output 0 (DO 0) on terminals 19 and 20.

The inverter 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.

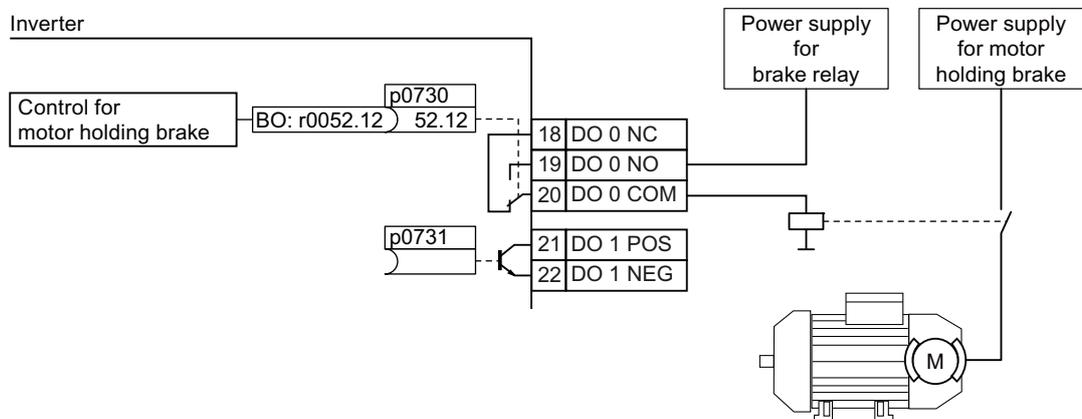


Figure 8-16 Simplified diagram of motor holding brake connected to DO 0 of the inverter

### Principle of operation after OFF1 and OFF3 command

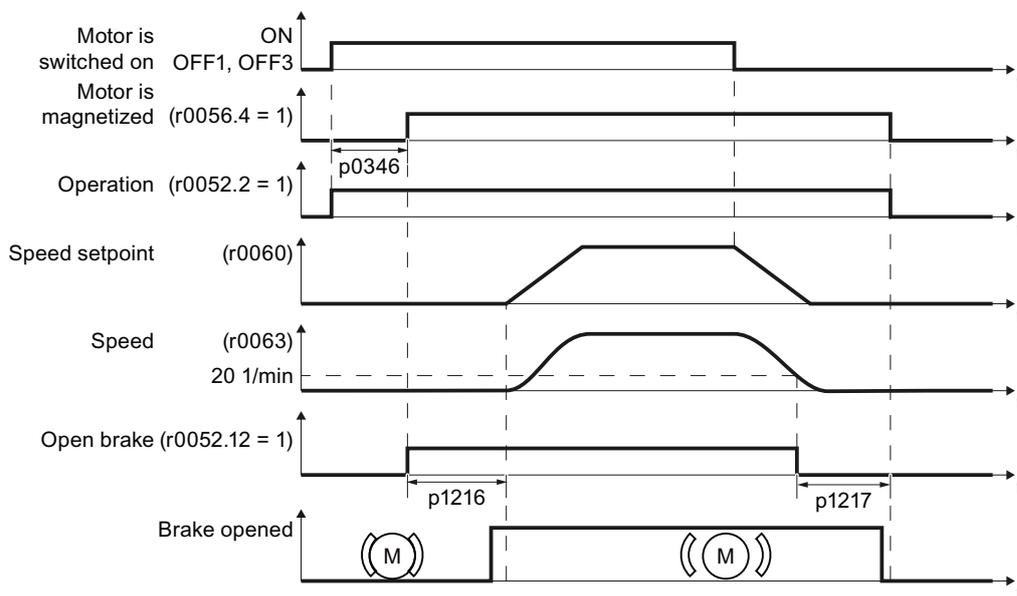


Figure 8-17 Controlling the motor holding brake when the motor is switched on and off

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.

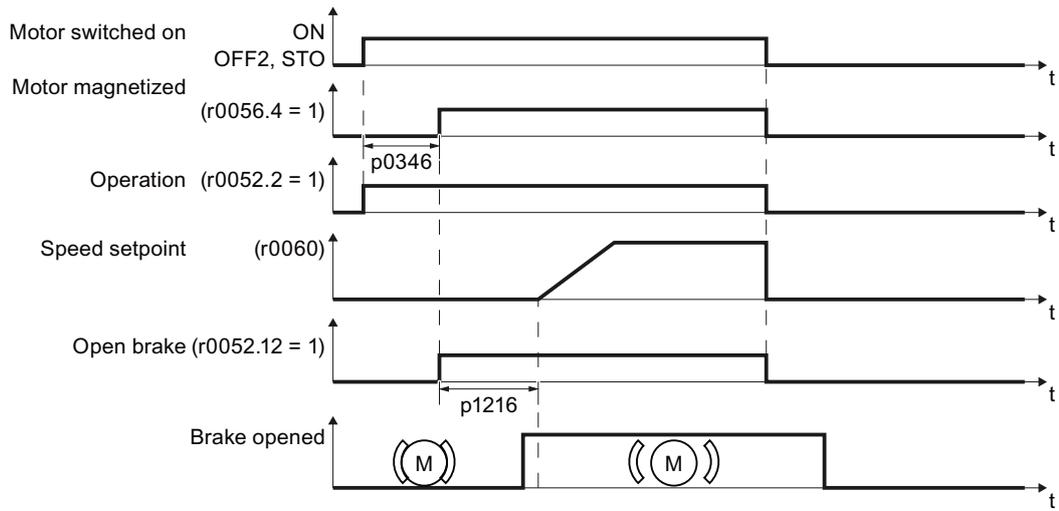


Figure 8-18 Controlling the motor holding brake after an OFF2 command or STO

## 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 8- 33 Control logic parameters of the motor holding brake

Parameter	Description
p1215 = 1	<b>Enable motor holding brake</b> 0 Motor holding brake locked (factory setting) 3: Motor holding brake just like the sequential control, connected via BICO
p1216	<b>Motor holding brake opening time</b> (factory setting 0.1 s) p1216 > braking signal relay runtimes + brake release time
p1217	<b>Motor holding brake closing time</b> (factory setting 0.1 s) p1217 > braking signal relay runtimes + brake closing time
r0052.12	<b>"Open motor holding brake" command</b>
p0730 = 52.12	<b>Signal source for terminal DO 0</b> Control motor holding brake via digital output 0
p0731 = 52.12	<b>Signal source for terminal DO 1</b> Control motor holding brake via digital output 1

Table 8- 34 Advanced settings

Parameter	Description
p0346	<b>Magnetizing time</b> (factory setting 0 s) During this time the induction motor is magnetized. The inverter calculates this parameter using p0340 = 1 or 3.
p0855	<b>Open motor holding brake (imperative)</b> (factory setting 0)
p0858	<b>Close motor holding brake (imperative)</b> (factory setting 0)
p1351	<b>Starting frequency of motor holding brake</b> (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	<b>Starting frequency for motor holding brake</b> (factory setting 1351) Setting the signal source for the frequency set value at the slip compensation output when starting with motor holding brake.
p1475	<b>Speed controller torque set value for motor holding brake</b> (factory setting 0) Setting the signal source for the torque set value when starting with motor holding brake.

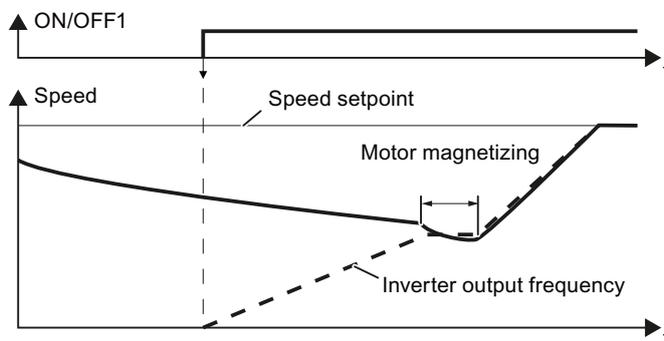
### 8.9.3 Automatic restart and flying restart

#### 8.9.3.1 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.



Principle of operation of the "flying restart" function

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 8- 35 Basic setting

Parameter	Description
P1200	<b>Flying restart operating mode</b> (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 8- 36 Advanced settings

Parameter	Description
P1201	<b>Flying restart enable signal source</b> (factory setting: 1) Defines a control command, e.g. a digital input, through which the flying restart function is enabled.
P1202	<b>Flying restart search current</b> (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	<b>Flying restart search speed factor</b> (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).

### 8.9.3.2 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 221).
- Using p1210, select the automatic restart mode that best suits your application.

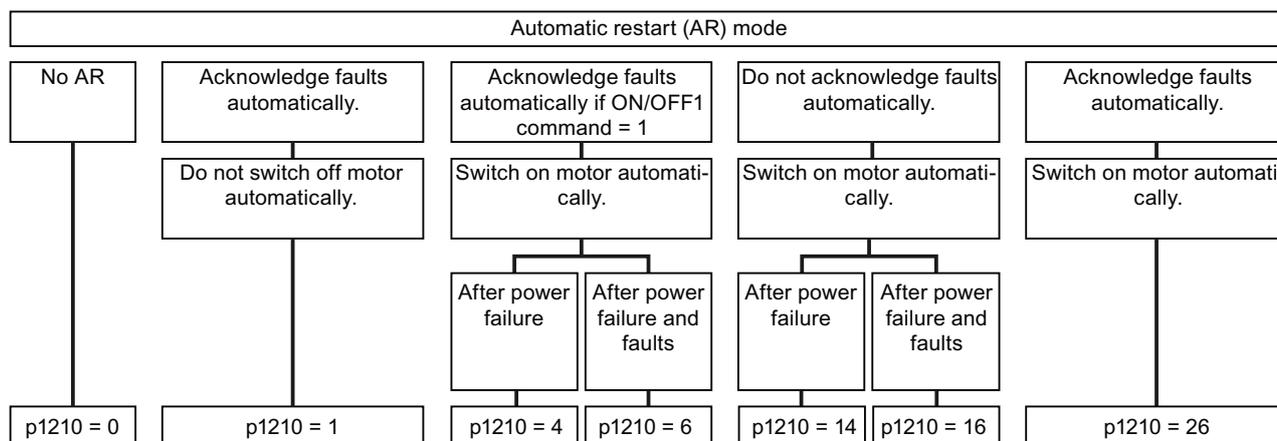
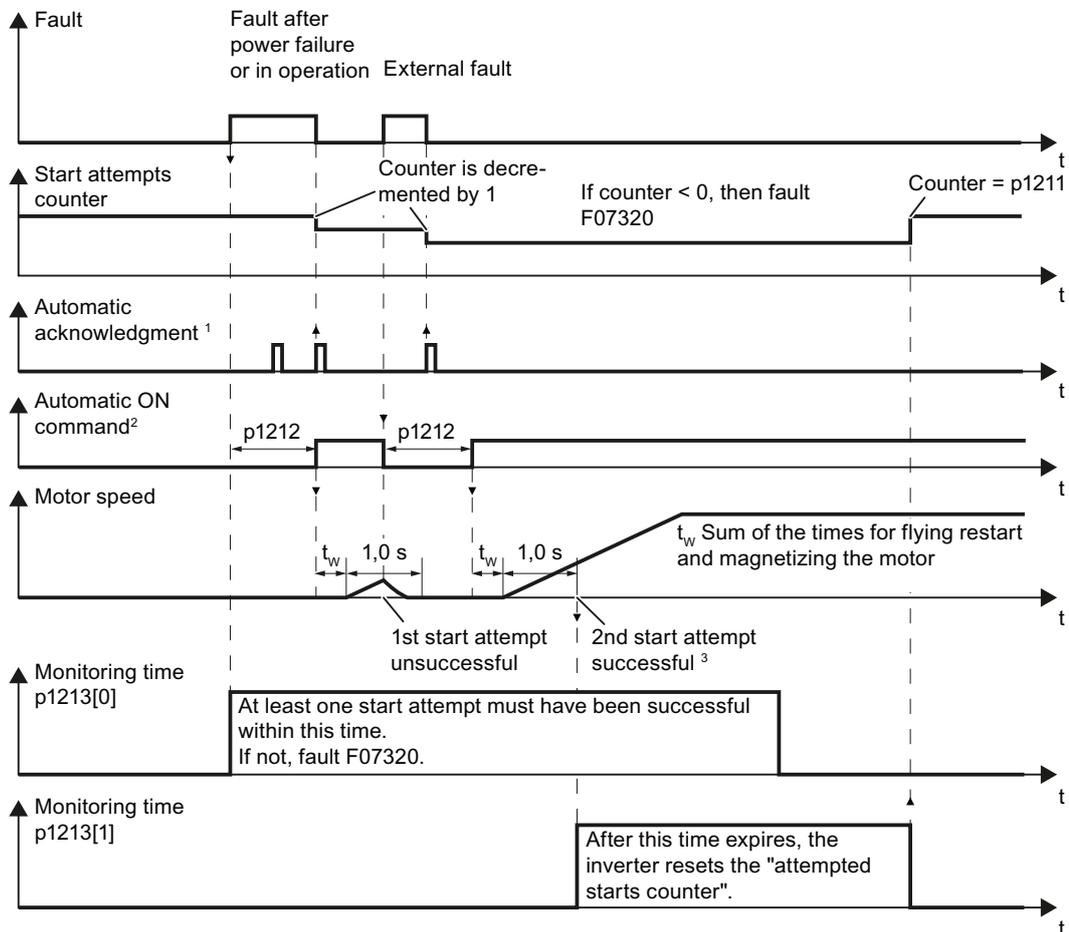


Figure 8-19 Selecting the automatic restart mode

- 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.



<sup>1</sup> 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.

<sup>2</sup> 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).

<sup>3</sup> 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 8-20 Time response of the automatic restart

Table 8- 37 Setting the automatic restart

Parameter	Explanation
p1210	<p><b>Automatic restart mode</b> (factory setting: 0)</p> <p>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</p>
p1211	<p><b>Automatic restart start attempts</b> (factory setting: 3)</p> <p>This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26.</p> <p>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.</p> <p>For p1211 = n, up to n + 1 start attempts are made. Fault F07320 is output after n + 1 unsuccessful start attempts.</p> <p>The inverter sets the start attempt counter back again to the value of p1211, if one of the following conditions is fulfilled:</p> <ul style="list-style-type: none"> <li>• After a successful start attempt, the time in p1213[1] has expired.</li> <li>• After fault F07320, withdraw the ON command and acknowledge the fault.</li> <li>• You change the start value p1211 or the mode p1210.</li> </ul>
p1212	<p><b>Automatic restart wait time start attempt</b> (factory setting: 1.0 s)</p> <p>This parameter is only effective for the settings p1210 = 4, 6, 26.</p> <p>Examples for setting this parameter:</p> <ol style="list-style-type: none"> <li>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.</li> <li>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.</li> </ol>

Parameter	Explanation
p1213[0]	<p><b>Automatic restart monitoring time for restart</b> (factory setting: 60 s)</p> <p>This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26.</p> <p>With this monitoring function, you limit the time in which the inverter may attempt to automatically switch-on the motor again.</p> <p>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.</p> <p>Set the monitoring time longer than the sum of the following times:</p> <ul style="list-style-type: none"> <li>+ P1212</li> <li>+ time that the inverter requires to start the motor on the fly.</li> <li>+ Motor magnetizing time (p0346)</li> <li>+ 1 second</li> </ul> <p>You deactivate the monitoring function with p1213 = 0.</p>
p1213[1]	<p><b>Automatic restart monitoring time to reset the fault counter</b> (factory setting: 0 s)</p> <p>This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26.</p> <p>Using this monitoring time, you prevent that faults, which continually occur within a certain time period, are automatically acknowledged each time.</p> <p>The monitoring function starts with a successful start attempt and ends after the monitoring time has expired.</p> <p>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.</p>

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

### Advanced settings

If you wish 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.

 <b>WARNING</b>
<p>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.</p> <p>Example: A communication failure via PROFIBUS is signaled using fault code F01910. You should therefore set p1206[n] = 1910 (n = 0 ... 9).</p>

### 8.9.4 PID technology controller

The technology controller permits all types of simple process controls to be implemented. You can use the technology controller for e.g. pressure controllers, level controls or flow controls.

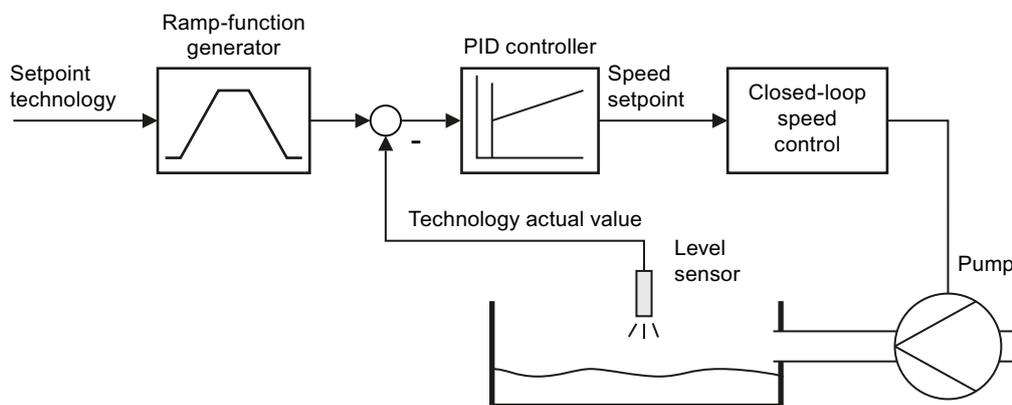


Figure 8-21 Example: technology controller as a level controller

#### Principle of operation

The technology controller specifies the speed setpoint of the motor in such a way that the process variable to be controlled corresponds to its setpoint. The technology controller is designed as a PID controller, which makes it highly flexible.

The technology controller setpoint is entered via an analog input or via the fieldbus.

Table 8- 38 Technology controller parameters

Parameter	Description
P2200 = ...	Enable technology controller
P2201 ... r2225	Fixed speeds for the technology controller
P2231 ... P2248	Motorized potentiometer for the technology controller
P2251 ... r2294	General adjustment parameters of the technology controller
P2345 = ...	Changing the fault reaction for the technology controller

Additional information about this function is provided in the parameter list and in the function diagrams 7950 ... 7958 in the List Manual.

## 8.10 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 304).

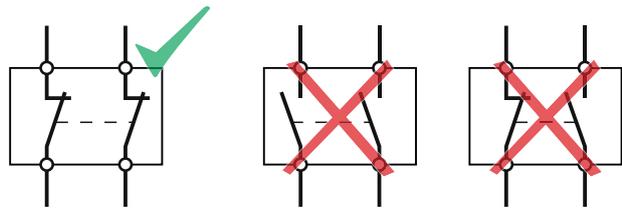
### 8.10.1 Prerequisite for STO use

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.

### 8.10.2 Permitted sensors

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

It is not possible to directly connect sensors with two NO contacts and antivalent contacts (1 NO contact and 1 NC contact).



Permitted sensors

The fail-safe digital inputs are configured for both directly connecting safety sensors, e.g. emergency stop control devices or light curtains, as well as for connecting pre-processing safety relays, e.g. fail-safe controls.

On the following pages, you will find examples of interconnecting the fail-safe digital input from "Basic safety", in accordance with PL d to EN 13849-1 and SIL2 to IEC 61508. You can find further examples and information in the Safety Integrated Function Manual.

### 8.10.3 Connecting fail-safe digital inputs

On the following pages, you will find examples of connecting the fail-safe digital input from "Basic safety", in accordance with PL d according to EN 13849-1 and SIL2 according to IEC 61508 for the case that all of the components are installed in a control cabinet.

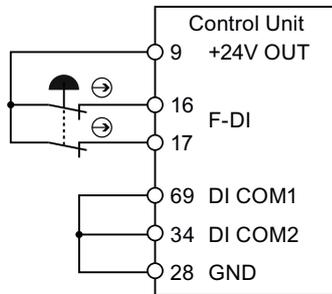


Figure 8-22 Connecting a sensor, e.g. Emergency Stop mushroom pushbutton or limit switch

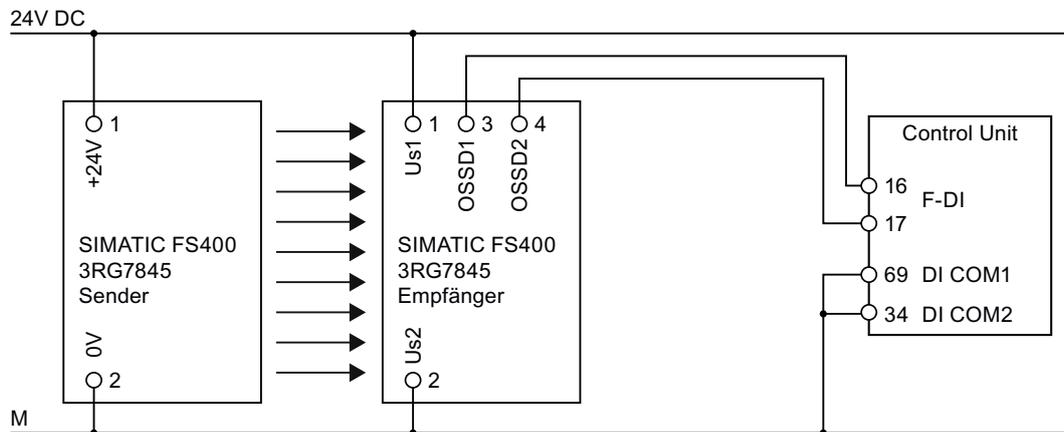


Figure 8-23 Connecting an electronic sensor, e.g. SIMATIC FS-400 light curtain

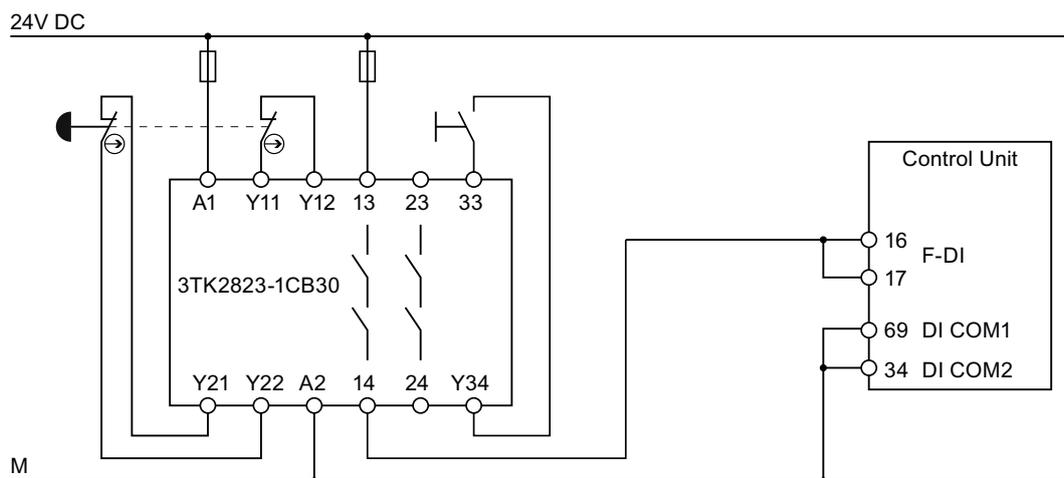


Figure 8-24 Connecting a safety relay, e.g. SIRIUS 3TK28

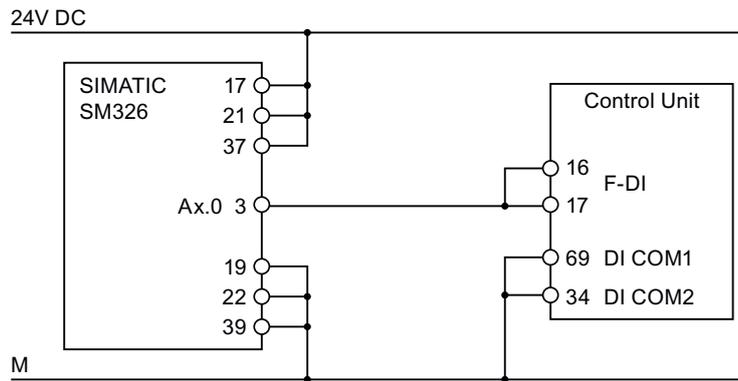


Figure 8-25 Connecting an F digital output module, e.g. SIMATIC F digital output module

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 304).

### 8.10.4 Signal filtering

The inverter checks the signals of the fail-safe digital input for consistency. Consistent signals at both inputs always assume the same signal state (high or low).

#### Discrepancy

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 points toward a fault in the wiring of a fail-safe input, e.g. a wire break.

An adjustable filter in the inverter prevents faults caused by temporary discrepancy. Within the filter tolerance time (parameters p9650 and p9850), the inverter suppresses the discrepancy monitoring of the fail-safe inputs.

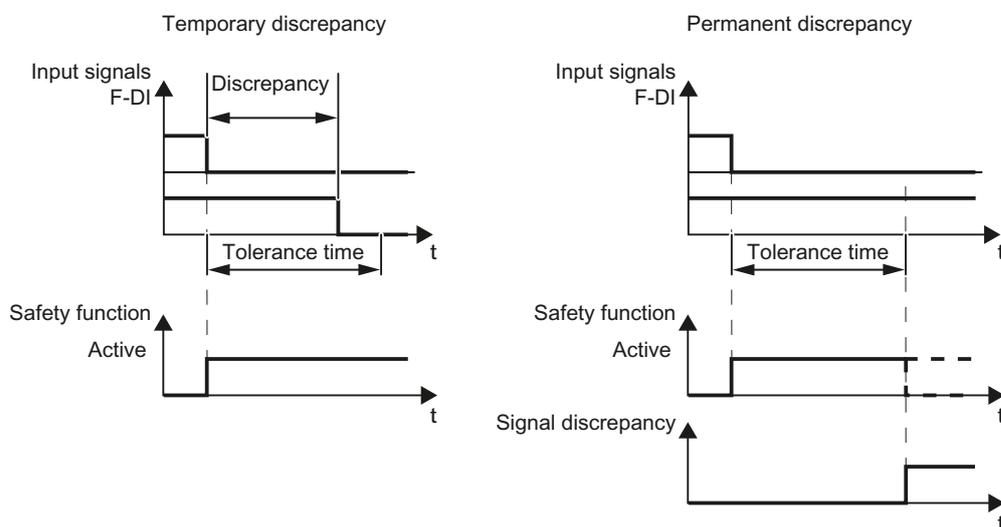


Figure 8-26 Filter for suppressing discrepancy monitoring

The filter does not increase the inverter response time. The inverter activates its safety functions as soon as one of the two F-DI signals changes its state from high to low.

**Bit pattern test of fail-safe outputs and contact bounces of sensors**

The inverter normally responds immediately to signal changes at its fail-safe input. This is not required in the following cases:

1. When you interconnect the fail-safe input of the inverter with an electromechanical sensor, contact bounce may result in signal changes occurring, to which the inverter 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 or cross circuiting. When you interconnect the fail-safe input of the inverter with a fail-safe output of a control module, the inverter responds to these test signals.

A signal change during a bit pattern test usually lasts 1 ms.

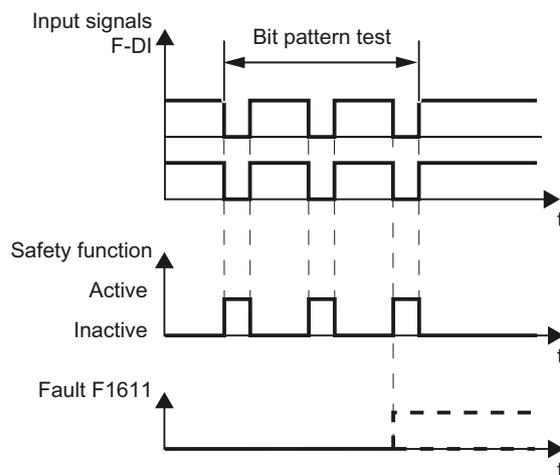


Figure 8-27 Inverter response to a bit pattern test

If the signal to control STO is not "stable", then the inverter responds with a fault.  
 (Definition of a stable signal: Following a change to the F-DI input signals, the inverter triggers an internal monitoring time. Up until the end of the time interval  $5 \times p9650$ , both input signals must have a constant signal level. A constant signal level is a high or a low state, for a period of at least  $p9650$ ).

An adjustable signal filter in the inverter suppresses temporary signal changes using bit pattern test or contact bounce.

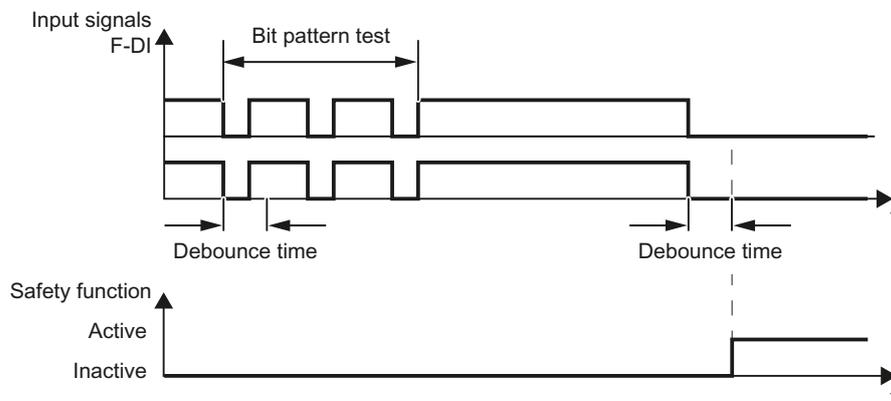


Figure 8-28 Filter for suppressing temporary signal changes

**Note**

The filter increases the inverter response time. The inverter only activates its safety function after the debounce time has elapsed (parameters p9651 and p9851).

**Note**

**Debounce times for standard and safety functions**

The debounce time p0724 for "standard" digital inputs has no influence over the fail-safe input signals. Conversely, the same applies: The F-DI debounce time does not influence the signals of the "standard" inputs.

If you use an input as a standard input, set the debounce time at p0724.

If you use an input as fail-safe input, set the debounce time as described above.

### 8.10.5 Forced dormant error detection

To fulfill the requirements of standards EN 954-1, ISO 13849-1 and IEC 61508 regarding timely error detection, the inverter must regularly test its safety-relevant circuits to ensure that they function correctly - this must be performed at least once every year.

After the power supply has been connected, the inverter checks its circuits to switch-off the torque each time the STO function is selected.

The inverter monitors the regular test of its safety-relevant circuits using a time module.

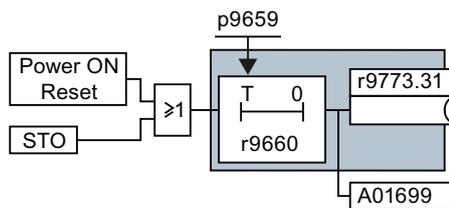


Figure 8-29 Forced dormant error detection monitoring

r9660 contains the remaining time until the monitoring responds. The inverter signals Alarm A01699 after the monitoring time expires.

You define the monitoring time while commissioning the system depending on your particular application.

**Examples for the times when forced dormant error detection 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).

If alarm A01699 signals that the monitoring time has expired, then you must initiate the forced dormant error detection at the next opportunity. These alarms do not affect the operation of your machine.

### 8.10.6 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.

---

The factory setting for the password is "0". During commissioning, choose your password from the permissible range 1 ... FFFF FFFF.

## 8.10.7 Commissioning

### 8.10.7.1 Commissioning tool

We strongly recommend that you commission the safety functions using the STARTER PC tool.

Table 8- 39 STARTER commissioning tool (PC software)

Download	Order number
STARTER ( <a href="http://support.automation.siemens.com/WW/view/en/10804985/130000">http://support.automation.siemens.com/WW/view/en/10804985/130000</a> )	PC Connection Kit The kit contains a STARTER DVD and USB cable 6SL3255-0AA00-2CA0

### 8.10.7.2 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.
- Open the screen form of the safety functions.
- Click on the "Restore Safety factory settings" button.



- Enter the password,for the safety functions.
- Confirm that the parameters have been saved (RAM to ROM).
- Go offline with STARTER.
- Switch off the converter supply voltage.
- Wait until all LEDs on the converter go dark. Now switch on the converter power supply again (power on reset).

8.10 Fail-safe function Safe Torque Off (STO)

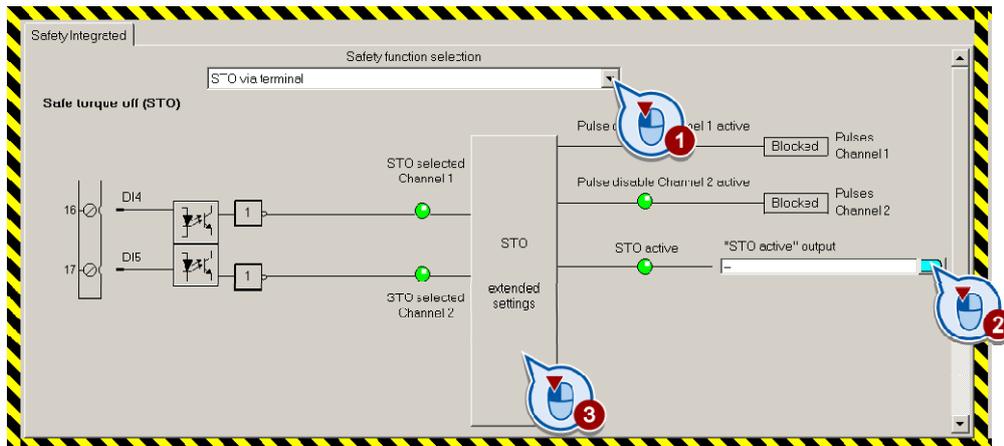
Procedure

- Go online with STARTER.
- In STARTER, call up the screens displaying the fail-safe functions and click on "Change settings":



8.10.7.3 Defining commissioning method

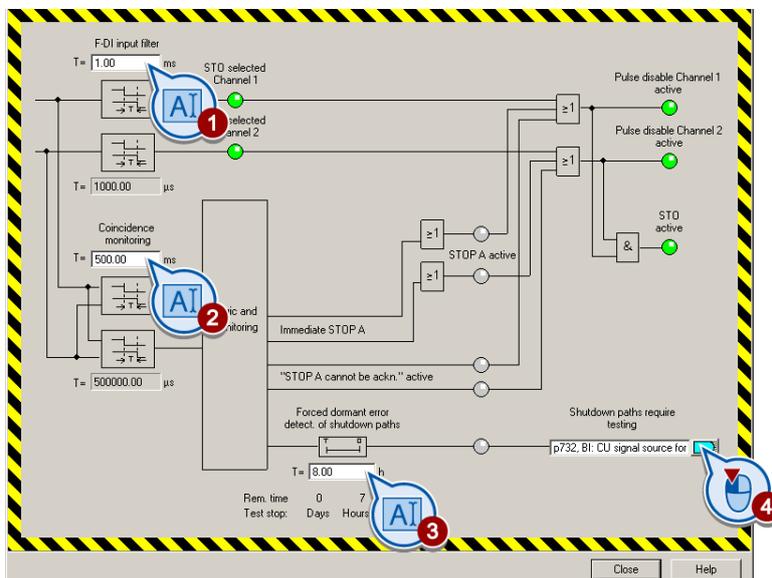
- Select "STO via terminal".



- If you require the status signal "STO active" in your higher-level controller, interconnect it accordingly.
- Click the button to call up the advanced settings for STO.

### 8.10.7.4 Setting STO

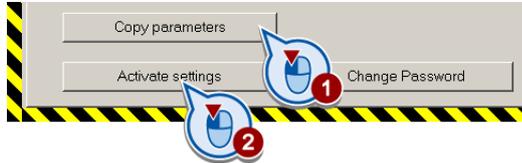
- You can adapt the STO function according to your requirements in the following screen.



- Set the following in the above screen:
  - ① ② **F-DI input filter (debounce time) and monitoring for simultaneous operation (discrepancy):**  
The method of functioning of the two filters is described in the section entitled Signal filtering (Page 231).
  - ③ ④ **Time interval for forced dormant error detection:**  
Information regarding forced dormant error detection can be found in the Forced dormant error detection (Page 234) section.
- Close the screen.

8.10.7.5 Activate settings

- Click "Copy parameters" and then click "Activate settings":



- You are prompted to allocate a password if the password = 0 (factory setting). 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 234).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the inverter supply voltage.
- Wait until all LEDs on the inverter go dark. Now switch on the inverter supply voltage again. Your settings only become effective after this power-on reset.

8.10.7.6 Multiple assignment of the DI

- 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:

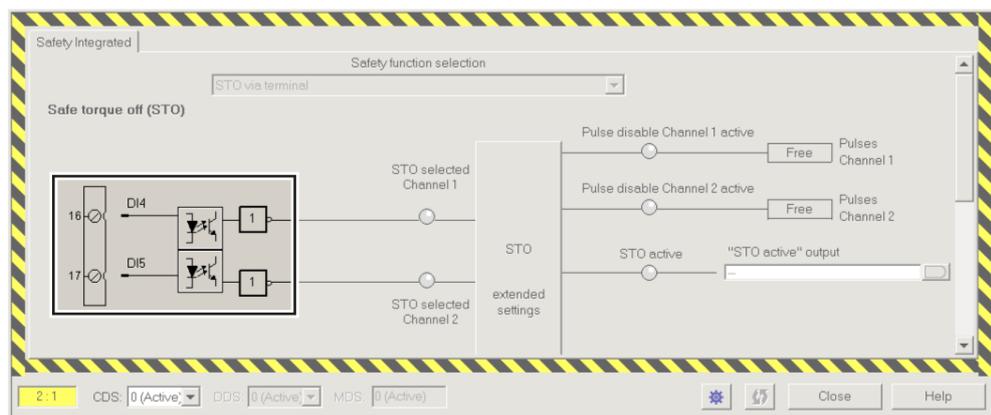


Figure 8-30 Example: automatic assignment of digital inputs DI 4 and DI 5 with STO

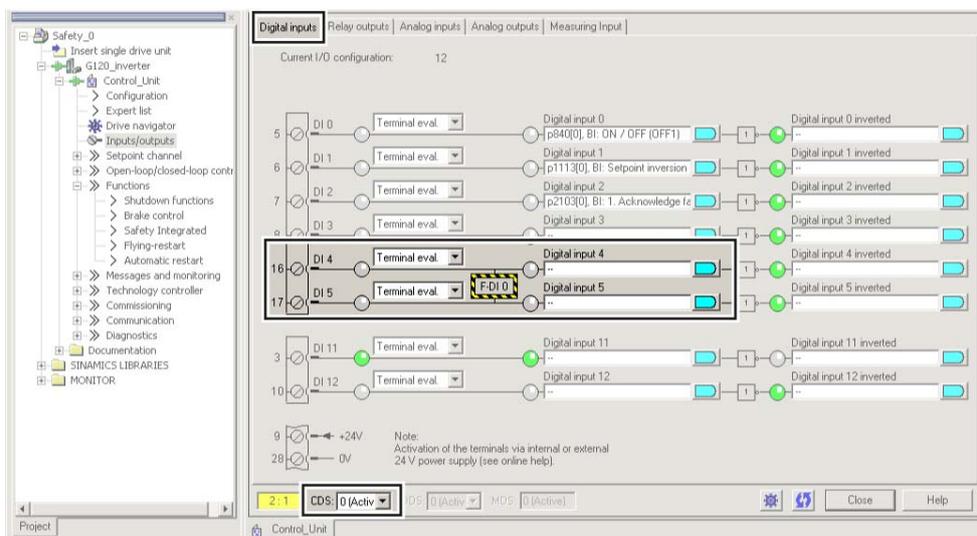


Figure 8-31 Remove pre-assignment of digital inputs DI 4 and DI 5

- When you use the data set changeover CDS, you must delete the multiple assignment of the digital inputs for all CDS.

## 8.10.8 Acceptance test

### 8.10.8.1 Prerequisites and authorized persons

Requirements for acceptance tests are derived from the EC Machinery Directive and ISO 13849-1.

- Check the safety-related functions and machine parts following commissioning.
- Issue an "Acceptance certificate" which describes 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 must be complete. These include, for example:
  - Configuration of the setpoint channel.
  - Position control in the higher-level controller.
  - Drive 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.

### 8.10.8.2 Complete acceptance test

A complete acceptance test includes the following:

1. Documentation
  - Description of the machines and overview/block diagram
  - Safety functions of the drive
  - Description of safety equipment
2. Function test
  - Test of the shutdown paths
  - Test of safety functions used
3. Conclusion of the report
  - Inspection of safety function parameters
  - Recording of the checksums
  - Verify the data backup
  - Countersignatures

### 8.10.8.3 Reduced acceptance test

A complete acceptance test is only necessary following first commissioning. An acceptance test with a reduced scope is sufficient for expansions of safety functions.

The reduced acceptance tests must be carried out separately for each individual drive, as far as the machine allows.

Table 8- 40 Reduced acceptance test for function extensions

Measure	Acceptance test		
	Documentation	Function test	Conclusion of the report
Replace the inverter.	Supplement: • Inverter data	Yes	Supplement: New checksums and countersignature
Replace the motor	No	Partially. Test the safety function SDI.	No
Replace the gear unit	No	Yes	No
Replace the safety-related peripherals (e.g. Emergency Off switch).	No	Partially. Limitation to replaced components.	No
Inverter firmware update.	Supplement: • Firmware version in the inverter data	Yes	Supplement: New checksums and countersignature.
Functional expansion of the machine (additional drive).	Supplement: • Machine overview • Inverter data • Function table • Limit values	Yes Testing the additional functions.	Supplement: New checksums and countersignature.
Transfer of inverter parameters to other identical machines by means of series commissioning.	Supplement to the machine description (checking of the firmware versions).	No	No, if data are identical (checking of checksums).

8.10.8.4 Documentation

Machine overview

Enter your machine's data into the following table.

Designation	...
Type	...
Serial number	...
Manufacturer	...
End customer	...
Overview image of the machine: ... ... ... ... ... ... ...	

Converter data

Document the hardware and firmware versions for each safety-related converter of your machine.

	MLFB and hardware version of the converter	Converter firmware version	Version of the safety functions			
			r9770[0]	r9770[1]	r9770[2]	r9770[3]
Designation of the 1st drive	...	r0018 = ...	r9590[0]	r9590[1]	r9590[2]	r9590[3]
	...					
Designation of the 2nd drive	...					
...	...					

**Function table**

Fill in the following table for your machine.

Mode of operation	Safety device	Drive	Activating the safety function	Status of the safety function
...	...	...	...	...
...	...	...	...	...

Table 8- 41 Example:

Mode of operation	Safety device	Drive	Activating the safety function	Status of the safety function
Production	Protective door closed and locked	1 2	- PROFIsafe	not active SLS level 2 active
	Protective door unlocked	1 2	F-DI 0 PROFIsafe	STO SS1
Setup	Protective door closed and locked	1 2	- PROFIsafe	not active SLS level 2 active
	Protective door unlocked	1 2	F-DI 1 PROFIsafe	SS1 SLS level 0 active

The following is checked during the function test:

- The hardware is functioning properly.
- The digital inputs of the inverter are assigned correctly to the safety function.
- The PROFIsafe address of the inverter has been set correctly.
- The safety function has been parameterized correctly.
- Routine for the dormant error detection of the switch-off signal paths of the inverter.

**Note**

Perform the acceptance test with the maximum possible velocity and acceleration.

8.10 Fail-safe function Safe Torque Off (STO)

8.10.8.5 Function test

Table 8- 42 "Safe Torque Off" (STO) function

No.	Description	Status
1.	Initial state:	
	• The inverter is in "Ready" state (p0010 = 0).	
	• The inverter indicates neither faults nor alarms for safety functions (r0945, r2122, r2132).	
	• STO is not active.	
2.	Switch on the motor (ON command).	
3.	Ensure that the correct motor is running.	
4.	Select STO while the motor is running <b>Note:</b> Test each configured activation, e.g. via digital inputs and PROFIsafe.	
5.	Check the following:	
	• 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 inverter indicates neither faults nor alarms for safety functions.	
	• The inverter indicates: "STO is selected" (r9773.0 = 1). "STO is active" (r9773.1 = 1).	
6.	Deselect STO.	
7.	Check the following:	
	• The inverter indicates neither faults nor alarms for safety functions.	
	• The inverter indicates: "STO is not selected" (r9773.0 = 0). "STO is not active" (r9773.1 = 0).	
	• The inverter is in "Closing lockout" state (p0046.0 = 1).	
8.	Switch the motor off (OFF1 command) and then on again (ON command).	
9.	Ensure that the correct motor is running.	

### 8.10.8.6 Completing the certificate

Document your machine's data for each drive based on the following specifications.

#### Parameters of the safety functions

The function test does not detect all faults in the parameter assignment of safety functions, e.g. forced dormant error detection time or filtering time of fail-safe inputs. Therefore, check all parameters once more.

	All parameter values checked
Designation of the 1st drive	
Designation of the 2nd drive	
...	

#### Checksums of the safety functions

The converter calculates checksums across all parameters and safety functions.

When you change the safety function settings, the converter calculates new checksums. This means that subsequent changes in your machine can be tracked.

In addition to the individual checksums of the parameters, the converter calculates and saves the following values:

1. The "total" checksum across all checksums.
2. Time of the last parameter changed.

Labeling the drive	Checksums			
	Processor 1	Processor 2	Total	Time stamp
Designation of the 1st drive	p9798	p9898	r9781[0]	r9782[0]
	p9799	p9899		
...	...			

**Data backup**

	Storage medium			Holding area
	Type	Designation	Date	
Parameter				
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 parameters recorded above are correct.

Date	Name	Company/dept.	Signature

## 9.1 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.

Replacing the inverter with external backup of the settings, e.g. on a memory card.			
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.			
<p>Replacement:</p> <ul style="list-style-type: none"> <li>• Same type</li> <li>• Same power rating</li> <li>• Same firmware version</li> </ul>	<p>Replacement:</p> <ul style="list-style-type: none"> <li>• Same type</li> <li>• Same power rating</li> <li>• <i>higher</i> firmware version (e.g. replace FW V4.2 by FW V4.3)</li> </ul>	<p>Replacement:</p> <ul style="list-style-type: none"> <li>• Same type</li> <li>• <i>Higher</i> power rating</li> <li>• Same firmware version</li> </ul>	<p>Replacement:</p> <ul style="list-style-type: none"> <li>• Same type</li> <li>• <i>Higher</i> power rating</li> <li>• <i>higher</i> firmware version (e.g. replace FW V4.2 by FW V4.3)</li> </ul>
			Inverter and motor must be adapted to one another (ratio of the motor and inverter rated power > 1/8)

**! WARNING**

In all other cases, you must recommission the drive.

## 9.2 Steps for replacing the inverter

We recommend that you save your settings of the inverter after commissioning to an external device. You find information about saving the inverter settings in the section Data backup and series commissioning (Page 71).

If the settings are not saved to an external device, you will have to recommission the inverter when it is replaced.

### Procedure for replacing the inverter with a memory card

- Disconnect the line voltage of the inverter.



**⚠ DANGER**

**Risk of electrical shock!**

Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off.

It is not permissible to carry out any installation work before this time has expired!

- Remove the connectors for line, motor and braking resistor of the inverter.
- Remove the signal cables of the inverter.
- Remove the defective inverter.
- Mount the new inverter.
- Remove the memory card from the old inverter and insert it in the new inverter.
- Reconnect the signal cables of the Control Unit.
- Reconnect the connectors for line, motor and braking resistor of the inverter.
- Connect up the line voltage again.
- The inverter 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 inverters of the same type and an equal or higher firmware version, you can switch on the inverter without any additional commissioning.  
Alarm A01028 will be output for inverters of different types. This alarm indicates that the parameter settings are not compatible with the inverter. In this case, delete the message using p0971 = 1 and recommission the drive.

### Procedure for replacing the inverter without a memory card

- Disconnect the line voltage of the inverter.



 <b>DANGER</b>
<b>Risk of electrical shock!</b> Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off. It is not permissible to carry out any installation work before this time has expired!

- Remove the connectors for line, motor and braking resistor of the inverter.
- Remove the signal cables of the inverter.
- Remove the defective inverter.
- Mount the new inverter.
- Reconnect the signal cables of the inverter.
- Reconnect the connectors for line, motor and braking resistor of the inverter.
- Connect up the line voltage again.
- The inverter 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 inverter.
  - For inverters 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 inverters of different types. This alarm indicates that the parameter settings are not compatible with the inverter. 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 71).

### **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 Complete acceptance test (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 test (Page 241).

## 9.3 Replacing the heat sink fan

### When do you have to replace the fan?

A defect fan involves an over temperature of the inverter. 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 inverter
- Disconnect all the cable connectors for line, motor and braking resistor.
- Remove the screening plate.

### Removal

The heat sink fan of the inverter is situated at the bottom of the inverter 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 Inverter by following the preparatory steps in reverse.

9.3 Replacing the heat sink fan

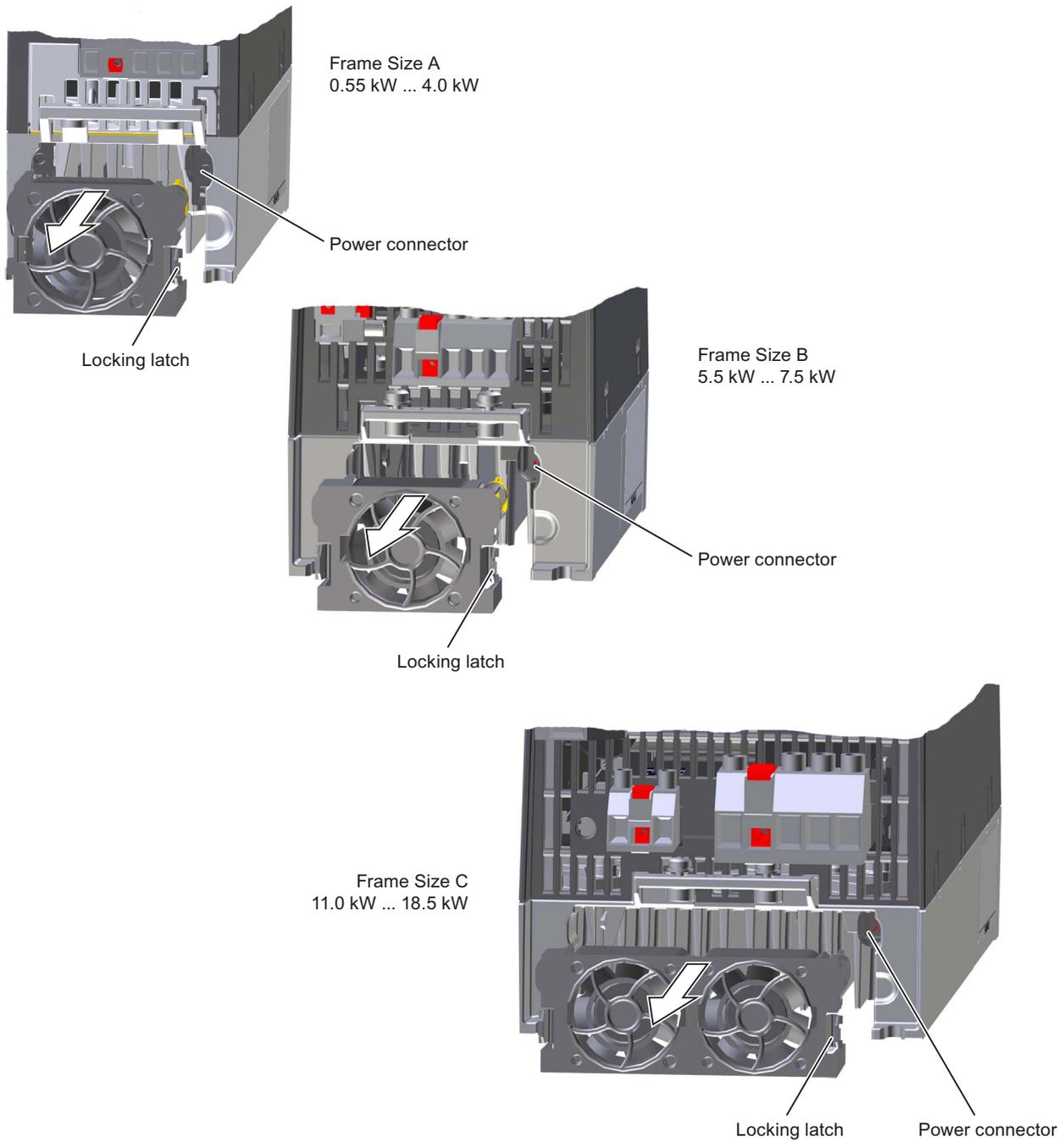


Figure 9-1 Heat sink fan replacement

## 9.4 Replacing the internal fan

### When do you have to replace the fan?

A defective fan involves an over temperature of the inverter. 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 inverter.

1. Power-down the Inverter



 <b>DANGER</b>
<b>Risk of electrical shock!</b>
Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off.
It is not permissible 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 inverter, 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 inverter.

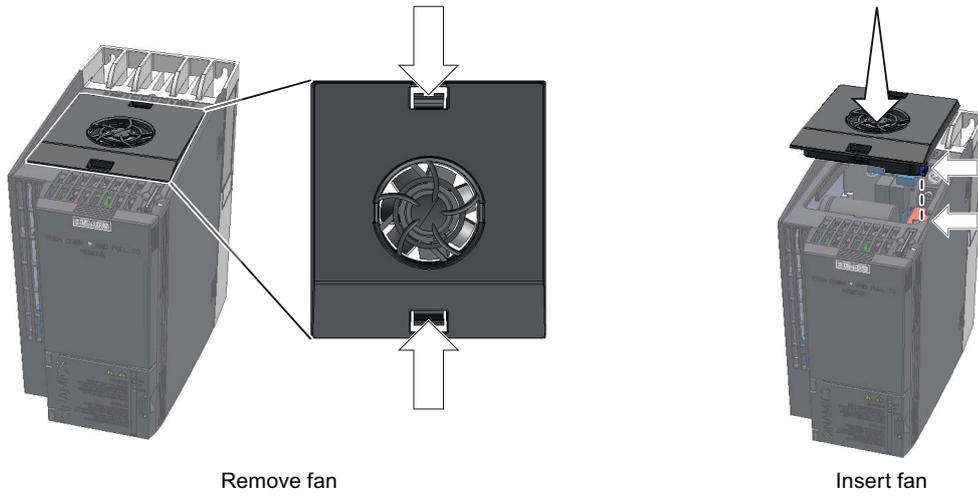


Figure 9-2 Fan replacement

## 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:

- The motor is switched off.
- You cannot communicate with the converter, either via the Operator Panel or other interfaces.

In this event proceed as follows:

- Remove the memory card if one is inserted in the converter.
- Repeat the power on reset until the converter outputs fault F01018:
  - Switch off the converter supply voltage.
  - Wait until all LEDs on the converter go dark. Now switch on the converter supply voltage again.
- If the converter signals fault F01018, repeat the power on reset one more time.
- The converter must now have been restored to its factory settings.
- Recommission the converter.

## 10.1 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:

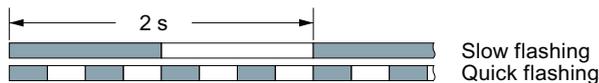


Table 10- 1 Inverter diagnostics

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 10- 2 Communication diagnostics via RS485

LED BF	Explanation
On	Receive process data
RED - slow	Bus active - no process data
RED - fast	No bus activity

Table 10- 3 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 10- 4 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:

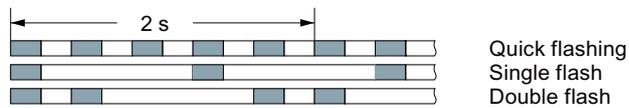


Table 10- 5 Communication diagnostics via CANopen

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)

## 10.2 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] r2134[0] I32 Float

Figure 10-1 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 10-2 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 10-3 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.

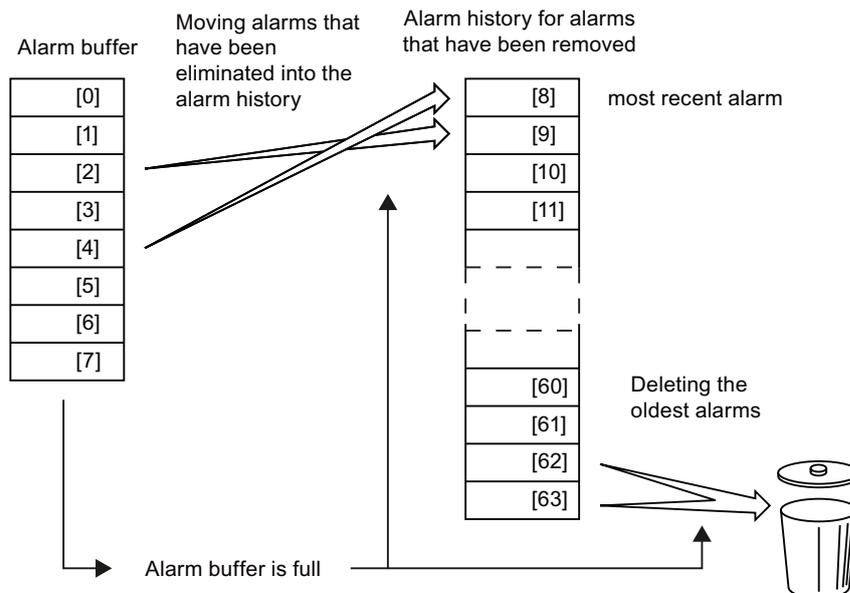


Figure 10-4 Shifting alarms that have been removed into the alarm history

10.2 Alarms

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 10- 6 Important parameters for alarms

Parameter	Description
r2122	<b>Alarm code</b> Displays the numbers of alarms that have occurred
r2124	<b>Alarm value</b> Displays additional information about the alarm
p2111	<b>Alarm counter</b> 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	<b>Actual alarm code</b> Displays the code of the alarm that last occurred
r2134	<b>Alarm value for float values</b> Displays additional information about the alarm that occurred for float values

**Extended settings for alarms**

Table 10- 7 Extended settings for alarms

Parameter	Description
You can change up to 20 different alarms into a fault or suppress alarms:	
p2118	<b>Setting the message number for the message type</b> Select the alarms for which the message type should be changed
p2119	<b>Setting the message type</b> 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.

## 10.3 Faults

A fault displays a severe fault during operation of the inverter.

The inverter signals a fault as follows:

- at the Operator Panel with Fxxxx
- at the Control Unit 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 inverter saves a fault code and fault value for every fault it receives.

	Fault code	Fault value
1st fault	r0945[0]	r0949[0] r2133[0] I32      Float

Figure 10-5 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 10-6 Saving the second fault in the fault buffer

10.3 Faults

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 10-7 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 monitoring of hardware and firmware inside the inverter 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).

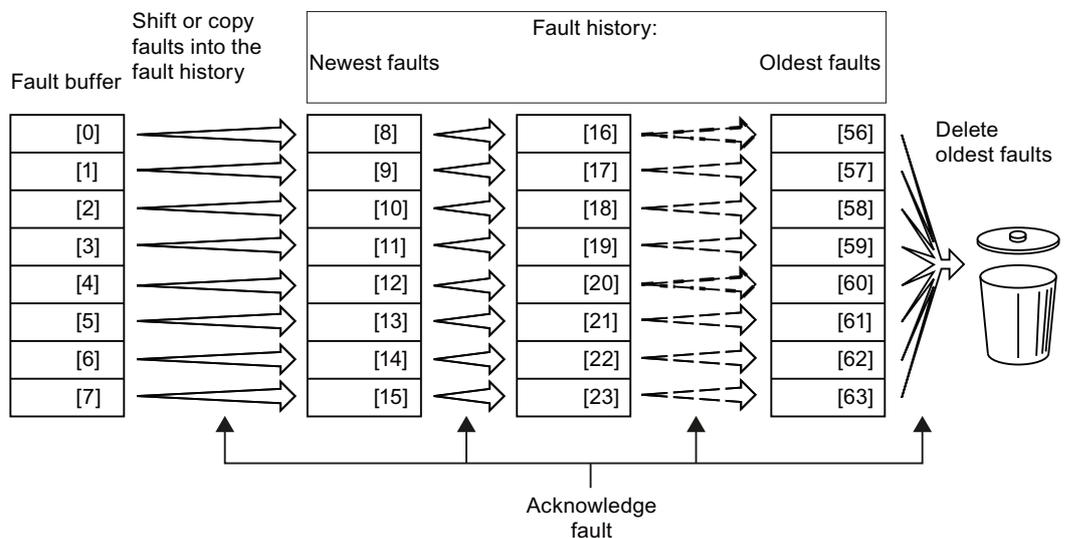


Figure 10-8 Fault history after acknowledging the faults

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 inverter 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 10- 8 Important parameters for faults

Parameter	Description
r0945	<b>Fault code</b> Displays the numbers of faults that have occurred
r0949	<b>Fault value</b> Displays additional information about the fault
p0952	<b>Fault cases, counter</b> Number of fault cases that have occurred since the last acknowledgement The fault buffer is deleted with p0952 = 0.
r2131	<b>Actual fault code</b> Displays the code of the oldest fault that is still active
r2133	<b>Fault value for float values</b> 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
- Does p0010 = 0?  
If not, the inverter 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 command and setpoint sources for the inverter (p0015) correctly parameterized?  
In other words, where is the inverter getting its speed setpoint and commands from (fieldbus or analog input)?
- Do the motor and inverter match?  
Compare the data on the motor's nameplate with the corresponding parameters in the inverter (P0300 ff).

## Extended settings for faults

Table 10- 9 Advanced settings

Parameter	Description
You can change the fault response of the motor for up to 20 different fault codes:	
p2100	<b>Setting the fault number for fault response</b> Selecting the faults for which the fault response should be changed
p2101	<b>Setting, fault response</b> Setting the fault response for the selected fault
You can change the acknowledgement type for up to 20 different fault codes:	
p2126	<b>Setting the fault number for the acknowledgement mode</b> Selecting the faults for which the acknowledgement type should be changed
p2127	<b>Setting, acknowledgement mode</b> 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	<b>Setting the message number for the message type</b> Selecting the message for which the message type should be selected
p2119	<b>Setting the message type</b> 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.

10.4 List of alarms and faults

## 10.4 List of alarms and faults

Axxxxx Alarm

Fyyyyy: Fault

Table 10- 10 The most important alarms and faults of the safety functions

Number	Cause	Remedy
F01600	STOP A initiated	Select STO and then deselect again
F01650	Acceptance test required	Carry out acceptance test and create test certificate. Switch the Control Unit off and then on again.
F01659	Write task for parameter rejected	Cause: A parameter reset was selected. The fail-safe parameters have not yet been reset, as the safety functions are enabled Remedy: block safety functions or reset fail-safe parameters (p0970 = 5), then reset the drive parameters once again.
A01666	Static 1 signal on the F-DI for secure acknowledgement	Setting F-DI to logical 0 signal
A01698	Commissioning mode active for safety functions	This message is withdrawn after the safety functions have been commissioned
A01699	Shutdown path test required	After the next time that the "STO" function is deselected, the message is withdrawn and the monitoring time is reset
F30600	STOP A initiated	Select STO and then deselect again

Table 10- 11 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.
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.

Number	Cause	Remedy
F30022	Power Module: Monitoring U <sub>CE</sub>	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 10- 12 The most important alarms and faults

Number	Cause	Remedy
F01018	Power-up aborted more than once	<ol style="list-style-type: none"> <li>1. Switch the module off and on again.</li> <li>2. After this fault has been output, the module is booted with the factory settings.</li> <li>3. Recommission the inverter.</li> </ol>
A01028	Configuration error	<p>Explanation: Parameterization on the memory card has been created with a different type of module (order number, MLFB)</p> <p>Check the module parameters and recommission if necessary.</p>
F01033	Unit switchover: Reference parameter value invalid	Set the value of the reference parameter not equal to 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	<p>Explanation: A PROFIBUS master is attempting to establish a connection with a faulty configuration telegram.</p> <p>Check the bus configuration on the master and slave side.</p>
F01910	Fieldbus SS setpoint timeout	Check the bus connection and communication partner, e.g. switch the PROFIBUS master to the RUN status.
A01920	PROFIBUS: Cyclic connection interrupt	<p>Explanation: The cyclic connection to PROFIBUS master is interrupted.</p> <p>Establish the PROFIBUS connection and activate the PROFIBUS master with cyclic operation.</p>
F03505	Analog input, wire break	<p>Check the connection to the signal source for interrupts.</p> <p>Check the level of the signal supplied.</p> <p>The input current measured by the analog input can be read out in r0752.</p>
A03520	Temperature sensor fault	Check that the sensor is connected correctly.
A05000 A05001 A05002 A05004 A05006	Power Module overtemperature	<p>Check the following:</p> <ul style="list-style-type: none"> <li>- Is the ambient temperature within the defined limit values?</li> <li>- Are the load conditions and duty cycle configured accordingly?</li> <li>- Has the cooling failed?</li> </ul>

10.4 List of alarms and faults

Number	Cause	Remedy
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 <sub>DC_max</sub> controller active	If the controller is not to intervene: <ul style="list-style-type: none"> <li>• Increase the ramp-down times.</li> <li>• Deactivate the V<sub>DC_max</sub> controller (p1240 = 0 for vector control, p1280 = 0 for V/f control).</li> </ul>
A07409	V/f control current limiting controller active	The alarm automatically disappears after one of the following measures: <ul style="list-style-type: none"> <li>• Increase the current limit (p0640).</li> <li>• Reduce load.</li> <li>• Increase the ramp-up time to the speed setpoint.</li> </ul>
F07426	Technology controller actual value limited	<ul style="list-style-type: none"> <li>• Adapt the limits to the signal level (p2267, p2268).</li> <li>• Check the actual value scaling (p2264).</li> </ul>

Number	Cause	Remedy
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	<ul style="list-style-type: none"> <li>• Reduce the continuous load.</li> <li>• Adapt the load cycle.</li> <li>• Check the assignment of rated currents of the motor and power unit.</li> </ul>
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.
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.
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.
A07921	Torque/speed too high	<ul style="list-style-type: none"> <li>• Check the connection between the motor and the load.</li> </ul>
A07922	Torque/speed out of tolerance	<ul style="list-style-type: none"> <li>• Adapt the parameterization corresponding to the load.</li> </ul>
F07923	Torque/speed too low	<ul style="list-style-type: none"> <li>• Check the connection between the motor and the load.</li> <li>• Adapt the parameterization corresponding to the load.</li> </ul>
F07924	Torque/speed too high	
A07927	DC braking active	Not required
A07980	Rotary measurement activated	Not required
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.

10.4 List of alarms and faults

Number	Cause	Remedy
F30001	Overcurrent	<p>Check the following:</p> <ul style="list-style-type: none"> <li>• Motor data, if required, carry out commissioning</li> <li>• Motor's connection method (Y / Δ)</li> <li>• U/f operation: Assignment of rated currents of motor and Power Module</li> <li>• Line quality</li> <li>• Make sure that the line commutating reactor is connected properly</li> <li>• Power cable connections</li> <li>• Power cables for short-circuit or ground fault</li> <li>• Power cable length</li> <li>• Line phases</li> </ul> <p>If this doesn't help:</p> <ul style="list-style-type: none"> <li>• U/f operation: Increase the acceleration ramp</li> <li>• Reduce the load</li> <li>• Replace the power unit</li> </ul>
F30002	DC-link voltage overvoltage	<p>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.</p>
F30003	DC-link voltage undervoltage	<p>Check the line voltage (p0210).</p>
F30004	Converter overtemperature	<p>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.</p>
F30005	I2t inverter overload	<p>Check the rated currents of the motor and Power Module.            Reduce current limit p0640.            When operating with U/f characteristic: Reduce p1341.</p>
F30011	Line phase failure	<p>Check the inverter's input fuses.            Check the motor cables.</p>
F30015	Motor cable phase failure	<p>Check the motor cables.            Increase the ramp-up or ramp-down time (p1120).</p>
F30021	Ground fault	<ul style="list-style-type: none"> <li>• Check the power cable connections.</li> <li>• Check the motor.</li> <li>• Check the current transformer.</li> <li>• Check the cables and contacts of the brake connection (a wire might be broken).</li> </ul>
F30027	Time monitoring for DC link pre-charging	<p>Check the supply voltage on the input terminals.            Check the line voltage setting (p0210).</p>
F30035	Overtemperature, intake air	<ul style="list-style-type: none"> <li>• Check whether the fan is running.</li> <li>• Check the fan filter elements.</li> <li>• Check whether the ambient temperature is in the permissible range.</li> </ul>
F30036	Overtemperature, inside area	

<b>Number</b>	<b>Cause</b>	<b>Remedy</b>
F30037	Rectifier overtemperature	See F30035 and, in addition: <ul style="list-style-type: none"><li>• Check the motor load.</li><li>• Check the line phases</li></ul>
A30049	Internal fan defective	Check the internal fan and if required replace.
F30059	Internal fan defective	Check the internal fan and if required replace.
A30502	DC link overvoltage	<ul style="list-style-type: none"><li>• Check the device supply voltage (p0210).</li><li>• Check the line reactor dimensioning</li></ul>
A30920	Temperature sensor fault	Check that the sensor is connected correctly.

For further information, please refer to the List Manual.



## Technical data

### 11.1 Technical data of inputs and outputs

Feature	Data
Output voltages	24 V (max. 100 mA) 10 V $\pm$ 0.5 V (max. 10 mA)
Setpoint resolution	0.01 Hz
Digital inputs	<ul style="list-style-type: none"> <li>• 6 digital inputs, DI 0 ... DI 5, isolated;</li> <li>• Low &lt; 5 V, high &gt; 11 V, maximum input voltage 30 V, current consumption 5.5 mA</li> <li>• Response time: 5.5 ms <math>\pm</math> 1 ms</li> </ul>
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 $\pm$ 2 ms
Digital outputs / relay outputs	<ul style="list-style-type: none"> <li>• DO 0: relay output, 30 V DC / max. 0.5 A with resistive load</li> <li>• DO 1: transistor output, 30 V DC / max. 0.5 A with resistive load, protection against incorrect voltage polarity</li> </ul> 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	<ul style="list-style-type: none"> <li>• PTC: Short-circuit monitoring 22 <math>\Omega</math>, switching threshold 1650 <math>\Omega</math></li> <li>• KTY84</li> <li>• ThermoClick sensor with dry contact</li> </ul>
Fail-safe Input	<ul style="list-style-type: none"> <li>• DI4 and DI5 are combined to form a single fail-safe input</li> <li>• Maximum input voltage 30 V, 5.5 mA</li> <li>• Response time:               <ul style="list-style-type: none"> <li>– Typical: 6 ms + debounce time (p9651)</li> <li>– Worst-case scenario: 10 ms + debounce time (p9651)</li> </ul> </li> </ul>
PFH	5 $\times$ 10E-8
USB-interface	Mini-B

## 11.2 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.

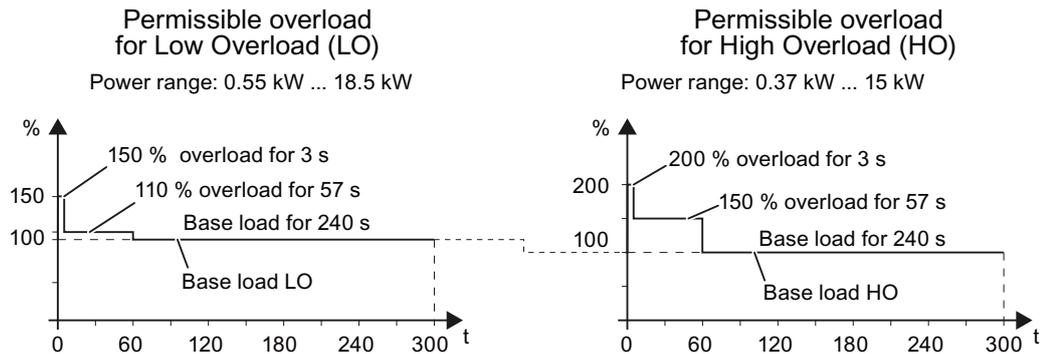


Figure 11-1 Duty cycles, "High Overload" and "Low Overload"

### 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 305).

### 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.

## 11.3 Common technical power data

Feature	Version	
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 $\lambda$	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	Without choke or output options at 4 kHz switching frequency
	Unshielded: 100 m	
Maximum motor cable length	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	
Operating temperature	0 °C ... +40 °C	At higher temperatures, the output power must be reduced
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

## 11.4 Electromagnetic Compatibility

### Electromagnetic compatibility

All manufacturers/assemblers of electrical apparatus which "performs a complete intrinsic function and is placed on the market as a single unit intended for the end user" must comply with the EMC directive.

There are three routes for the manufacturer/assembler to demonstrate compliance:

### Self-certification

This is a manufacturer's declaration that the European standards applicable to the electrical environment for which the apparatus is intended have been met. Only standards that have been officially published in the Official Journal of the European Community can be cited in the manufacturer's declaration.

### Technical construction file

A technical construction file can be prepared for the apparatus describing its EMC characteristics. This file must be approved by a 'Competent Body' appointed by the appropriate European government organization. This approach allows the use of standards that are still in preparation.

### EMC Standards

The SINAMICS G120 drives have been tested in accordance with the EMC Product Standard EN 61800-3:2004.

### EMC Emissions

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#### Note

Install all drives in accordance with the manufacturer's guidelines and in accordance with good EMC practices. See also: EMC-compliant connection (Page 36).

Use screened cable type CY. The maximal cable length is 25 m.

Do not exceed the default switching frequency 4 kHz.

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Table 11- 1 Conducted disturbance voltage and radiated emissions

EMC Phenomenon	Inverter type Remark	Level acc. to IEC 61800-3
Conducted emissions (disturbance voltage)	All inverters with integrated class A filters. Order number: 6SL3210-1KE**-*A*0	<b>Category C2</b> First Environment - Professional Use
Radiated emissions	Inverter frame sizes A and B with integrated class A filter. Order number: 6SL3210-1KE1*-*A*0 6SL3210-1KE21-*A*0  In a domestic environment this product may cause radio interference in which case supplementary mitigation measures may be required.	<b>Category C2</b> First Environment - Professional Use
	Inverter frame size C with integrated class A filter. Order number: 6SL3210-1KE22-*A*0 6SL3210-1KE23-*A*0  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.	<b>Category C3</b> Second Environment

## Harmonic Currents

Table 11- 2 Harmonic Currents

Typical Harmonic Current (% of rated input current) at U <sub>k</sub> 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 Immunity

The SINAMICS G120C drives have been tested in accordance with the immunity requirements of category C3 (industrial) environment:

Table 11- 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 $\mu$ s		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	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
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 ( $\pm$ 4 %)	A
Commutation Notches	EN 60146-1-1	Depth = 40 %	A
		Area = 250 % x degrees	

### Note

The immunity requirements apply equally to both filtered and unfiltered units.

## 11.5 Power-dependent technical data

### Note

The specified input currents apply for a 400 V line where  $V_k = 1\%$  referred to the inverter power. When using a line reactor, the currents are reduced by a few percent.

Table 11- 4 G120C Frame Sizes A, 3 AC 380 V ... 480 V,  $\pm 10\%$  - part 1  
6SL3210-...

Order No.	Filtered, IP20	... 1KE11-8U*0	... 1KE12-3U*0	... 1KE13-2U*0
	Unfiltered, IP20	... 1KE11-8A*0	... 1KE12-3A*0	... 1KE13-2A*0
<b>Rated / Low Overload values</b>				
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
<b>High Overload values</b>				
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 mm <sup>2</sup>	1.0 ... 2.5 mm <sup>2</sup>	1.0 ... 2.5 mm <sup>2</sup>
		18 ... 14 AWG	18 ... 14 AWG	18 ... 14 AWG
Tightening torque for line and motor cable		0.5 Nm	0.5 Nm	0.5 Nm
		4.4 lbf in	4.4 lbf in	4.4 lbf in
Weight, filtered		1.9 kg	1.9 kg	1.9 kg
Weight, unfiltered		1.7 kg	1.7 kg	1.7 kg

Technical data

11.5 Power-dependent technical data

Table 11- 5 G120C Frame Sizes A, 3 AC 380 V ... 480 V, ± 10 % - part 2  
6SL3210-...

Order No.	Filtered, IP20	... 1KE14-3U*0	... 1KE15-8U*0	... 1KE17-5U*0
	Unfiltered, IP20	... 1KE14-3A*0	... 1KE15-8A*0	... 1KE17-5A*0
<b>Rated / Low Overload values</b>				
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
<b>High Overload values</b>				
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 <sup>2</sup> 18 ... 14 AWG	1.5 ... 2.5 mm <sup>2</sup> 16 ... 14 AWG	1.5 ... 2.5 mm <sup>2</sup> 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, filtered		1.9 kg	1.9 kg	1.9 kg
Weight, unfiltered		1.7 kg	1.7 kg	1.7 kg

Table 11- 6 G120C Frame Sizes A, 3 AC 380 V ... 480 V, ± 10 % - part 3  
6SL3210-...

Order No.	Filtered, IP20	... 1KE18-8U*0
	Unfiltered, IP20	... 1KE18-8A*0
<b>Rated / Low Overload values</b>		
Rated / LO power		4.0 kW
Rated / LO input current		11.4 A
Rated / LO Output current		8.8 A
<b>High Overload values</b>		
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 <sup>2</sup> 16 ... 14 AWG
Tightening torque for line and motor cable		0.5 Nm 4.4 lbf in
Weight, filtered		1.9 kg
Weight, unfiltered		1.7 kg

Technical data

11.5 Power-dependent technical data

Table 11- 7 G120C Frame Sizes B, 3 AC 380 V ... 480 V, ± 10 % - part 4  
6SL3210-...

Order No.	Filtered, IP20 Unfiltered, IP20	... 1KE21-3U*0 ... 1KE21-3A*0	... 1KE21-7U*0 ... 1KE21-7A*0
<b>Rated / Low Overload values</b>			
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
<b>High Overload values</b>			
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 mm <sup>2</sup> 12 ... 10 AWG	4.0 ... 6.0 mm <sup>2</sup> 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, filtered		2.5 kg	2.5 kg
Weight, unfiltered		2.3 kg	2.3 kg

Table 11- 8 G120C Frame Sizes C, 3 AC 380 V ... 480 V, ± 10 % - part 5  
6SL3210-...

Order No.	Filtered, IP20 Unfiltered, IP20	... 1KE22-6U*0 ... 1KE22-6A*0	... 1KE23-2U*0 ... 1KE23-2A*0	... 1KE23-8U*0 ... 1KE23-8A*0
<b>Rated / Low Overload values</b>				
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
<b>High Overload values</b>				
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 mm <sup>2</sup> 10 ... 5 AWG	10 ... 16 mm <sup>2</sup> 7 ... 5 AWG	10 ... 16 mm <sup>2</sup> 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, filtered		4.7 kg	4.7 kg	4.7 kg
Weight, unfiltered		4.4 kg	4.4 kg	4.4 kg

## 11.6 Temperature, altitude and voltage derating

### Operating temperature derating

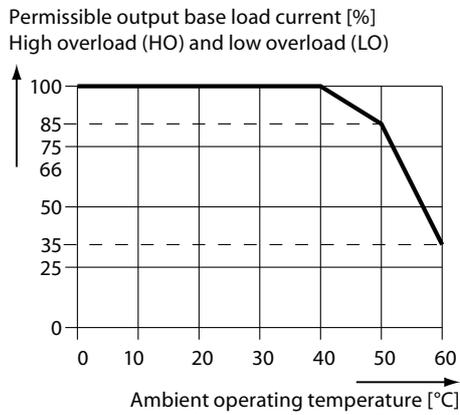


Figure 11-2 Temperature derating

### Operational altitude derating

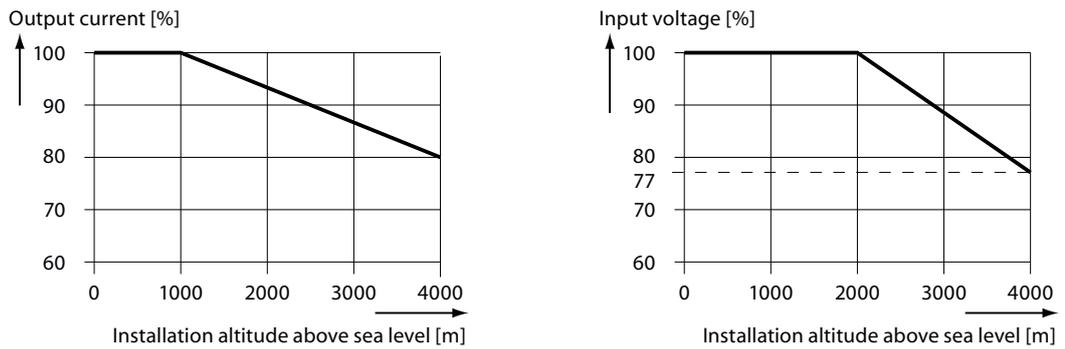


Figure 11-3 Current and voltage derating required according to altitude

### Operational voltage derating

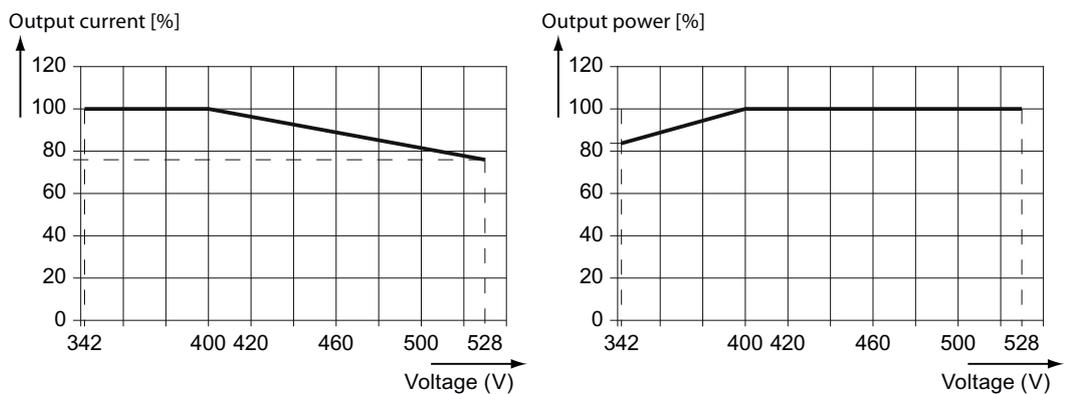


Figure 11-4 Current and Power derating required according to input voltage

## 11.7 Current reduction depending on pulse frequency

### Relationship between pulse frequency and output base-load current reduction

Table 11- 9 Current reduction depending on pulse frequency <sup>1</sup>

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

<sup>1</sup> The permissible motor cable length depends on the cable type and the chosen pulse frequency.

## 11.8 Accessories

### 11.8.1 Line reactor

The major electrical specification of the line reactors is the same as for the suitable inverter. This applies to:

- line voltage
- line frequency
- rated current

The admissible ambient conditions of the line reactors are the same as for the suitable inverter. This applies to:

- storage and transport temperature
- operating temperature
- relative humidity
- shock and vibration load

Table 11- 10 Technical specifications of the line reactors

Feature	Suitable for inverter with rated power of		
	0.55 kW ... 1.1 kW	1.5 kW ... 4.0 kW	5.5 kW ... 7.5 kW
	FSA		FSB
MLFB	6SL3203-0CE13-2AA0	6SL3203-0CE21-0AA0	6SL3203-0CE21-8AA0
MLFB of the suitable inverter	6SL3210-1KE11-8 □ □ 0 6SL3210-1KE12-3 □ □ 0 6SL3210-1KE13-2 □ □ 0	6SL3210-1KE14-3 □ □ 0 6SL3210-1KE15-8 □ □ 0 6SL3210-1KE17-5 □ □ 0 6SL3210-1KE18-8 □ □ 0	6SL3210-1KE21-3 □ □ 0 6SL3210-1KE21-7 □ □ 0
Inductance	2.5 mH	1 mH	0.5 mH
Power loss at 50/60 Hz	25 W	40 W	55 W
Cable cross section	2.5 mm <sup>2</sup> / 14 AWG	2.5 mm <sup>2</sup> / 14 AWG	6.0 mm <sup>2</sup> / 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	125 mm	125 mm	125 mm
Height	120 mm	140 mm	145 mm
Depth	71 mm	71 mm	90 mm
Fixing dimensions			
Width	100 mm	100 mm	100 mm
Height	55 mm	55 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 11- 11 Technical specifications of the line reactors

Feature	Suitable for inverter with rated power of	
	11.0 kW ... 18.5 kW	
	FSC	
MLFB	6SL3203-0CE23-8AA0	
MLFB of the suitable inverter	6SL3210-1KE22-6 □ □ 0 6SL3210-1KE23-2 □ □ 0 6SL3210-1KE23-8 □ □ 0	
Inductance	0.3 mH	
Power loss at 50/60 Hz	90 W	
Cross section	16 mm <sup>2</sup> / 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	180 mm	
Height	220 mm	
Depth	118.5 mm	
Fixing dimensions		
Width	136 mm	
Height	99.5 mm	
Fixing screw	4 × M6 (10 Nm)	
Weight	7.8 kg	

### 11.8.2 Braking resistor

The admissible ambient conditions of the braking resistors are the same as for the suitable inverter. This applies to:

- storage and transport temperature
- operating temperature
- relative humidity
- shock and vibration load

Table 11- 12 Technical specifications of the braking resistors

Feature	Suitable for inverter with rated power of		
	0.55 kW ... 1.5 kW	2.2 kW ... 4.0 kW	5.5 kW ... 7.5 kW
	FSA		FSB
MLFB	6SL3203-0CE13-2AA0	6SL3203-0CE21-0AA0	6SL3203-0CE21-8AA0
MLFB of the suitable inverter	6SL3210-1KE11-8 □ □ 0 6SL3210-1KE12-3 □ □ 0 6SL3210-1KE13-2 □ □ 0 6SL3210-1KE14-3 □ □ 0	6SL3210-1KE15-8 □ □ 0 6SL3210-1KE17-5 □ □ 0 6SL3210-1KE18-8 □ □ 0	6SL3210-1KE21-3 □ □ 0 6SL3210-1KE21-7 □ □ 0
Pulse power 5 % (cycle time 240 s)	1.5 kW	4 kW	7.5 kW
Permanent power	75 W	200 W	375 W
Resistance	370 Ω	140 Ω	75 Ω
Cable cross section resistor	2.5 mm <sup>2</sup> / 14 AWG	2.5 mm <sup>2</sup> / 14 AWG	2.5 mm <sup>2</sup> / 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
Cable cross section temperature contact	2.5 mm <sup>2</sup> / 14 AWG	2.5 mm <sup>2</sup> / 14 AWG	2.5 mm <sup>2</sup> / 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	105 mm	105 mm	175 mm
Height	295 mm	345 mm	345 mm
Depth	100 mm	100 mm	100 mm
Fixing dimensions			
Width	72 mm	72 mm	142 mm
Height	266 mm	316 mm	316 mm
Fixing screw	4 × M4 (3 Nm)	4 × M4 (3 Nm)	4 × M4 (3 Nm)
Weight	1.5 kg	1.8 kg	2.7 kg

Table 11- 13 Technical specifications of the line reactors

Feature	Suitable for inverter with rated power of	
	11.0 kW ... 18.5 kW	
	FSC	
MLFB	6SL3203-0CE23-8AA0	
MLFB of the suitable inverter	6SL3210-1KE22-6 □ □ 0 6SL3210-1KE23-2 □ □ 0 6SL3210-1KE23-8 □ □ 0	
Pulse power 5 % (cycle time 240 s)	18.5 kW	
Permanent power	925 W	
Resistance	30 Ω	
Cable cross section resistor	6 mm <sup>2</sup> / 10 AWG	
Tightening torque	0.6 Nm / 5.5 lbf in	
Cable cross section temperature contact	2.5 mm <sup>2</sup> / 14 AWG	
Tightening torque	0.5 Nm / 4.5 lbf in	
Degree of protection	IP20	
Overall dimensions		
Width	250 mm	
Height	490 mm	
Depth	140 mm	
Fixing dimensions		
Width	217 mm	
Height	460 mm	
Fixing screw	4 × M5 (6 Nm)	
Weight	6.2 kg	

## 11.9 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 compliance with the following standards:

EN 61800-5-1 — Semiconductor inverters –General requirements and line commutated inverters

EN 60204-1 — Safety of machinery –Electrical equipment of machines

### European Machinery Directive

The SINAMICS G120C inverter 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



### 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 Inverters 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.1 Application examples

#### A.1.1 Configuring the communication with STEP 7

##### A.1.1.1 Task

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 how to basically use an S7 control and the STEP 7 engineering tool and is not part of this description.

##### A.1.1.2 Required components

The examples given in this manual for configuring communication between the control and inverter are based on the hardware listed below:

Table A- 1 Hardware components (example)

Component	Type	Order no.	Qty
Central controller			
Power supply	PS307 2 A	6ES7307-1BA00-0AA0	1
S7 CPU	CPU 315-2DP	6ES7315-2AG10-0AB0	1
Memory card	MMC 2MB	6ES7953-8LL11-0AA0	1
DIN rail	DIN rail	6ES7390-1AE80-0AA0	1
PROFIBUS connector	PROFIBUS connector	6ES7972-0BB50-0XA0	1
PROFIBUS cable	PROFIBUS cable	6XV1830-3BH10	1
Drive			
SINAMICS G120C DP	Order number depends on power rating: 6SL3210-1KE**-**P0		1
PROFIBUS connector	PROFIBUS connector	6GK1500-0FC00	1

In order to configure communication you also require the following software packages:

Table A-2 Software components

Component	Type (or higher)	Order no.	Qty
SIMATIC STEP 7	V5.3 + SP3	6ES7810-4CC07-0YA5	1
STARTER	V4.2	6SL3072-0AA00-0AG0	1

Drive ES Basic is the basic software of the engineering system, which combines the drive technology and Siemens controllers. The STEP 7 Manager user interface acts as a basis with which Drive ES Basic is used to integrate drives in the automation environment with respect to communication, configuration, and data storage.

### A.1.1.3 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 and assign a project name, e.g. "G120\_in\_S7". Add an S7 300 CPU.

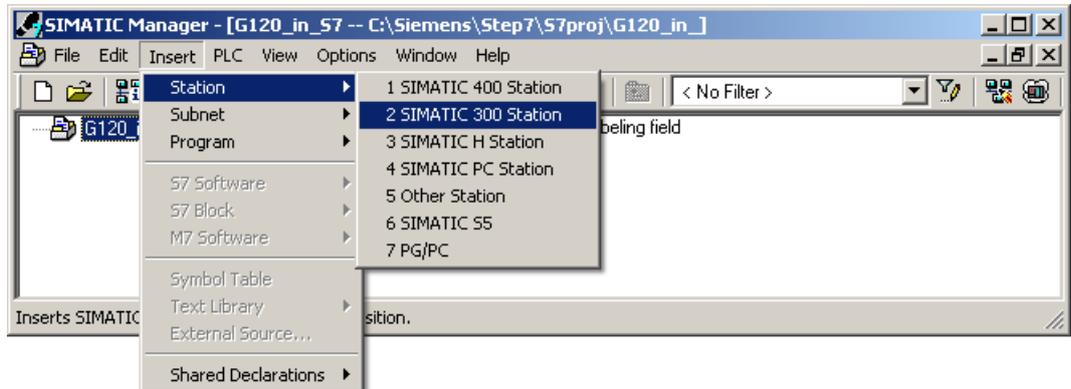


Figure A-1 Inserting a SIMATIC 300 station into a STEP 7 project

- 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.

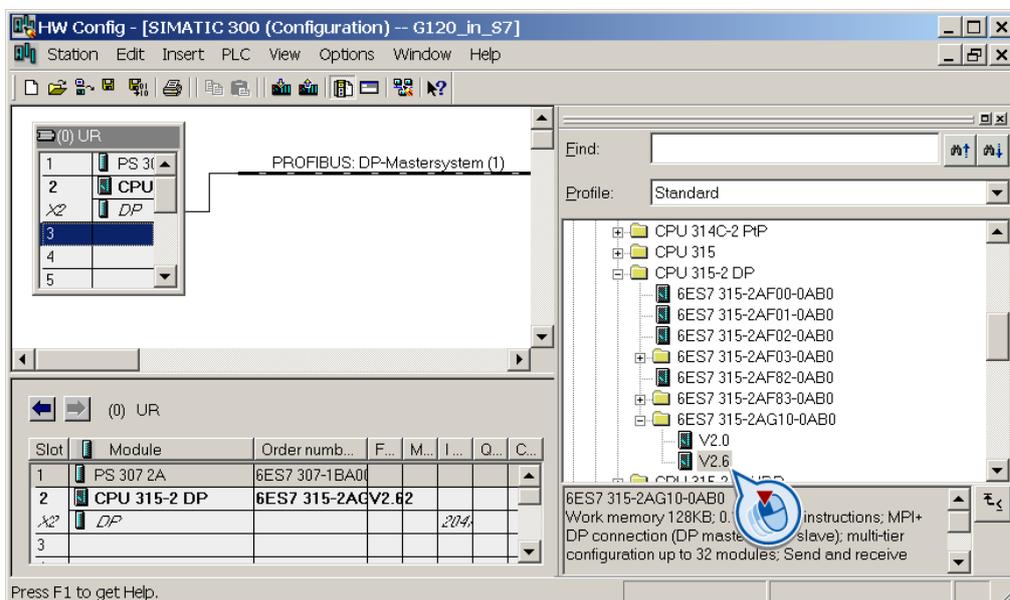


Figure A-2 Inserting a SIMATIC 300 station with PROFIBUS DP network

#### A.1.1.4 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 22)).

The following section describes how to configure the inverter using the GSD.

### A.1.1.5 Inserting the inverter into the STEP 7 project

- Install the GSD of the inverter in STEP 7 via HW Config (Menu "Options - Install GSD files").

Once the GSD has been installed, the inverter appears under "PROFIBUS DP - Additional field devices" in the hardware catalog of HW Config.

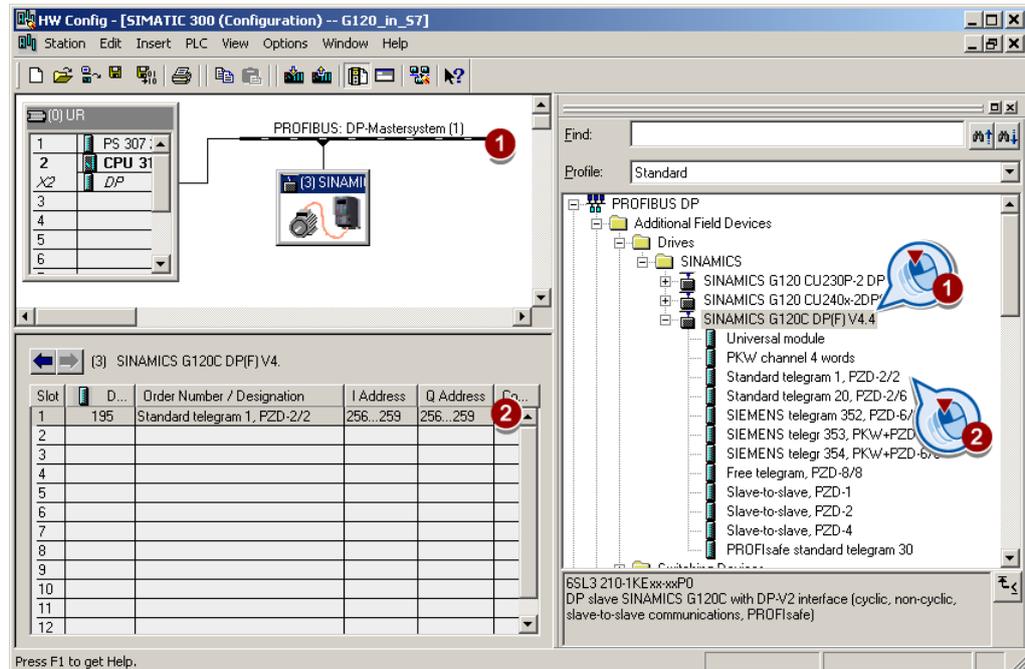


Figure A-3 Inserting a drive object

- Drag and drop the inverter into the PROFIBUS network. Enter the PROFIBUS address set at the inverter in HW Config.
- Insert the required telegram type from the HW Catalog to slot 1 of the inverter by 'dragging and dropping'.  
More information on the telegram types can be found in Chapter Cyclic communication (Page 94).

### Sequence when assigning the slots

1. PROFIsafe module (if one is used)  
Information on connecting the inverter 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.1.2 STEP 7 programming examples

### A.1.2.1 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 91)).

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, see Inserting the inverter into the STEP 7 project (Page 294).

Table A-3 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.1.2.2 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 in the <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-4 Reading parameters

## Explanation of FC 1

Table A- 4 Request to read parameters

Data block DB 1	Byte n	Bytes n + 1	n
Header	Reference <i>MB 40</i>	01 hex: Read request	0
	01 hex	Number of parameters (m) <i>MB 62</i>	2
Address, parameter 1	Attribute <i>10 hex: Parameter value</i>	Number of indices <i>MB 58</i>	4
	Parameter number <i>MW 50</i>		6
	Number of the 1st index <i>MW 63</i>		8
Address, parameter 2	Attribute <i>10 hex: Parameter value</i>	Number of indices <i>MB 59</i>	10
	Parameter number <i>MW 52</i>		12
	Number of the 1st index <i>MW 65</i>		14
Address, parameter 3	Attribute <i>10 hex: Parameter value</i>	Number of indices <i>MB 60</i>	16
	Parameter number <i>MW 54</i>		18
	Number of the 1st index <i>MW 67</i>		20
Address, parameter 4	Attribute <i>10 hex: Parameter value</i>	Number of indices <i>MB 61</i>	22
	Parameter number <i>MW 56</i>		24
	Number of the 1st index <i>MW 69</i>		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.

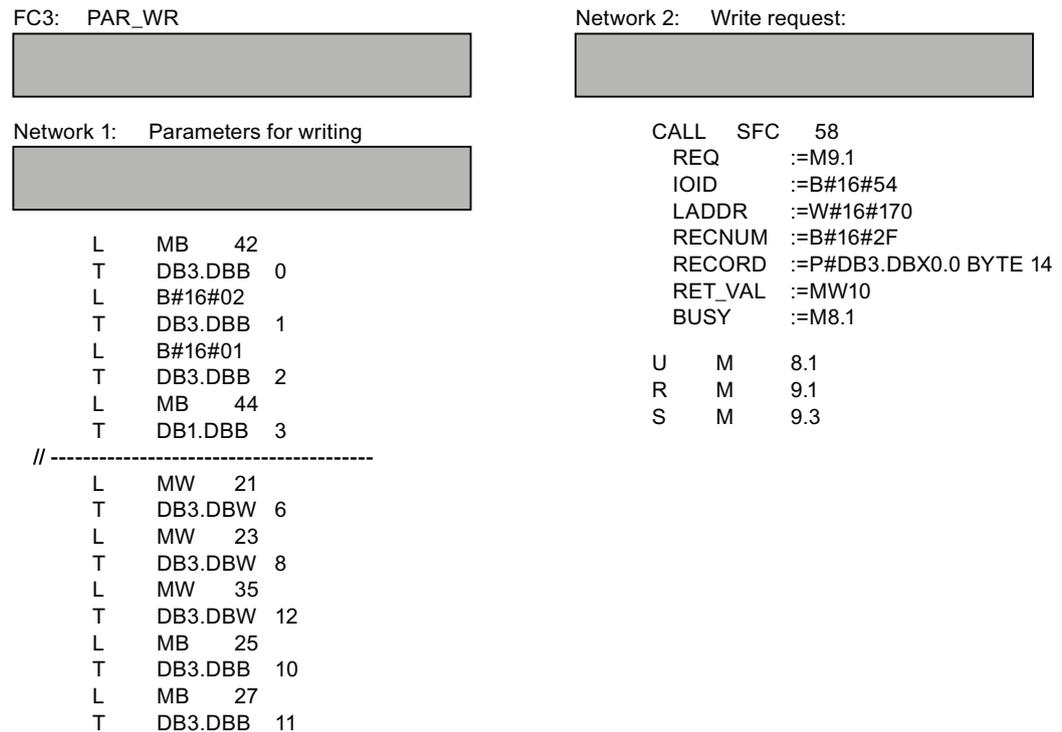


Figure A-5 Writing parameters

### Explanation of FC 3

Table A-5 Request to change parameters

Data block DB 3	Byte n	Bytes n + 1	n
Header	Reference <i>MB 42</i>	02 hex: Change request	0
		01 hex	Number of parameters <i>MB 44</i>
Address, parameter 1	10 hex: Parameter value	Number of indices <i>00 hex</i>	4
	Parameter number <i>MW 21</i>		6
	Number of the 1st index <i>MW 23</i>		8
Values, parameter 1	Format <i>MB 25</i>	Number of index values <i>MB 27</i>	10
	Value of 1st index <i>MW35</i>		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.1.3 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).

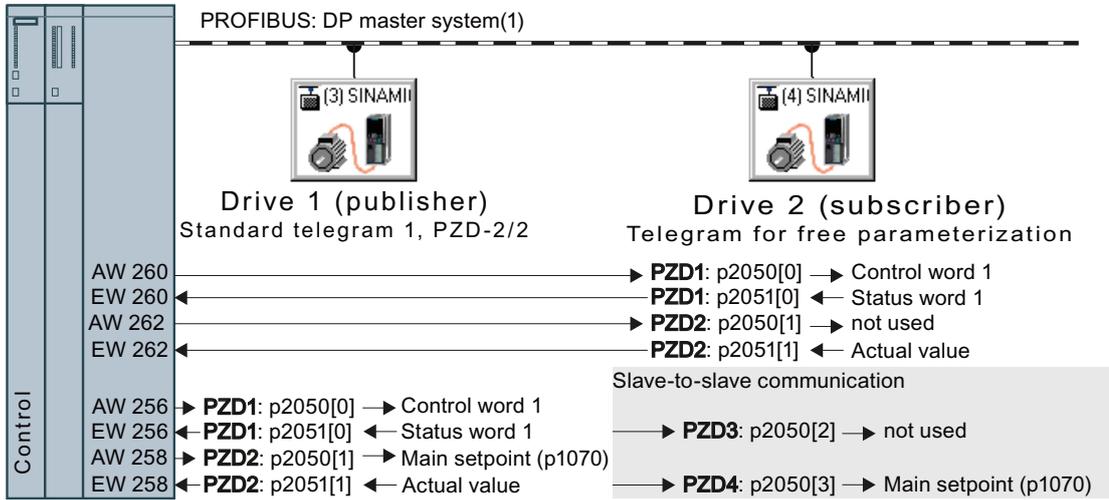
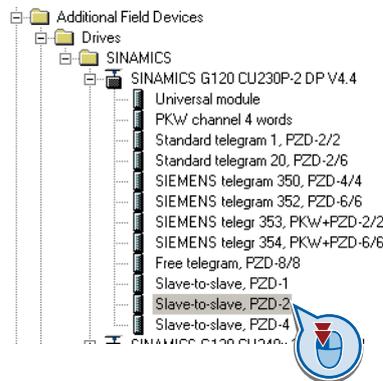


Figure A-6 Communication with the higher-level control and between the drives with slave-to-slave communication

#### Settings in the control

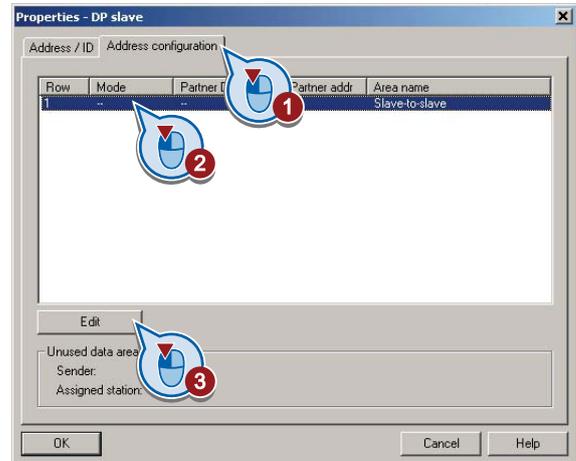
In HW Config in drive 2 (Subscriber), insert a slave-to-slave communication object, e.g. "Slave-to-slave, PZD2".



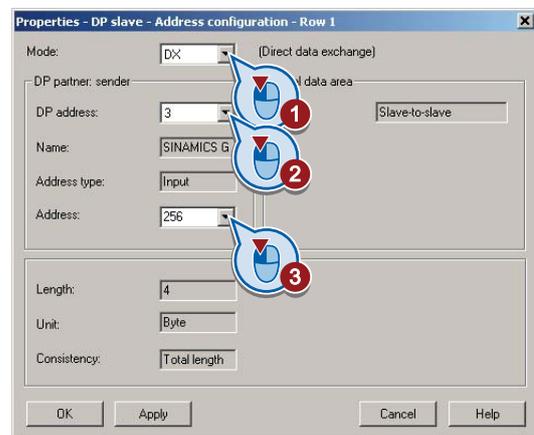
With a double-click, open the dialog box to make additional settings for the slave-to-slave communication.

Slot	D.	Order Number / Designation	I Address	Q Address	Co...
1	195	Standard telegram 1, FZD-2/2	260...263	260...263	
2	129	Slave-to-slave, FZD-2			
3					
4					
5					
6					

- 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.2 Further information on your inverter

### A.2.1 Manuals for your inverter

Table A- 6 Manuals for your inverter

Depth of the information	Manual	Contents	Available languages	Download or order number
+	<b>Getting Started</b> SINAMICS G120C	Installing and commissioning the inverter.	English, German,	Download manuals <a href="http://support.automation.siemens.com/WW/view/en/22339653/133300">http://support.automation.siemens.com/WW/view/en/22339653/133300</a>  Order numbers: <b>SD Manual Collection (DVD)</b> <ul style="list-style-type: none"> <li>6SL3298-0CA00-0MG0 supplied once.</li> <li>6SL3298-0CA10-0MG0 update service for 1 year; supplied 4 times per year.</li> </ul>
++	<b>Operating instructions</b>	(this manual)	Italian, French, Spanish	
+++	<b>Function Manual for Safety Integrated</b>	Configuring PROFI-safe. Installing, commissioning and operating fail-safe functions of the inverter.	English, German	
+++	<b>List Manual</b> SINAMICS G120C	Complete list of all parameters, alarms and faults. Graphic function diagrams.		
+++	<b>Operation and installation instructions</b>	For inverter accessories, e.g. operator panel or reactors.		

## A.2.2 Configuring support

Table A- 7 Support when configuring and selecting the converter

Manual or tool	Contents	Languages	Download or order number
Catalog D 11.1	Ordering data and technical information for the standard SINAMICS G converters	English, German, Italian, French, Spanish	All about SINAMICS G120C ( <a href="http://www.siemens.com/sinamics-g120c">www.siemens.com/sinamics-g120c</a> )
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 ( <a href="http://support.automation.siemens.com/W/view/en/10804987/130000">http://support.automation.siemens.com/W/view/en/10804987/130000</a> )
Configuration Manual	Selecting geared motors, motors and converters using calculation examples	English, German	You can obtain the Configuration Manual from your local sales office.

### A.2.3 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, we offer our complete knowledge base on the Internet at: Here, you will 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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Siemens AG  
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GERMANY

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