SINAMICS G120

Control Units CU240E, CU240S, CU240S DP, CU240S DP-F, CU240S PN, CU240S PN-F

Operating Instructions · 11/2008 - Review Version

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SINAMICS G120

Control Units
Frequency inverter

Operating Instructions

Edition 12/2008, FW 3.2 - Review version

08.10. 2008
t.b.d.

Legal information

Warning notice system

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

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

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

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

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

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

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

Qualified Personnel

The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

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

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Ordernumber: t.b.d.
℗ 01/2009

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Introduction 1

1.1 About this manual

Who requires the Operating Instructions and why?

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 assemble, connect-up, parameterize, and commission the frequency inverters safely and in the correct manner.

What is described in the Compact Manual?

The Operating Instructions provide a summary of all of the information required to operate the frequency 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.

1.2 Adapting the frequency inverter to the particular application (parameter assignment for entry-level personnel)

1.2.1 General basics

Parameterizable frequency inverters transform standard motors into variable-speed drives

Frequency inverters are parameterized to adapt them to the motor being driven so that this can be optimally operated and protected. This is realized using one of the following operator units:

- Keyboard and display unit (Operator Panel) that is snapped onto the frequency inverter.
- Software (STARTER commissioning tool) that allows the frequency inverter to be parameterized and controlled from a PC.

Frequency inverters are especially used to improve and expand the starting and speed response of motors.

Many standard applications can function with the default parameters

Although frequency inverters can be parameterized for very specific applications, many standard applications can be configured by means of just a few parameters.

Use the factory settings (where possible)

For basic applications, commissioning can be carried out using just the factory settings (see Section "Commissioning with factory settings").

Use quick commissioning (for simple, standard applications)

In the majority of standard applications, commissioning can be carried out by entering or changing just a few parameters during quick commissioning (see "Section "Commissioning with Operator Panel").

1.2.2 Parameter

Parameter types

There are two types of parameters, adjustable and display parameters.

Adjustable parameters

Adjustable parameters are represented with four digits preceded by the letter "P". You can change the value of these parameters within a defined range.

Example:
P0305 is the parameter for the rated motor current in Amps. This parameter is set during commissioning. You can enter values between 0.01 and 10000.

Display parameters

Display parameters are represented with four digits preceded by the letter "r". You cannot change the value of these parameters.

Example:
r0027 is the parameter for the frequency inverter output current. The inverter measures the current and writes the current value to the parameter. You can display the parameter value, e.g. using an analog output of the frequency inverter.

Change protection for write parameters

The process of changing parameter values is subject to certain conditions. If an attempt to change a parameter is rejected by the inverter, this can have a number of causes:

1. The inverter operating state does not allow you to change parameters.
   For example, certain parameters can only be changed when the inverter is in commissioning mode.
2. In some cases, you may not be able to change certain parameters due to follow-on parameterization.
   When P0701 = 1, for example, the ON/OFF1 command is connected to digital input 0. P0840 (source of the ON/OFF1 command) is then assigned 722.0 (status of digital input 0) due to follow-on parameterization, which means that P0840 can no longer be changed.
3. Parameter protection via P0927 has been activated.
   For example, you can no longer change parameters via the BOP because this has been blocked (P0927 = 1101).

For each parameter, the List Manual specifies whether and which conditions apply for changing the values.

1.2.3 Parameters with follow-on parameterization

Parameters with follow-on parameterization

When you change certain parameters, the system may automatically change other parameters accordingly. This makes it much easier to parameterize complex functions.

Example: Parameter P0700 (command source)

Parameter P0700 can be used to switch the command source from the fieldbus to digital inputs. When the value of P0700 is changed from 6 (command source "fieldbus") to 2 (command source "digital inputs"), other parameter values are changed automatically:

- New functions are assigned to the digital inputs (P0701 ... P0713)
- New functions are assigned to the digital outputs (P0731 ... P0733)
- Inverter control is interconnected with the signals from the digital inputs (P0800, P0801, P0840, etc.)

For more information about follow-on parameterization for P0700, see the List Manual.

1.3 Frequently required parameters

All-round and emergency parameters

Table 1- 1 This is how you filter the parameter list to keep the number of displayed parameters transparent

Parameter	Description
P0003 =	User access level 1: Standard level: Allows access to the most frequently used parameters (factory setting) 2: Advanced level: Extended access, e.g. to frequency inverter I/O functions 3: Expert level: To be used by experts
P0004 =	Parameter filter 0: All the parameters are displayed (factory setting). 2: Only the user access level, parameter filter, operating state switchover, and firmware version are displayed. 3: Only the parameters for the output filter and motor data are displayed. 4: Only the parameters for the optional speed encoder are displayed.

Table 1- 2 How to switch to commissioning mode or restore the factory settings

Parameter	Description
P0010 =	Switching operating state 0: Ready for operation (factory setting). 1: Perform quick commissioning 30: Change over to factory settings

Table 1- 3 How to determine the firmware version of the Control Unit

Parameter	Description
r0018	The firmware version is displayed:

Table 1- 4 This is how you reset the parameters to the factory setting

Parameter	Description
P0010 = 30	30: Change over to factory settings
P0970 = 1	1: Restoring all of the parameters to the factory setting (Exception: Password-protected parameters of the safety functions are not reset!)

Table 1- 5 This is how you select the source for the control signals (ON/OFF, reversing) of the frequency inverter

Parameter	Description
P0700 =	0: Factory default setting 1: Operator Panel 2: Digital inputs (P0701 … P0709); factory setting non-fieldbus-capable frequency inverters 4: USS on RS 232 5: USS on RS 485 (not available for CU240S DP or CU240S DP-F) 6: Fieldbus (P2050 … P02091); (factory setting for fieldbus-capable frequency inverters)

Table 1- 6 This is how you select the source for the speed setpoint

Parameter	Description
P1000 =	0: No main setpoint 1: MOP setpoint 2: Analog setpoint (factory setting for non-fieldbus-capable frequency inverters) 3: Fixed frequency 4: USS on RS 232 5: USS on RS 485 6: Fieldbus (factory setting for fieldbus-capable frequency inverters) 7: Analog setpoint 2

1.4 Extended adaptation options using BICO parameters (parameterization for advanced level personnel)

1.4.1 BICO technology: basic principles

Functional principle of BICO technology and frequency inverter closed/open-loop control functions

The inverter software offers a range of open/closed-loop control functions, communication functions, as well as various diagnostics and operating functions. These functions are interconnected via internal signal paths and represent the default control structure.

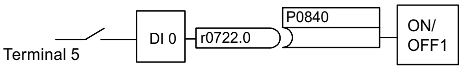


Figure 1-1 Example: Pre-assigned signal interlocking for digital input 0 of a non-bus-capable Control Unit

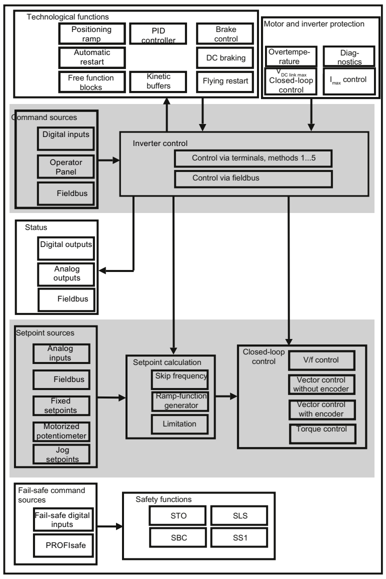


Figure 1-2 Overview of inverter functions

The functions can be parameterized and interconnected as required. The functions are interconnected using special software, however, rather than on the basis of electrical circuit logic by means of cables. The various functions use a range of inputs, outputs, and parameters.

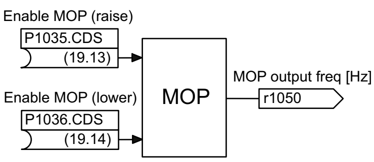


Figure 1-3 Example: MOP function (motorized potentiometer)

Binectors and connectors

Connectors and binectors are elements used to exchange signals between the individual functions. Connectors and binectors can be seen as "storage compartments":

- Connectors are used to store "analog" signals (e.g. speed setpoint)
- Binectors are used to store "digital" signals (e.g. 'MOP raise' command)

Definition of BICO technology

BICO technology describes the type of parameterization that can be used to disconnect all the internal signal interconnections between the functions or establish new connections. This is realized using **Bi**nectors and **Co**nnectors. hence the name **BICO** technology.

BICO parameters

You can use the BICO parameters to define the sources of the input signals of a function. This means that using BICO parameters you can define from which connectors and binectors a function reads-in its input signals. thereby enabling you to "interconnect" the functions stored in the devices in accordance with your requirements. Four different BICO parameter types are available:

- Binector inputs: BI
- Connector inputs: CI
- Binector outputs: BO
- Connector outputs: CO
- Binector/connector outputs: CO/BO

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 feature reduces the number of parameters and makes it easier to set parameters by means of the serial interface (data transfer).

BICO parameters of type CO, BO, or CO/BO can be used more than once.

BICO symbols, representation, and description

Table 1- 7 Binector symbols

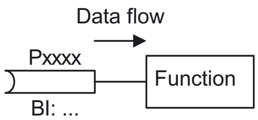
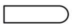
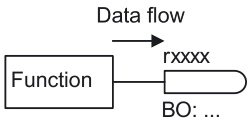
Abbreviation and symbol	Description	Function
BI 	Binector input	
BO 	Binector output	

Table 1- 8 Connector symbols

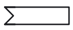
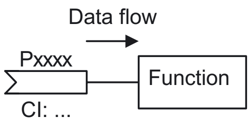
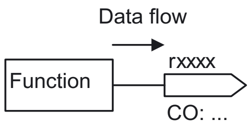
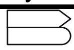
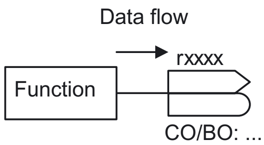
Abbreviation and symbol	Description	Function
CI 	Connector input	
CO 	Connector output	

Table 1- 9 Connector and binector output symbols

Abbreviation and symbol	Description	Function
CO/BO 	Binector/connector output	

When do you need to use BICO technology?

BICO technology allows you to adapt the drive in line with 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 setpoint to the analog input.

What precautions should you take when using BICO technology?

Always take care when establishing 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 software contains 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 interconnections (e.g. assigning a different function to digital inputs).
- The parameter list in the List Manual is sufficient for more complex interconnections.
- You can also refer to the function diagrams in the List Manual for complex interconnections.

1.4.2 BICO technology: example

Example: Shifting a basic PLC functionality into the frequency inverter

A conveyor system is to be configured in such a way that it can only start when two signals are present simultaneously. These could be the following signals, for example:

- The oil pump is running (the required pressure level is not reached, however, until after five seconds)
- The protective door is closed

The task is realized by inserting free blocks between the digital input 0 and the internal ON command for the motor and interconnecting them.

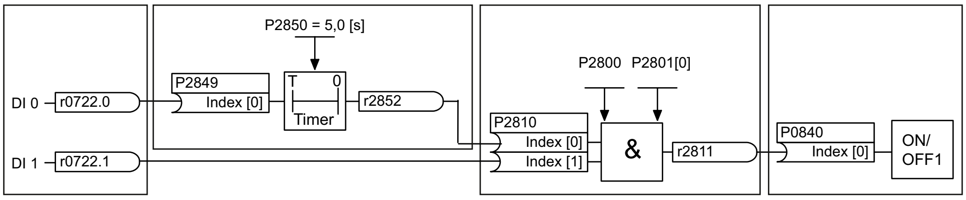


Figure 1-4 Example: Signal interconnection for interlock

Parameter	Description
P0003 = 3	Enable expert access to parameters
P0700 = 2	Select the command source
P0701 (e.g.) = 99	Enable/"open" digital input 0 (DI0) for BICO parameterization
P0702 (e.g.) = 99	Enable/"open" digital input 1 (DI1) for BICO parameterization
P2800 = 1	Group enable all freely-programmable function blocks (FFB)
P2801 [In000] = 1	Individual enable of the AND function block
P2802 [In000] = 1	Individual enable of the TIMER function block
P2850 = 5.0	Set the TIMER delay time: 5 seconds
P2849 = r0722.0	Connect the status of DI0 to the TIMER input r0722.0 = Parameter that displays the status of digital input 0.
P2810 [In000] = r2852	Connect the TIMER output to the 1st input of the AND
P2810 [In001] = r0722.1	Connect the status of DI1 to the 2nd AND input r0722.1 = Parameter that displays the status of digital input 1.
P0840 = r2811	Connect the AND output to the control command ON/OFF1

Explanations of the example

Open the default signal interconnection for BICO parameterization

The default setting P0701 = 1 indicates the following internal signal interconnection:

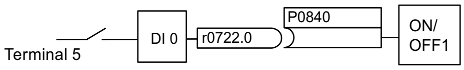


Figure 1-5 Default parameterization

The setting P0701 = 99 means that a pre-assigned signal interconnection is disconnected and therefore the connection opened for BICO parameterization.

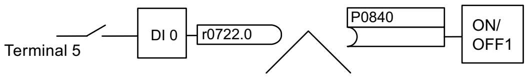


Figure 1-6 BICO parameterization

When P0701 = 99, the binector input of the ON/OFF1 function (P0840) is available for activation by a signal source other than r0722.0 (in this case r2852).

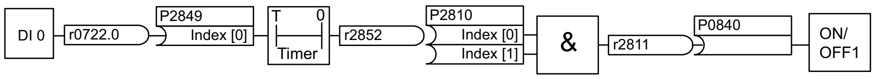


Figure 1-7 Interconnection after insertion of two functions

Principle of connecting functions by means of BICO technology

A connection between two functions comprises a connector/binector and a BICO parameter. Connections are always established with respect to the input of a particular function, which means that the output of an upstream function must always be assigned to the input of a downstream function. 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.

With this functional logic in mind, **where does the signal come from?**

2 Description

Overview of the SINAMICS G120 family of frequency inverters

Thanks to their modular design, SINAMICS G120 frequency converters can be used in a wide range of applications with respect to functionality and power.

Each SINAMICS G120 frequency inverter comprises a Control Unit and a Power Module. The output range extends from 0.37 kW to 132 kW.

The Basic Operator Panel (BOP) and STARTER software are available for commissioning purposes.

A range of additional, application-specific components are also available (e.g. filters, reactors, braking resistors).

2.1 Modularity of the converter system

Main components of the frequency inverter

Each SINAMICS G120 frequency inverter comprises a Control Unit and Power Module. In the SINAMICS G120 range, the Control Units can be combined with any Power Module.

- The Control Unit controls and monitors the Power Module and the connected motor in various different control modes (which can be selected as required). It supports communication with a local or central controller as well as with monitoring devices.
- The Power Modules are available for motors with an output range of between 0.37 kW and 132 kW. IGBT technology and pulse-width modulation are used to ensure reliable and flexible motor operation.

Power Module | Control Unit

Supplementary components

In addition to the main components, the following components are available for commissioning and parameterization:

	Basic Operator Panel (BOP) for parameterization, diagnostics, and control as well as for copying drive parameters.
	Memory card MMC for carrying out standard commissioning of more than one frequency inverter and for external data backup purposes.
	PC-frequency inverter connection kit and STARTER software for guided, PC-based commissioning.
	Filters and reactors • Line filters (classes A and B) • Line reactors • Braking resistors • Output reactors
	Further options • Brake Relay • Safe Brake Relay • Adapter for DIN rail mounting • Shield connection kit

2.2 Overview of Control Units

					Control Units with safety-relevant functions	
			Control Units with fieldbus interface			
	CU240E	CU240S	CU240S DP	CU240S PN	CU240S DP-F	CU240S PN-F
	Cost-effective variants Functionally identical with the CU240S however, no encoder connection, fewer I/Os	Control Unit CU240S for operation via terminals and USS via RS485	Control Unit CU240S additionally with PROFIBUS DP interface	Control Unit CU240S additionally with PROFINET interface	Control Unit CU240S additionally with PROFIBUS DP interface and safety-relevant functions via terminals or PROFIsafe	Control Unit CU240S additionally with PROFINET interface and safety-relevant functions via terminals or PROFIsafe

Figure 2-1 Control Unit variants

2.3 Overview of Power Modules

Figure 2-2 Power Module variants

A number of Power Module variants are available for different supply voltages in an output range of between 0.37 kW and 132 kW. Depending on the Power Module used, the energy released in regenerative mode is either

- fed back to the supply system (Efficient Infeed Technology) or
- stored in the DC link and/or fed to an external braking resistor.

Overview of the available Power Modules

Depending on the output, Power Modules are available with different frame sizes The frame sizes extend from FSA to FSG.

		FSA	FSB	FSC	FSD	FSE	FSF	FSG
PM240 3-ph. 400V AC		0.37 kW … 1.5 kW	2.2 kW … 4kW	7.5 kW … 15 kW	18.5 kW … 30 kW	37 kW … 45 kW	55 kW … 132 kW	160 kW … 250 kW
	With integr. Line filter, class A	○	●	●	●	●	◑ 1)	◑ 2)
	With integr. Braking chopper	●	●	●	●	●	●	◑ 2)
PM250 3-ph. 400V AC		-	-	7.5 kW … 15 kW	18.5 kW- 3 0 kW	37 kW … 45 kW	55 kW … 90 kW	-
	With integr. Line filter, class A			●	●	●	●	
	Capable of energy recovery			●	●	●	●	
PM260 3-ph. 690V AC		-	-	-	11 kW … 18.5 kW	-	30 kW … 55 kW	-
	With/without integr. Line filter, class A				●		●	
	With integr. Sine-wave filter				●		●	
	Capable of energy recovery				●		●	

1) PM240 Power Modules, 110 kW and higher, are only available without an integrated class A filter. Instead, an optional class A line filter for side mounting is available.

2) PM240 FSG Power Module is only available without integrated components. Instead, optional line reactor, line filter, motor reactor, sine-wave filter, braking chopper, braking resistor and Brake Relay are available.

2.4 Reactors and filters

Overview

Depending on the Power Module, the following combinations with filters and reactors are permitted:

	Line-side components				Load-side components	
	Line reactor	Line filters class B	Braking resistor	Power Module	Output filter	Motor reactor
PM240	●	●	●	PM240	●	●
PM250	-	●	-	PM250	●	●
PM260	-	●	-	PM260	-	-

Connection 3

3.1 Procedure for installing the frequency inverter

Prerequisites for installing the frequency inverter

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

- Are the ambient conditions permissible?
- Are the components required for installation available?
- Are all the necessary tools and spare parts available?
- Have the cables and wires been routed in accordance with the applicable regulations? (Are the cables from the power and control terminals physically separated?)
- Are the minimum distances from other equipment complied with? (Is the volume of cooling air sufficient?)

Installation sequence

1. Install the Power Module (for detailed instructions, see the Hardware Installation Manual for the Power Module)
   – Remove terminal covers - where applicable
   – Connect motor cable and power cable
   – Terminate the shield over a large area, if necessary using a shield connection set
   – Refit the terminal covers
2. Mount the Control Unit
   – Open the terminal covers of the Control Unit
   – Connect the control lines to the terminals
   – Terminate the shield over a large area, if necessary using a shield connection set
   – Close the terminal covers again
3. Control Unit – for operation in a higher-level control – connect to the fieldbus
   – For PROFIBUS DP and CANopen connect it via the 9-pin sub D connector
   – For RS 485, connect it via the two-part bus connector
4. To commission the drive unit, either plug-in the operator control/display instrument (Operator Panel) or connect the frequency inverter to the PC using the PC-frequency inverter connection kit.

Installation has now been completed and you can begin commissioning.

3.2 Mounting reactors and filters

Mounting system components in a space-saving fashion for the frequency inverters

Many system components for the frequency inverters are designed as sub-chassis components, that is, the component is mounted on the baseplate and the frequency inverter mounted above it to save space. Up to two base components can be mounted above one another.

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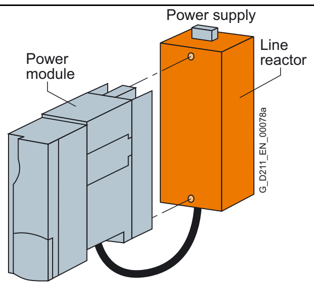
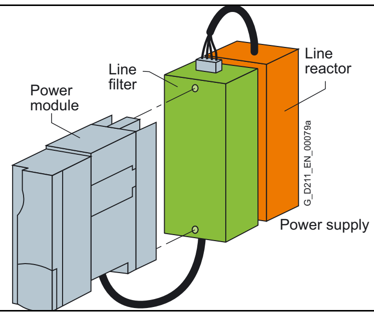
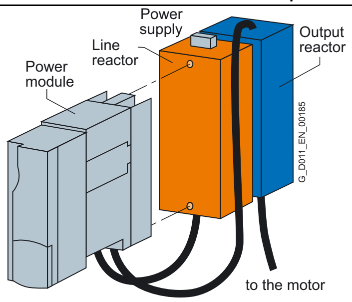
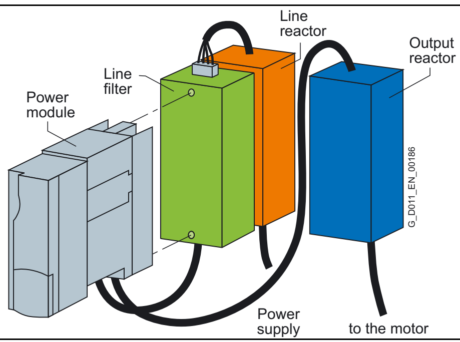
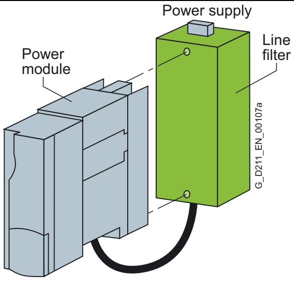
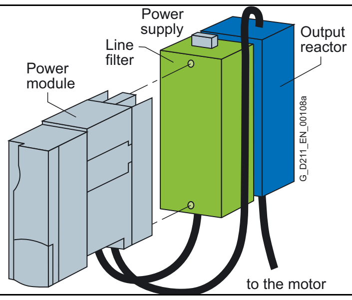
<tr><td>
</td><td>
</td></tr>
<tr><td>Basic layout of a PM240 Power Module with line reactor as base component</td><td>PM240 Power Module frame size FSA with line reactor and class A line filter</td></tr>
<tr><td colspan="2">The line-side reactors are equipped with terminals while the reactors on the Power Module side are equipped with a prefabricated cable. In the final installation position, the mains terminals are at the top on frame sizes FSA to FSC, and at the bottom on frame sizes FSD to FSE.
For frame size FSA, in addition to the line reactor, a class A line filter can be used. In this case, the mains connection is at the bottom.
Power Modules of frame size FSB and higher are available with integrated class A line filters (an external class A line filter is not required in this case).</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>PM240: frame size FSA with line reactor and output reactor</td><td>PM240 Power Modules: frame size FSA with line reactor, line filter, and output reactor</td></tr>
<tr><td colspan="2">In installations containing more than two base-type system components (e.g. line filter + line reactor + output reactor), the components must be installed to the side of the Power Modules. whereby the line reactor and line filter are installed under the Power Module and the output reactor to the side.</td></tr>
</table>

PM250	
	
Basic layout of a PM250 Power Module with class B line filter as a base component	Basic layout of a PM250 Power Module with a class B line filter as a base component

3.3 Mounting Power Modules

Options for installing the Power Module

Depending on the format, various options are available for installing frequency inverters. This manual describes how to install frequency converters directly on the cabinet wall.

Installation options	Types of construction					
	A	B	C	D	E	F
Installation on standard rails	X	X	X	---	---	---
Installation on cabinet wall with shield connection kit	X	X	X	X	X	X
Installation directly on the cabinet wall	X	X	X	X	X	X

Installing Power Modules

Choose the best installation option for your application and install the Power Module in accordance with the instructions provided in this section.

NOTICE

Information about installation

The Power Module must not be installed horizontally.

Correct

Incorrect

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

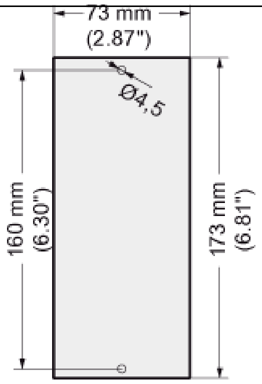
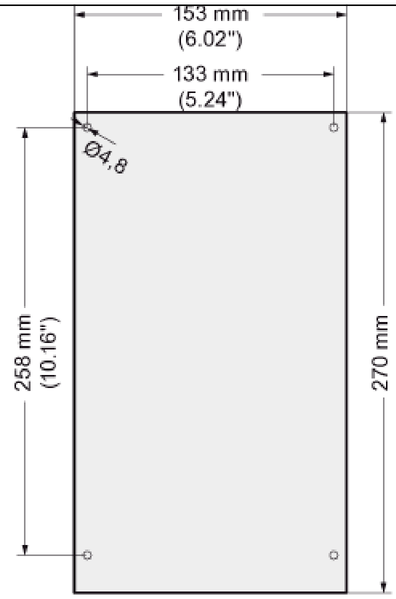
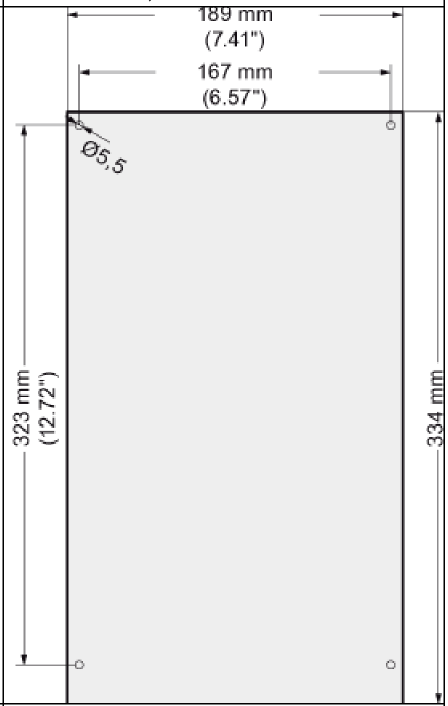
Installing additional components

Depending on the application, line reactors, filters, braking resistors, or brake control relays, for example, may also be required.

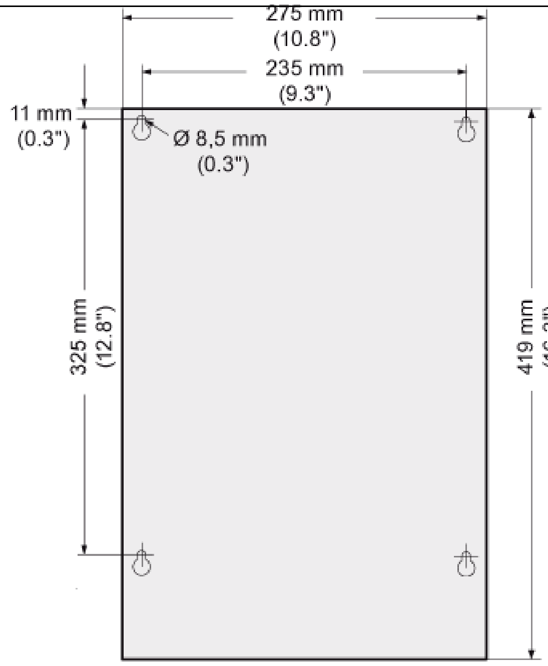
Please observe the mounting and installation instructions supplied with these components!

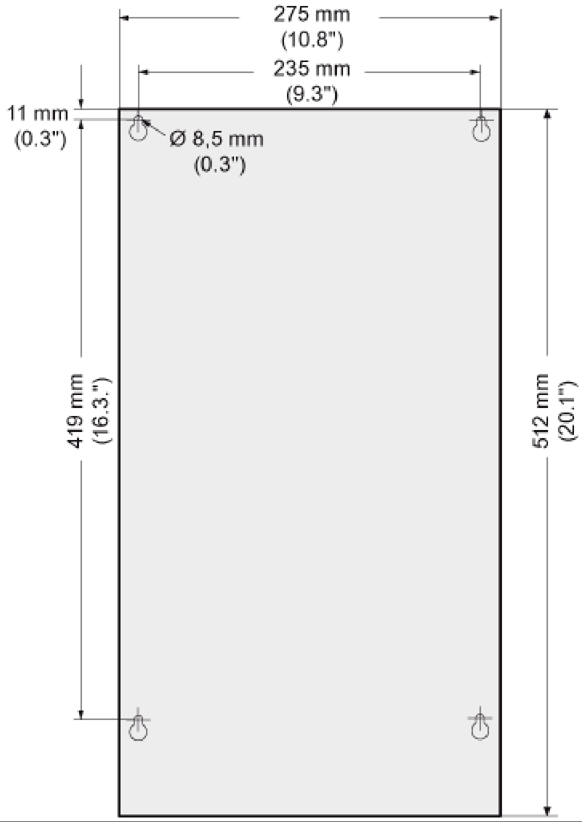
3.3.1 Dimensions, hole drilling templates, minimum clearances, tightening torques

Overview of dimensions and hole drilling templates for the Power Modules

0.37 kW … 1.5 kW	2,2 kW … 4 kW	7,5 kW … 15 kW
		
Retaining type • 2 x M4 bolts • 2 x M4 nuts • 2 x M4 washers	Retaining type • 4 x M4 bolts • 4 x M4 nuts • 4 x M4 washers	Retaining type • 4 x M5 bolts • 4 x M5 nuts • 4 x M5 washers
Tightening torques • 2.5 Nm (22.1 lbf.in)	Tightening torques • 2.5 Nm (22.1 lbf.in)	Tightening torques • 2.5 Nm (22.1 lbf.in)
Distances from other devices • Lateral: 30 mm (1.18 inch) • Top/bottom: 100 mm (3.93 inch)	Distances from other devices • Lateral: 40 mm (1.57 inch) • Top/bottom: 100 mm (3.93 inch)	Distances from other devices • Lateral: 50 mm (1.96 inch) • Top/bottom: 125 mm (4.92 inch)
Depth • Standalone: 145 mm (5.71 inch) • With CU240E: 187 mm (7.36 inch) • With CU240S: 208 mm (8.19 inch)	Depth • Standalone: 165 mm (6.50 inch) • With CU240E: 207 mm (8.15 inch) • With CU240S: 228 mm (8.98 inch)	Depth • Standalone: 185 mm (7.28 inch) • With CU240E: 227 mm (8.94 inch) • With CU240S: 248 mm (9.76 inch)

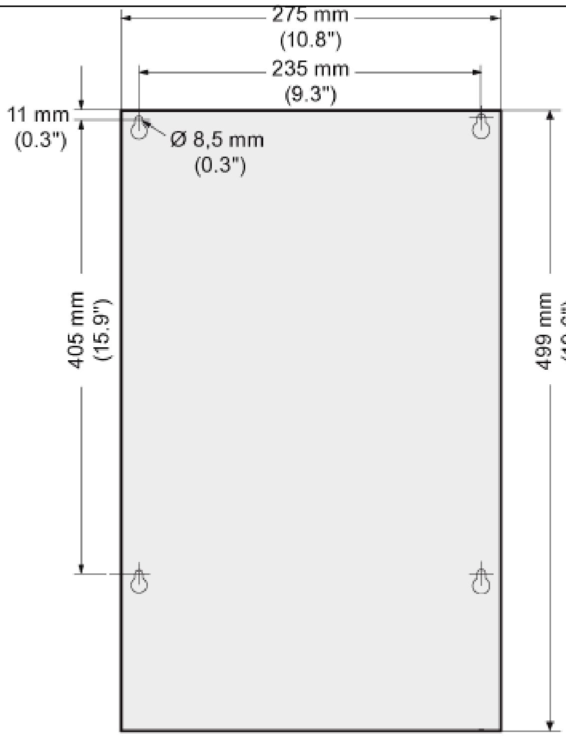
18.5 kW … 30 kW without filter	18.5 kW … 30 kW with filter for PM240 and PM250 11 kW … 18 kW for PM260

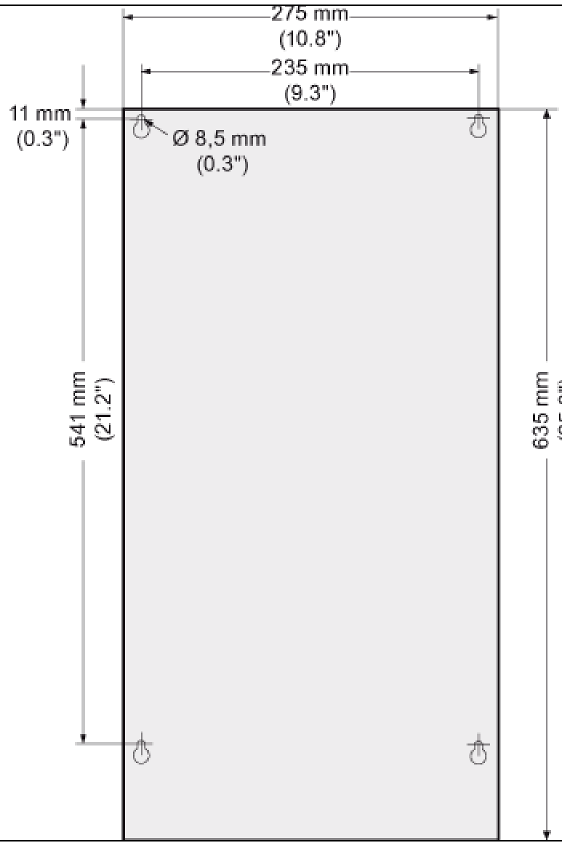




Mounting type	• 4 x M6 bolts • 4 x M6 nuts • 4 x M6 washers
Tightening torques	• 6 Nm (53 lbf.in)
Distances from other devices	• Lateral: 0 mm (0 inch) • Top/bottom: 300 mm (11.81 inch)
Depth	• Standalone: 204 mm (8.03 inch) • With CU240E: 246 mm (9.68 inch) • With CU240S: 267 mm (10.51 inch)

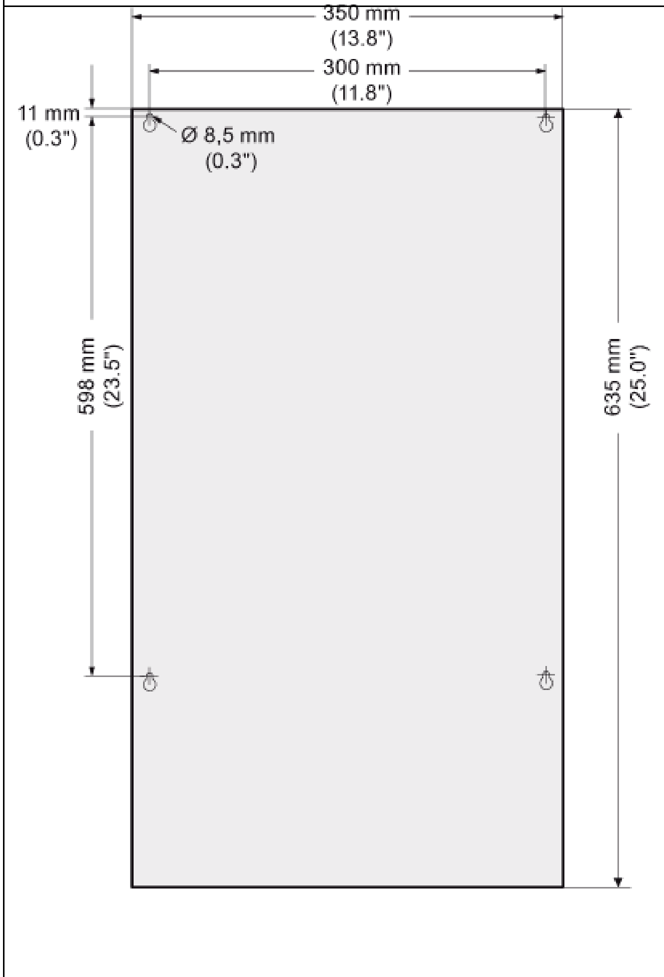
37 kW … 45 kW without filter	37 kW … 45 kW with filter

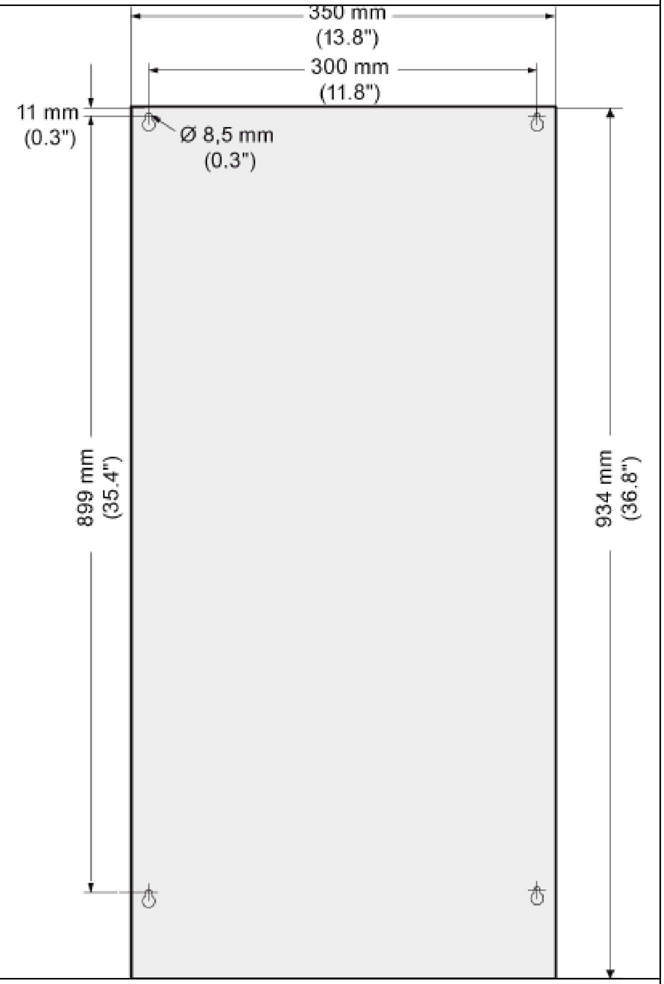




Mounting type	• 4 x M6 bolts • 4 x M6 nuts • 4 x M6 washers
Tightening torques	• 6 Nm (53 lbf.in)
Distances from other devices	• Lateral: 0 mm (0 inch) • Top/bottom: 300 mm (11.81 inch)
Depth	• Standalone: 204 mm (8.03 inch) • With CU240E: 246 mm (9.68 inch) • With CU240S: 267 mm (10.51 inch)

55 kW … 132 kW without filter for PM240 and PM250 30 kW … 55 kW for PM260	55 kW … 132 kW with filter





Mounting type	• 4 x M8 screws • 4 x M8 nuts • 4 x M8 washers
Tightening torques	• 13 Nm (115 lbf.in)
Distances from other devices	• Lateral: 0 mm (0 inch) • Top/bottom: 350 mm (13.77 inch)
Depth	• Standalone: 316 mm (12.44 inch) • With CU240E: 358 mm (14.09 inch) • With CU240S: 379 mm (14.92 inch)

3.3.2 Wiring Power Modules

Prerequisites

Once the Power Module 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 supply and motor side. If this is not carried out properly, 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 carry hazardous voltages even after the inverter has been switched off. After disconnecting the line supply, wait at least 5 minutes until the drive unit has discharged itself. Only then, carry out any installation and mounting work.
When connecting the frequency inverter to the line supply, ensure that the motor terminal box is closed.
Even if the LEDs 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 (the inverter must not be connected to a higher supply voltage).
If a residual-current circuit breaker is installed on the supply side of the electronic devices to protect against direct or indirect contact, only type B is permissible. In all other cases, other protective measures must be implemented, such as creating a barrier between the electronic devices and the environment by means of double or reinforced insulation, or disconnecting them from the supply by means of a transformer.

CAUTION
Supply and control cables
The control cables must be laid separately from the supply cables to ensure that the system is not affected by inductive or capacitive interference.

Note

Electrical protective equipment

Make sure that suitable circuit breakers and/or fuses (with the prescribed rated currents) are installed between the supply system and inverter (see the technical specifications).

Connection example: Power Module PM240

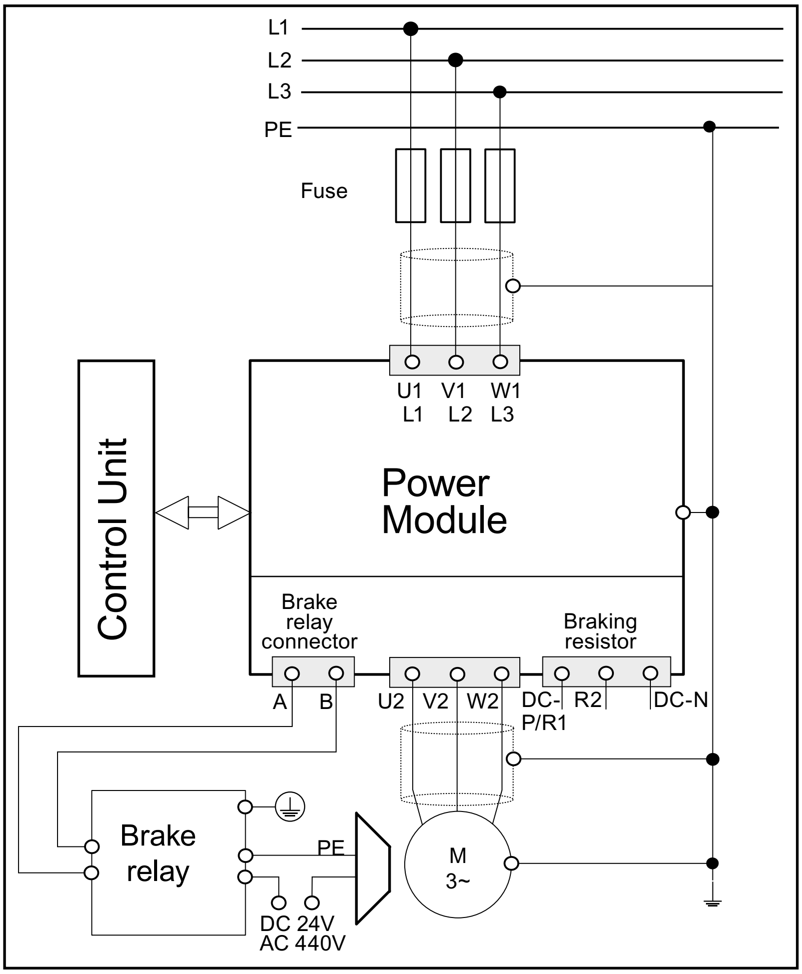
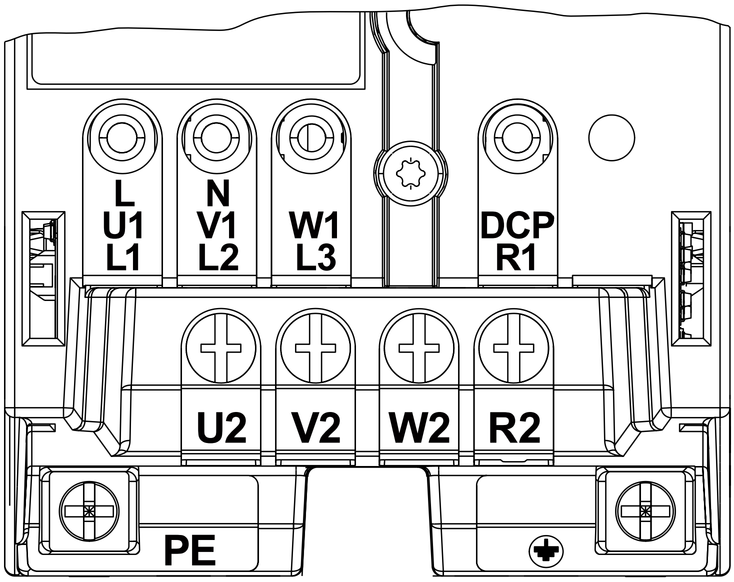


Figure 3-1 Connection diagram: PM240 Power Module with Brake Relay

Connecting-up Power Modules

Line supply connection	Motor connection	Connect the braking resistor
The supply system is connected to terminals U1/L1, V1/L2, and W1/L3. Power Modules without an integrated line filter can be connected to grounded (TN, TT) and non-grounded (IT) line supply systems. Power Modules with an integrated class A line filter are only suitable for TN supply systems.	The motor is connected to terminals U2, V2, and W2. The following cable lengths are permissible: • Unshielded 100 m • Shielded, 50 m for converters without filter 25 m for converters with filter Additional information is provided in Catalog D11.1 for longer cable lengths	A braking resistor can be connecting at terminals DCP/R1 and R2.



	FSA	FSB	FSC	FSD	FSE	FSF
Power	0.37 kW … 1.5 kW	2.2 kW … 4 kW	7.5 kW … 15 kW	18.5 kW … 30 kW	37 kW … 45 kW	55 kW … 132 kW
Connection cross-section	1 mm² … 2.5 mm²	1.5 mm² … 6 mm²	4 mm² … 10 mm²	10 mm² … 35 mm²	10 mm² … 35 mm²	35 mm² … 120 mm²
Torque	1.1 Nm	1.5 Nm	2.25 Nm	6 Nm	6 Nm	13 Nm

3.3.3 EMC-compliant connection

EMC-compliant connection

Using an example, the diagram shows how shielding is implemented for frame size FSA using a shield connection kit. Corresponding shield connection kits are available for all Power Module frame sizes (you will find more information in Catalog D11.1).

The cable shields must be connected to the shield connection kit with the greatest possible surface area by means of the shield clips.

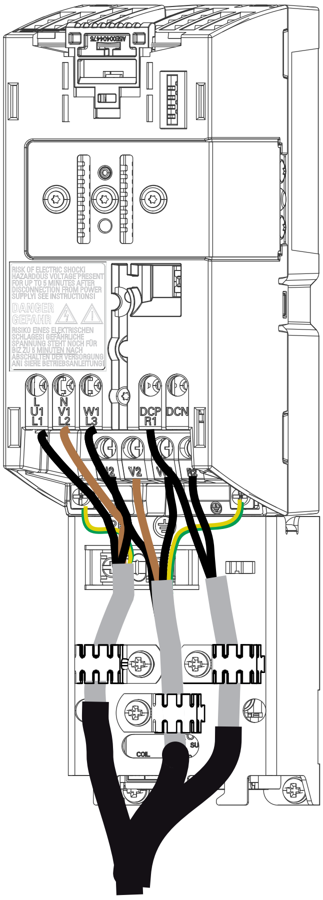


Figure 3-2 Shield connection kit FSA

Note

EMC-compliant shielding can also be implemented without this optional shield connection kit. In this case, you must ensure that the cable shields are connected to the ground potential with the greatest possible surface area.

Avoiding electromagnetic disturbances

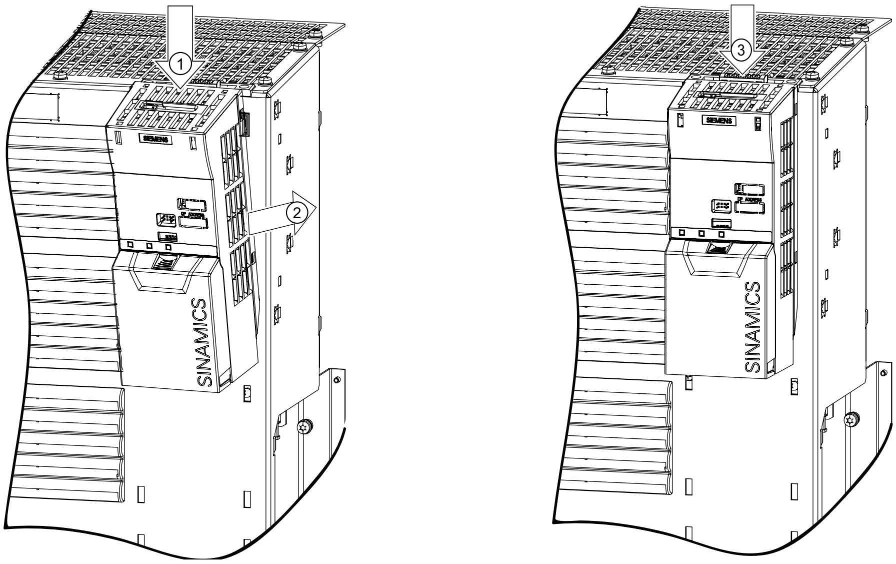
The frequency inverters are designed for operation in industrial environments where high values of electromagnetic noise and disturbances are expected. Generally, correct installation guarantees safe, reliable and disturbance-free operation. If difficulties do arise, then please note the following guidelines.

Required measures

- Ensure that all of the devices in the cabinet are well-grounded using short grounding cables with high cross-sections, connected to a common grounding point or a grounding bar.
- Ensure that every control device (e.g. a PLC) connected to the frequency inverter is connected to the same ground or the same grounding point as the frequency inverter through a short cable with a large cross-section.
- Connect the return ground of the motors, which are controlled from the frequency inverters, directly at the ground connection (PE) of the associated frequency inverter.
- Flat cables are preferred as they have a lower impedance at higher frequencies.
- The cable ends must be cleanly terminated and it must be ensured that unshielded cables are as short as possible.
- The control cables must be routed separately from the supply cables. Power and control cables should cross at a 90° angle.
- If at all possible, use shielded cables to connect the control circuit.
- Ensure that the contactors in the cabinet have the necessary interference suppression components; either using an RC circuit for AC contactors or using "free-wheeling diodes" for DC contactors, whereby the noise suppression elements should be connected at the coils. Varistor suppressors are also effective. This is important if the contactors are controlled from the frequency inverter relay.
- Use shielded cables for the motor connections, and ground the shielding at both ends using cable clamps.

3.4 Installing the Control Unit

Locating the Control Unit on the power unit



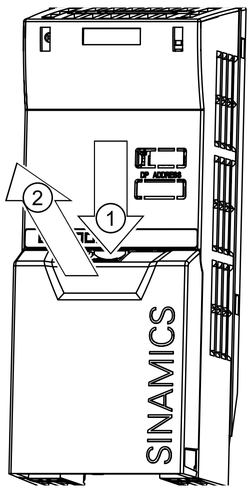
The Control Unit is simply snapped-on to a Power Module. This also establishes all of the electrical connections between the two components.

The Control Unit can be removed by pressing the release button ③.

Removing the terminal cover

To access the control terminals, remove the cover as shown in the adjacent diagram.

- Maximum cable cross-section for control terminals, 2.5 mm^2.
- Tightening torque, 0.25 Nm



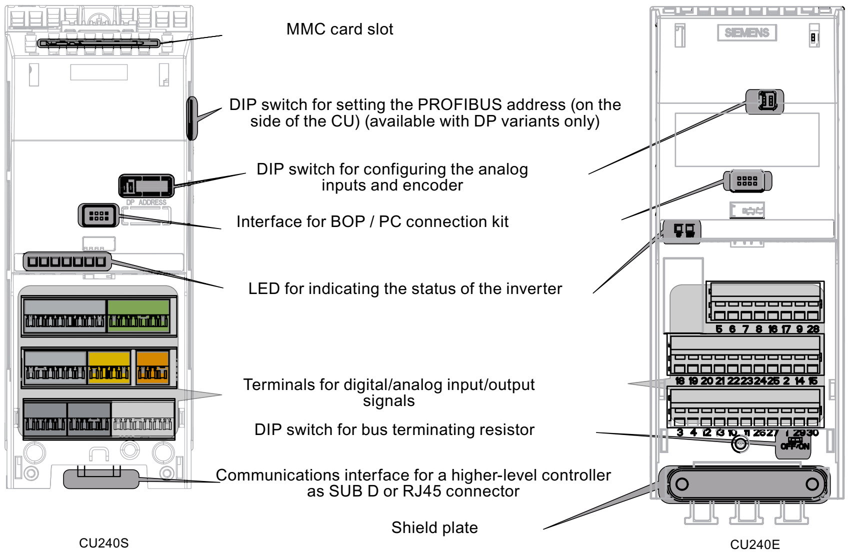
3.4.1 Interfaces, connectors, switches, control terminals, LEDs on the CU

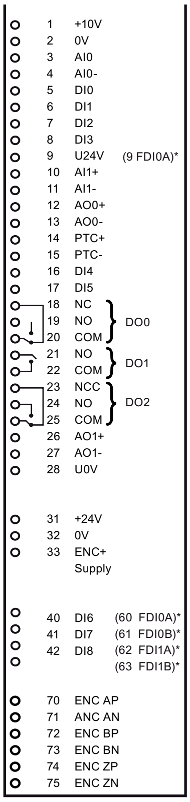
Overview of the process and user interfaces

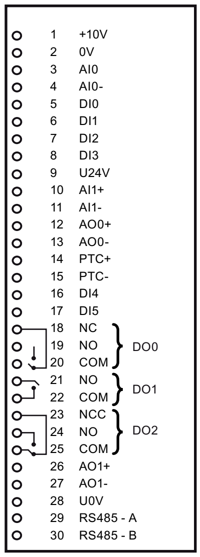
The following interfaces are provided on the Control Unit

- Terminals for the input and output signals
- Card slot to upload and download frequency inverter settings
- Connector to communicate with higher-level controls
- DIP switches to configure the speed encoder, the analog inputs and, if required, to set the PROFIBUS address.
- LEDs for diagnostics

It also shows where they are located.




1 +10V
2 0V
3 AI0
4 AI0-
5 DI0
6 DI1
7 DI2
8 DI3
9 U24V (9 FDI0A)*
10 AI1+
11 AI1-
12 AO0+
13 AO0-
14 PTC+
15 PTC-
16 DI4
17 DI5
18 NC
19 NO
20 COM
DO0
21 NO
22 COM
DO1
23 NCC
24 NO
25 COM
DO2
26 AO1+
27 AO1-
28 U0V
31 +24V
32 0V
33 ENC+ Supply
40 DI6 (60 FDI0A)*
41 DI7 (61 FDI0B)*
42 DI8 (62 FDI1A)*
(63 FDI1B)*
70 ENC AP
71 ANC AN
72 ENC BP
73 ENC BN
74 ENC ZP
75 ENC ZN


1 +10V
2 0V
3 AI0
4 AI0-
5 DI0
6 DI1
7 DI2
8 DI3
9 U24V
10 AI1+
11 AI1-
12 AO0+
13 AO0-
14 PTC+
15 PTC-
16 DI4
17 DI5
18 NC
19 NO
20 COM
DO0
21 NO
22 COM
DO1
23 NCC
24 NO
25 COM
DO2
26 AO1+
27 AO1-
28 U0V
29 RS485 - A
30 RS485 - B

Arrangement and function of the terminals on the CU240S Control Unit

All Control Units are equipped with the same control terminals. However, depending on the CU version, the factory set activation for certain digital inputs and interfaces differ. (see the block diagram for CU240S/E and for CU240S-DP/CU240S-DPF/CU240S-PN/CU240S-PN-F).

Unlike the standard Control Units, the fail-safe Control Units CU240S DP-F and CU240S PN-F only have six digital inputs instead of nine. They are instead equipped with two fail-safe digital inputs. Fail-safe digital inputs are redundant and each have two terminals.

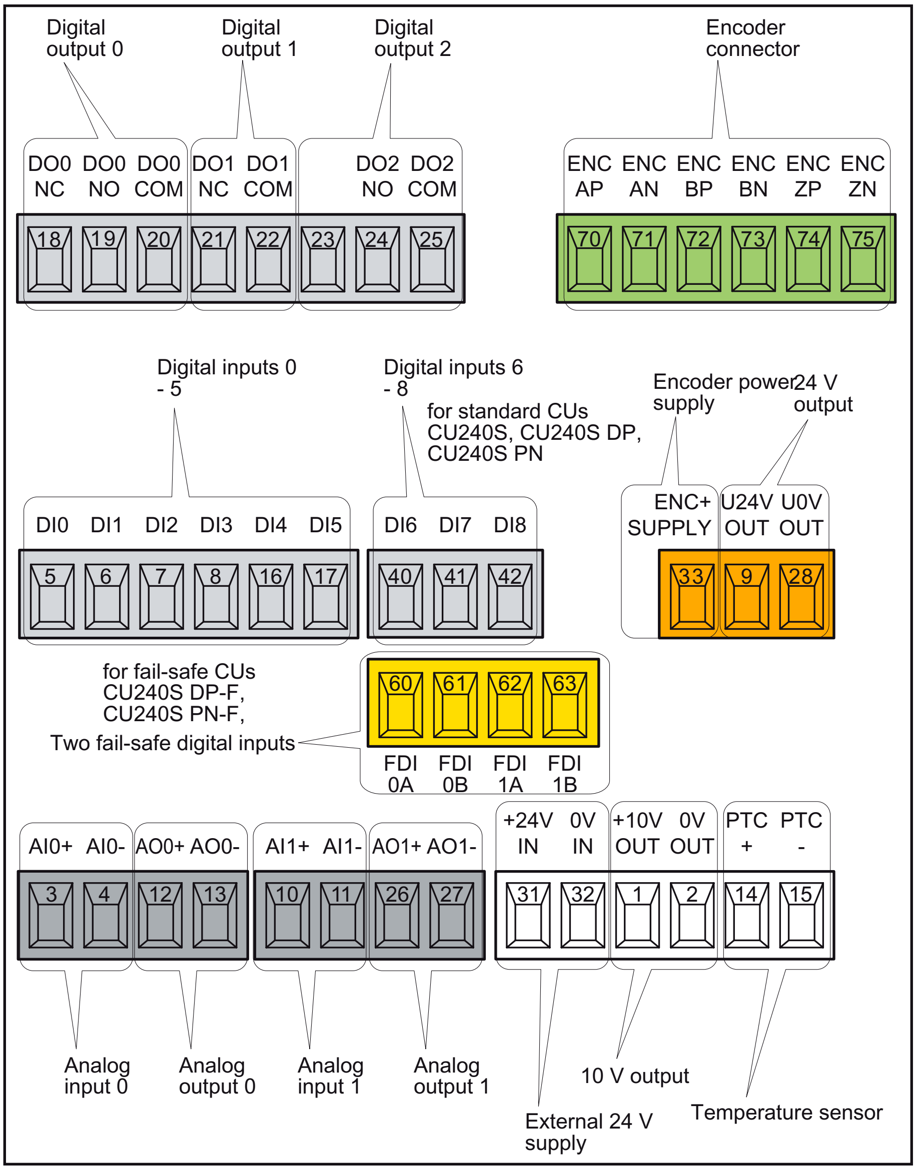


Figure 3-3 Terminal overview: CU240S-DP /-DP-F/ -PN /-PN-F

4 Commissioning

Alternative commissioning options

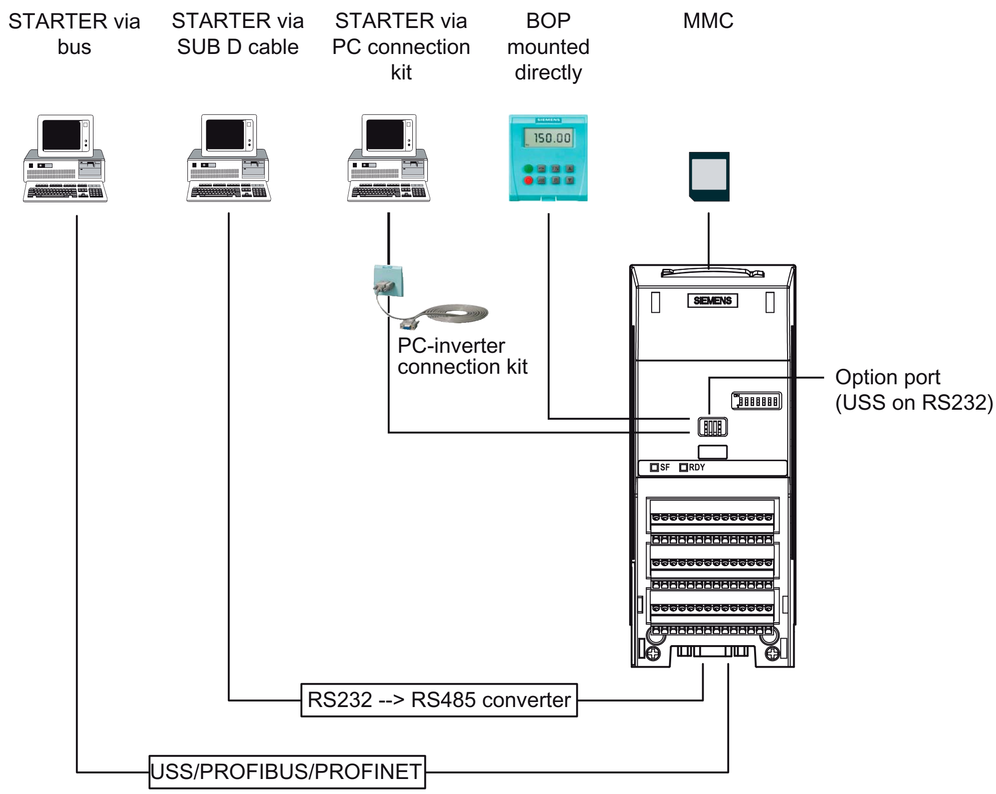
The functions of a frequency inverter are activated and configured using parameters. Parameters can either be accessed from the operator control/display instrument (Operator Panel) or using the STARTER software from the PC via the appropriate frequency inverter interface.

Inverters can also be parameterized by saving the valid inverter parameter set on an MMC memory card or on the Operator Panel and then transferring it to a different frequency inverter with the same configuration and function.

The commissioning scenarios listed below are described in the following sections:

- Commissioning, using the factory settings
- Commissioning with the STARTER software
- Commissioning using the Operator Panel
- Data backup with the Operator Panel and MMC memory card

Users can access the inverter parameters via the following interfaces



4.1 Initial coupling of the CU and PM - message F0395

Description

Message "F0395" is displayed when Control Units or Power Modules are switched on for the first time or after they have been replaced.

This message monitors the two inverter components (CU and PM) to ensure that they are not replaced without authorization. Make sure that the parameter set on the Control Unit is compatible with the Power Module and the application before acknowledging message 'F0395' as described below.

When you acknowledge F0395, you accept the parameter set on the Control Unit.

Acknowledging message F0395

Depending on which command source is set, you can acknowledge message F0395 in the following ways:

- If the command source is "BOP": press function key FN
- If the command source is 'Terminals' (P0700 = 2): digital input 2 (factory setting for the acknowledge command)
- If the command source is 'Fieldbus' (P0700 = 6): control word 1 (STW1 / bit 7)

Message F0395 is also acknowledged when 'Restoring the factory settings'.

4.2 Restoring the factory settings

If nothing else works, restore the factory settings!

You can restore the factory settings using parameter P0970.

Parameter or procedure	Description
P0003 = 1	**User access level** 1: Standard level
P0010 = 30	**Commissioning parameter** 30: Factory setting, parameter transfer
P0970 = 1	**Restore factory settings** 1: Restore the factory parameter settings
BOP displays "BUSY" STARTER displays progress bar	Once the factory settings have been restored, P0970 and P0010 are set to 0 and the BOP returns to the standard display.

Note

Data transfer is interrupted while the factory parameter settings are being restored.

The following parameters remain unchanged even after the factory settings have been restored:

- P0014 Storage mode
- P0100 Europe / North America
- P0201 Power stack code number
- Communication parameters
- Power-Module-specific data

4.3 Preparing commissioning

Prerequisites: before you start

Before you start parameterization, you should clarify the following issues about commissioning your application.

Are the factory settings sufficient for your application?

Check which factory settings can be used and which need to be changed (see Section 'Commissioning with factory settings'). When doing so, you may find that you only need to change just a few parameters.

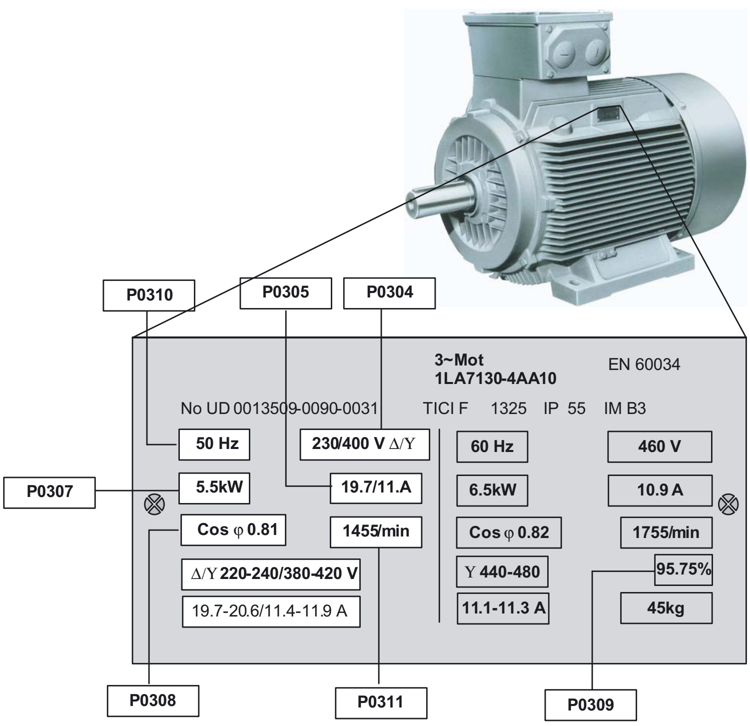
Which motor are you using? [P0300]

- A synchronous or induction motor?

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

Motor data / data on the motor rating plate

If you use the STARTER software and a SIEMENS motor, you only have to specify the 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/delta), i.e. with 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 ICE: 50 Hz [kW] - factory setting
- North America NEMA: 60 Hz [hp] or 60 Hz [kW]

Are you using an external speed encoder? If so, what is its pulse number? [P0400]

- Speed encoder type
- Number of encoder pulses (resolution) per revolution

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

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

What control mode do you want to use for your 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 a frequency 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 command and setpoint sources are you using?

The command and setpoint sources that are available depend on the frequency inverter. Depending on whether you use a frequency inverter with or without fieldbus interface, with or without fail-safe functions, the default command and setpoint sources set in the factory differ.

- **Possible command sources [P0700]**
  - Operator Panel
  - Fieldbus (factory setting for bus-capable and fail-safe frequency inverters)
  - Local digital inputs/switches (factory setting for non-bus-capable frequency inverters)
- **Possible setpoint sources [P1000]**
  - Motorized potentiometer
  - Analog setpoint
  - Fixed frequency
  - Fieldbus

Controlling motors via terminals

There are various methods to start, stop and reverse the direction of a motor. The various methods can be configured using parameter P0727.

The following two-wire control variants are available with the factory setting (P0727 = 0):

- Switching on and off with one control command and reversing with the second control command.
- Switching on and switching off a direction of rotation with each control command.

Minimum/maximum frequency of the motor

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

- Minimum frequency [P1080] - factory setting 0 Hz
- Maximum frequency [P1082] - factory setting 50 Hz

Ramp-up time and ramp-down time

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 interval between motor standstill and the maximum frequency, or between the maximum frequency and motor standstill.

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

4.4 Commissioning with factory settings

Prerequisites for using the factory settings

In simple applications, commissioning can be carried out just using the factory settings. This section explains what prerequisites must be fulfilled for this purpose and how they are fulfilled.

1. The frequency inverter and motor must match one another; otherwise you must perform a complete *quick commissioning* (see Chapter 'Quick commissioning').
2. The binary and analog inputs must be connected in accordance with the wiring example (see Section 'Wiring example').
3. You then have to "tell" the converter the following,
   - the source of its commands:
     - from an 0perator panel,
     - from the digital inputs
     - from the fieldbus interface

     You can change this *command source* using parameter P0700 if the factory setting is not appropriate for your application.
   - where it gets its speed setpoint (setpoint source)

     - from an analog input (analog setpoint)

     - as fixed frequency from a digital input

     - from the fieldbus interface

     You can change this *frequency setpoint source* using parameter P1000 if the factory setting is not appropriate for your application.

4.4.1 Wiring examples for the factory settings

Many applications function using the factory settings

To ensure that the factory settings can be used, you must wire the control terminals on your inverter as shown in the following examples.

Default settings for the control terminals on the CU240E

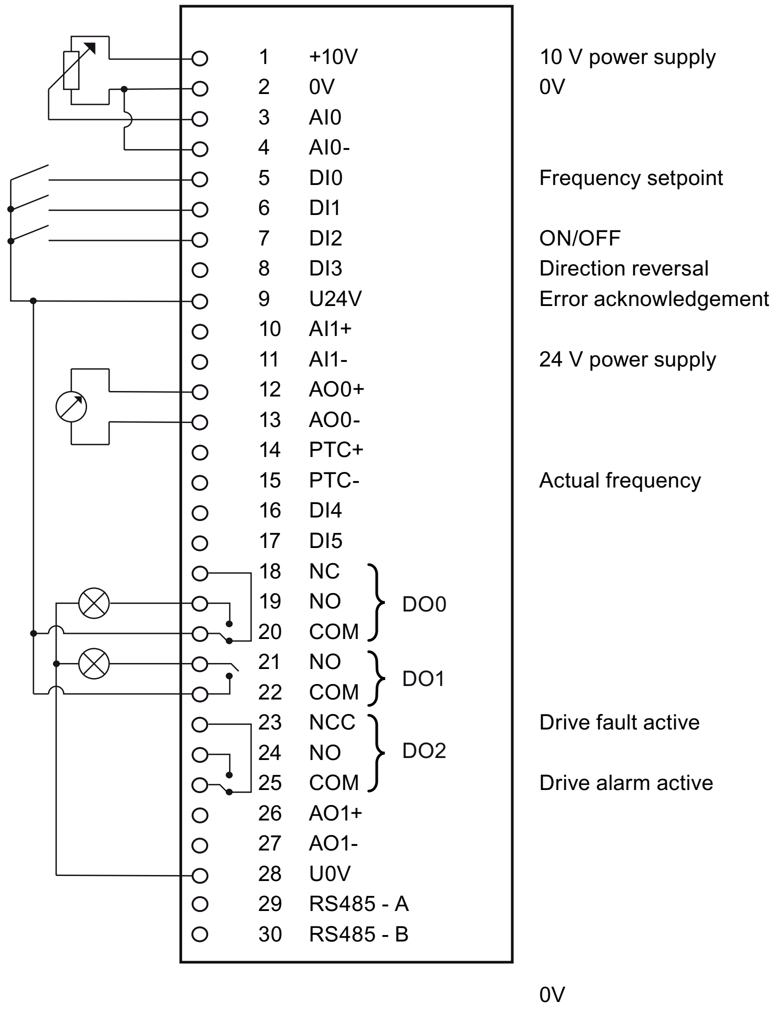
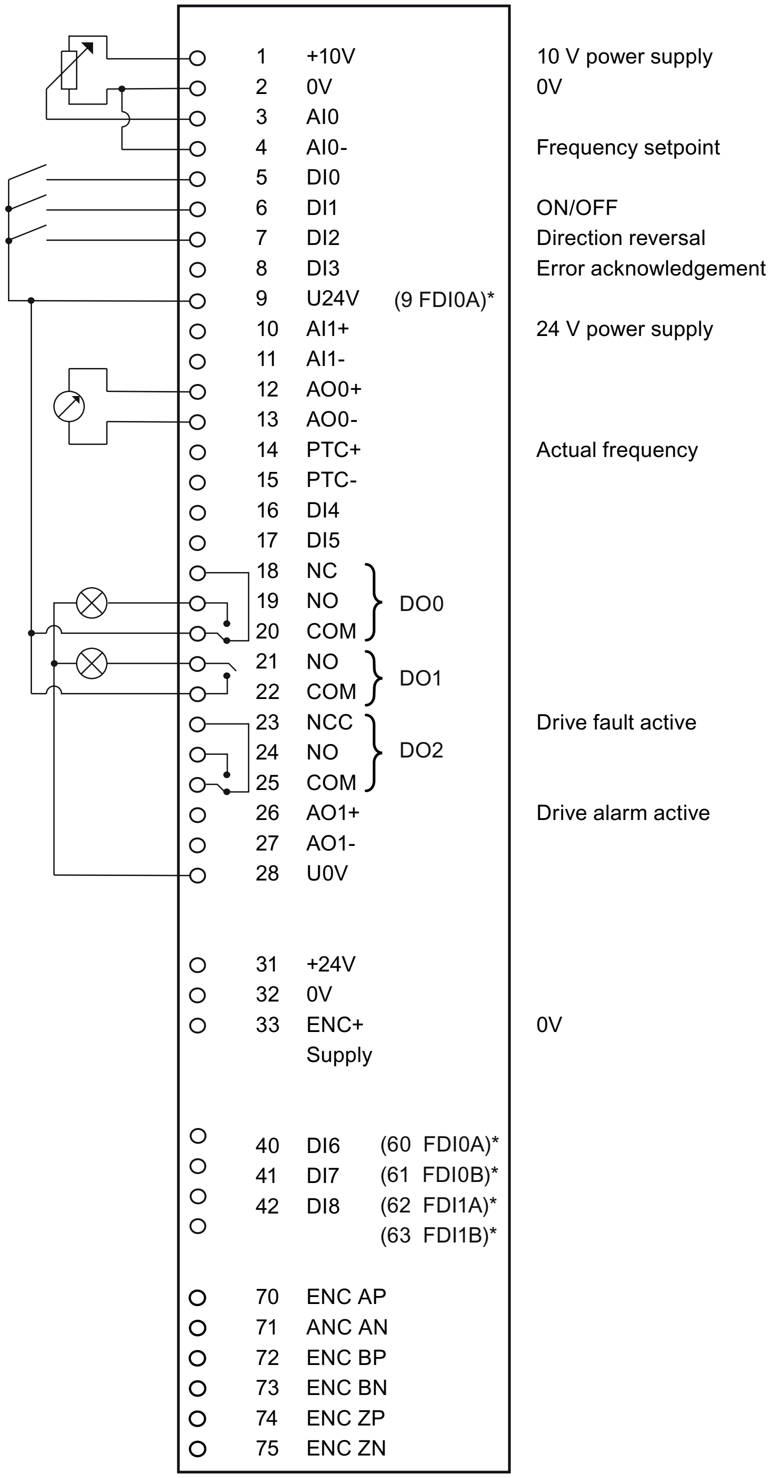


Figure 4-1 CU240E terminal overview: wiring example for using the factory settings

Default settings for the control terminals on the non-bus-capable CU240E



* Failsafe versions in brackets

Figure 4-2 CU240S terminal overview: wiring example for using the factory settings

4.4.2 Factory setting of the frequency inverter

Default command and setpoint sources

Frequency inverters used in automation solutions have the appropriate fieldbus interfaces. These frequency inverters are preset in the factory so that the appropriate control and status signals can be exchanged via the fieldbus interface.

Frequency inverters without a fieldbus interface are pre-set in the factory so that the digital and analog and input output signals are exchanged via terminals.

For instance, if you do not want to control a frequency inverter equipped with a fieldbus interface via the fieldbus, but instead using switches and pushbuttons that are connected to the binary inputs, then you must change parameter P0700 as follows.

Table 4- 1 **Command and setpoint sources**

Parameter	Description
P0700 = 2 or 6	**Select the command source** 2: Digital intputs (P0701 … P0709) (factory setting for CUs without fieldbus interface) 6: Fieldbus (P2050 … P2091), (factory setting for CUs with fieldbus interface)
P1000 = 2 or 6	**Select the setpoint source** 2: Analog setpoint (factory setting for CUs without fieldbus interface) 6: Fieldbus (factory setting for CUs with fieldbus interface)

Table 4- 2 Factory setting of additional important parameters

Parameter	Factory setting	Meaning of the factory setting	Function	Access level
P0003	1	Access to the most frequently used parameters	Selecting the user access level	1
P0004	0	All parameters are displayed	Parameter filter: filters parameters in accordance with the functionality	1
P0010	0	Ready to be entered	Commissioning parameter	1
P0100	0	Europe [50 Hz]	Frequency of the regional supply network • IEC, Europe • NEMA, North America	1
P0300	1	Induction motor	Select the motor type (induction motors / synchronous motor)	2
P0304	400	[V]	Rated motor voltage (in accordance with rating plate in V)	1
P0305	depends on the Power Module	[A]	Rated motor current (in accordance with rating plate in A)	1
P0307	depends on the Power Module	[kW/hp]	Rated motor output (in accordance with the rating plate in kW/hp)	1
P0308	0	[cos phi]	Rated motor power factor (in accordance with rating plate in cos 'phi') when P0100 = 1.2, then P0308 is irrelevant	1
P0309	0	[%]	Rated motor efficiency (in accordance with rating plate in %) when P0100 = 0, then P0309 is irrelevant	1
P0310	50	[Hz]	Rated motor frequency (in accordance with rating plate in Hz)	1
P0311	1395	[rpm]	Rated motor speed (in accordance with rating plate in rpm)	1
P0335	0	Non-ventilated: Shaft-mounted fan in the motor	Motor cooling (specify the motor cooling system)	2
P0625	20	°C	Ambient temperature of motor	3
P0640	200	[%]	Motor overload factor (entered in % referred to P0305)	2
P0700	2 or 6	6 for bus-capable CUs 2 for stand-alone CUs	Select the command source	1
P0727	0	DI0: On / off DI1: Direction reversal	Control response when the motor starts (start, stop, reverse)	3
P0970	0	Blocked	Restore factory settings	1
P1000	2 or 6	6 for bus-capable CUs 2 for stand-alone CUs	Select the source of the frequency setpoint (setpoint input)	1
P1080	0	[Hz]	Minimum frequency	1
P1082	50	[Hz]	Maximum frequency	1
P1120	10	[s]	Ramp-up time	1
P1121	10	[s]	Ramp-down time	1
P1300	0	V/f control with linear characteristic	Control mode	2
P3900	0	No quick commissioning	Completes the quick commissioning.	1

4.4.3 Default terminal settings

Factory settings of the process interfaces

Digital inputs				
Terminal	Abbreviation	Parameter	Factory setting	Meaning of the factory setting
5	DI0	P0701	1	ON / OFF1
6	DI1	P0702	12	Direction reversal
7	DI2	P0703	9	Error acknowledgment
8	DI3	P0704	15	Fixed setpoint selector bit 0 (direct) [P1001]
16	DI4	P0705	16	Fixed setpoint selector bit 1 (direct) [P1002]
17	DI5	P0706	17	Fixed setpoint selector bit 2 (direct) [P1003]
40	DI6	P0707	18	Fixed setpoint selector bit 3 (direct) [P1004]
41	DI7	P0708	0	Digital input blocked
42	DI8	P0709	0	Digital input blocked

Digital inputs of the safety functions				
Terminal	Abbreviation	Parameter	Factory setting	Meaning of the factory setting
60	FDI0A	P9603	0	Digital inputs of the safety functions are blocked
61	FDI0B			
62	FDI1A			
63	FDI1B			

Digital outputs (relay outputs)					
Terminal	Abbreviation		Parameter	Factory setting	Meaning of the factory setting
18	NC	DO0	P0731	52.3	Drive fault active
19	NO				
20	COM				
21	NO	DO1	P0732	52.7	Drive alarm active
22	COM				
23	NC	DO2	P0733	0.0	Relay output is blocked
24	NO				
25	COM				

Analog inputs					
Terminal	Abbreviation		Parameter	Factory setting	Meaning of the factory setting
3	AI0+	AI0	P0756 [0]	0	Set unipolar voltage input 0 V … +10 V DC in addition to parameterizing DIP switch on CU housing.
4	AI0-				
10	AI1+	AI1	P0756 [1]	0	Set unipolar voltage input 0 V … +10 V DC in addition to parameterizing DIP switch on CU housing.
11	AI1-				

Analog outputs					
Terminal	Abbreviation		Parameter	Factory setting	Meaning of the factory setting
12	AO0+	AO0	P0771[0]	21	Frequency on the inverter output; analog output 0 can be switched from current output to voltage output by means of P0776
13	AO0-				
26	AO1+	AO1	P0771[1]	21	Frequency on the inverter output; analog output 1 is current output only
27	AO1-				

Encoder interface (encoder)				
Terminal	Function	Parameter	Factory setting	Meaning of the factory setting
70	Channel A - non-inverting	P0400	0	Evaluation of the speed encoder is blocked
71	Channel A - inverting			
72	Channel B - non-inverting			
73	Channel B - inverting			
74	Zero pulse - non-inverting			
75	Zero pulse - inverting			

PTC/KTY84 interface				
Terminal	Abbreviation	Parameter	Factory setting	Meaning of the factory setting
14	PTC+	P0601	0	Evaluation of the motor temperature sensor is blocked
15	PTC-			

4.5 Commissioning with STARTER

Requirements

The STARTER commissioning tool features a project Wizard that guides you step-by-step through the commissioning process. Configuring the frequency inverter using the PC is significantly more user friendly and faster than commissioning using the Operator Panel.

The following is required to commission the frequency inverter via the PC:

- A PC connection kit for connecting the inverter to a PC.
  Order no.: 6SL3255-0AA00-2AA0

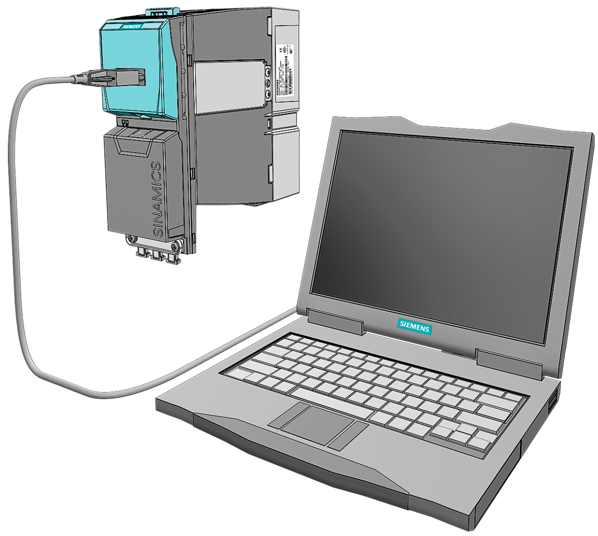


Figure 4-3 PC connection kit

- The installed STARTER software.
  (supplied with the PC connection kit). You can download the latest version from the Internet under the following address ().
- The motor must be connected to the frequency inverter.

4.5.1 Creating a STARTER project

Description

A frequency inverter can be parameterized in a user-friendly fashion using the Project Wizard. The commissioning procedure described here follows the Project Wizard. The PC communicates with the frequency inverter via the USS interface.

- Switch on the frequency inverter supply voltage
- Launch the STARTER commissioning tool.
- Use the Project Wizard and click on the "Find drive units online ..."

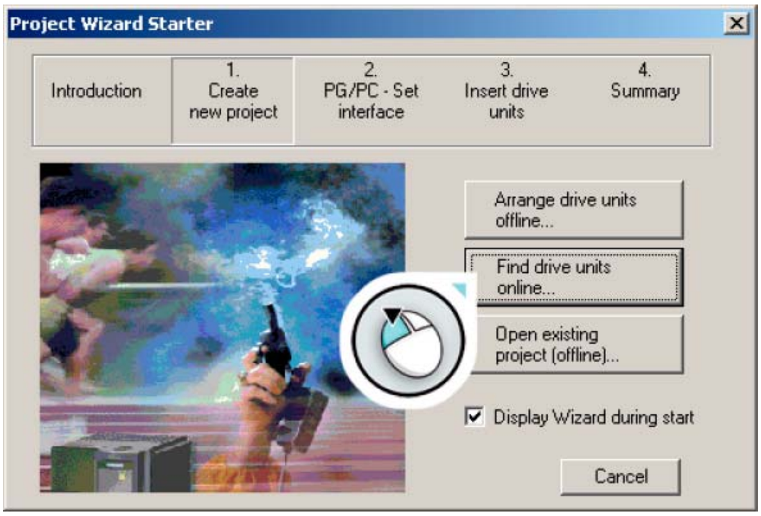


Figure 4-4 Start field

- In the screen that follows (not shown here), enter a meaningful name into your project, e.g. "Basic Commissioning" and click on "Continue". The following dialog box is displayed.

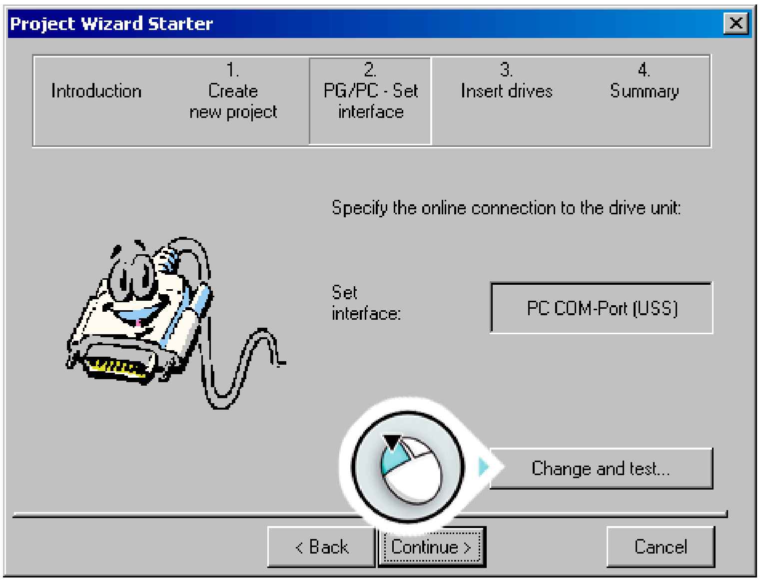


Figure 4-5 Setting the PC interface

- Click "Change and test..." to set up the PG/PC interface.

PG/PC - Set interface

- Select "PC COM-Port (USS)" from the list and click on "Properties …"

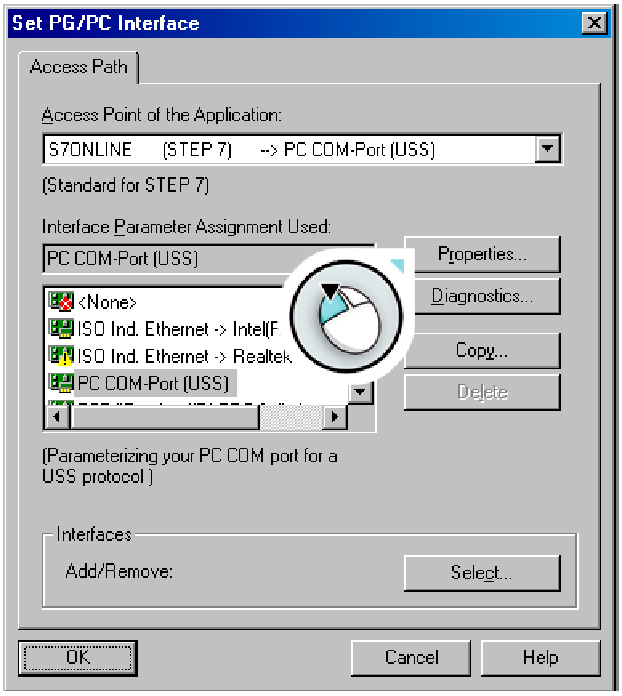


Figure 4-6 Setting the USS interface

- If "PC COM-Port (USS)" is not available, click on "Select …" to install the "PC COM-Port (USS)" interface as shown in the "Install/Remove Interfaces" dialog box.

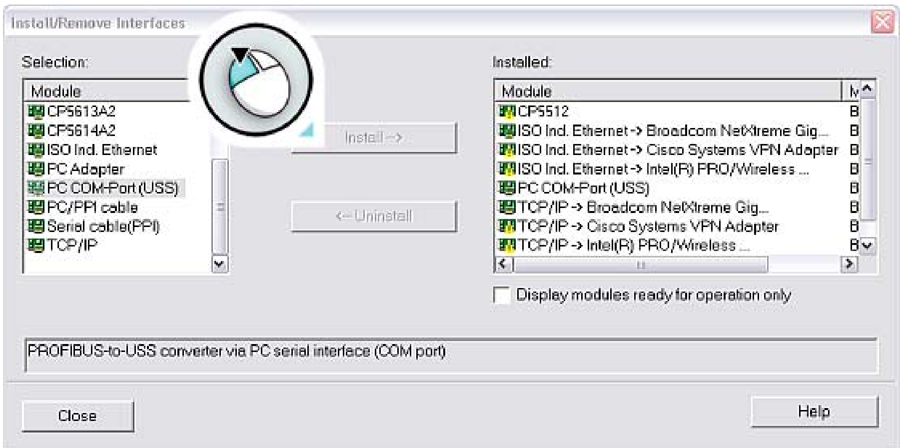


Figure 4-7 Installing the USS interface

- If you have installed the "PC COM-Port (USS)" interface, close the dialog box and now call up "Properties - PC COM-Port (USS)".

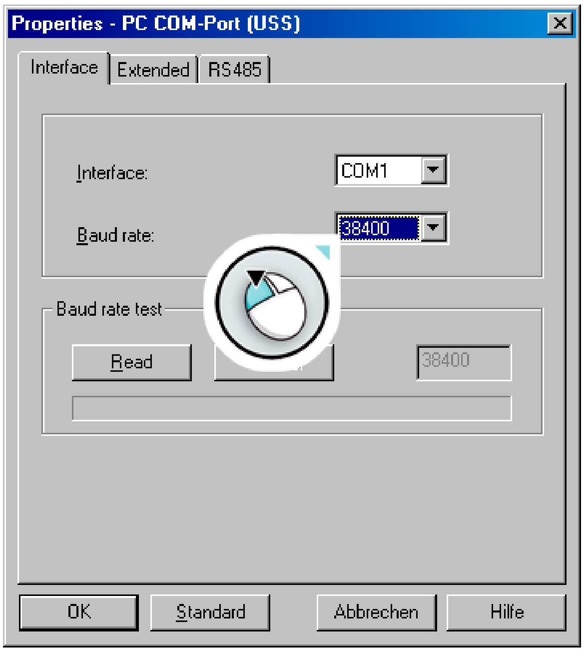


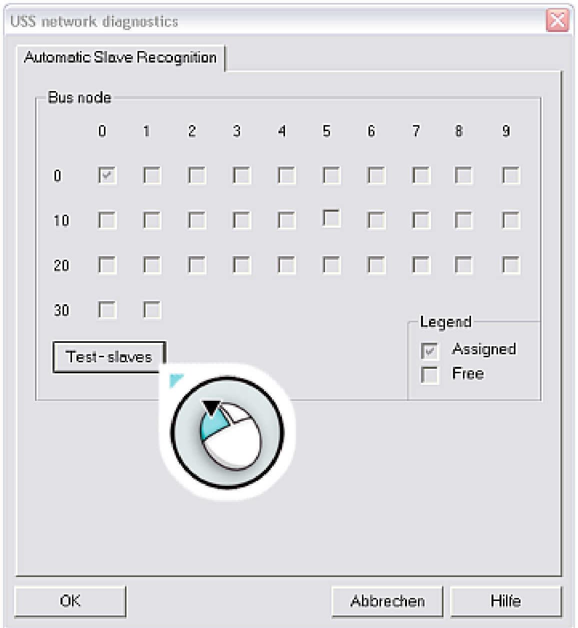
Figure 4-8 PC COM properties

- In this dialog box, you can set the COM interface (COM1, COM2, COM3) and baud rate (default: 38400).
- To determine the correct values of your interface, choose e.g. COM1, and then click on "Read".
- Under the "RS 485" tab, in addition, select the "Automatic mode". Using various baud rates in succession, the PC checks whether communications have been established to the frequency inverter. This can take several minutes.
- If "???" is displayed in the Baud rate test field then the baud rate test was unsuccessful. and you should choose a different COM interface. In the case of the correct COM interface, a value is displayed. Enter this value into the "baud rate" selection field.

- When you click "OK", the "Set PG/PC Interface" dialog box is displayed again.

Tip

In the "Set PG/PC Interface" dialog box, you can view the stations that can be accessed via USS by choosing "Diagnostics...":



- When you choose "OK" again, this takes you back to the Project Wizard.
- By clicking on "Continue", a search is made for devices that are available online and you then come to the step "Insert drives".

Insert drives

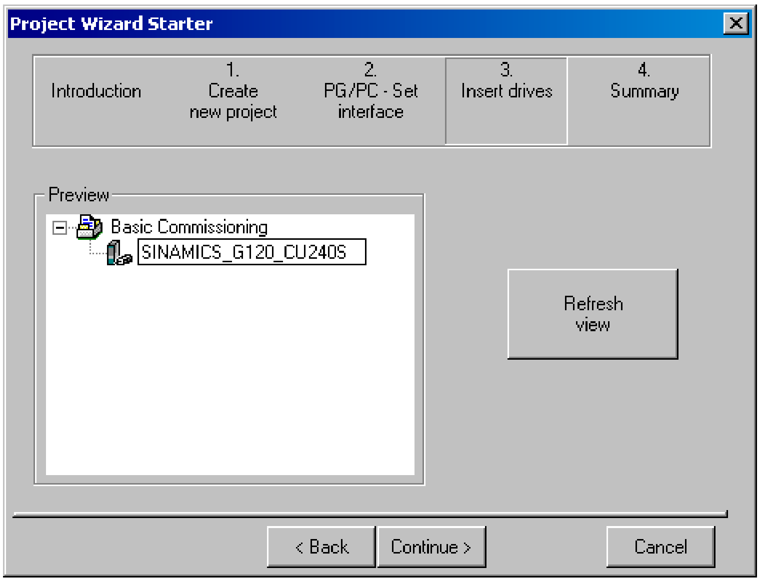


Figure 4-9 Insert drives

- In this dialog box, enter a name for your frequency inverter, e.g. "SINAMICS_G120_CU240S" (**no** blanks or special characters).
- Click on "Next".
- Close the "Summary" dialog box by choosing "Finish".

4.5.2 Establishing an online connection between the PC and converter (going "online")

Description

With the procedure described above, the project has been created and your frequency inverter is integrated into the project tree. However, there is no online connection.

- Click on  ("Connect to the target system"), in order to go online with the frequency inverter.

The left-hand column in the dialog box below contains the online data that has been saved, while the right-hand column contains the offline data that has been saved.

- Click on "Load HW configuration to PG" to download the online data into your PC.

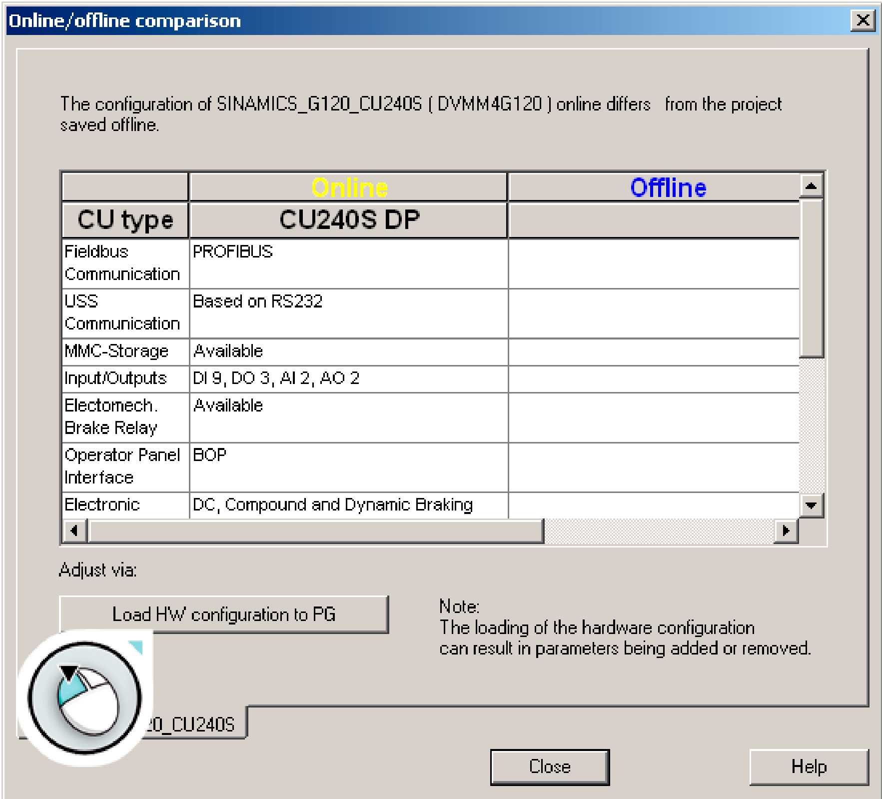


Figure 4-10 Frequency inverters found online (using the SINAMICS G120 with Control Unit CU240S DP as example)

- To conclude your entry, choose "Close".
- The status display changes from the "Offline mode" with blue background into the "Online mode" with yellow background.

4.5.3 Starting the general commissioning

Description

- When the final dialog box in the "Going online" section is closed, the text "Offline mode" in the bottom right of the dialog box changes to "Online mode".

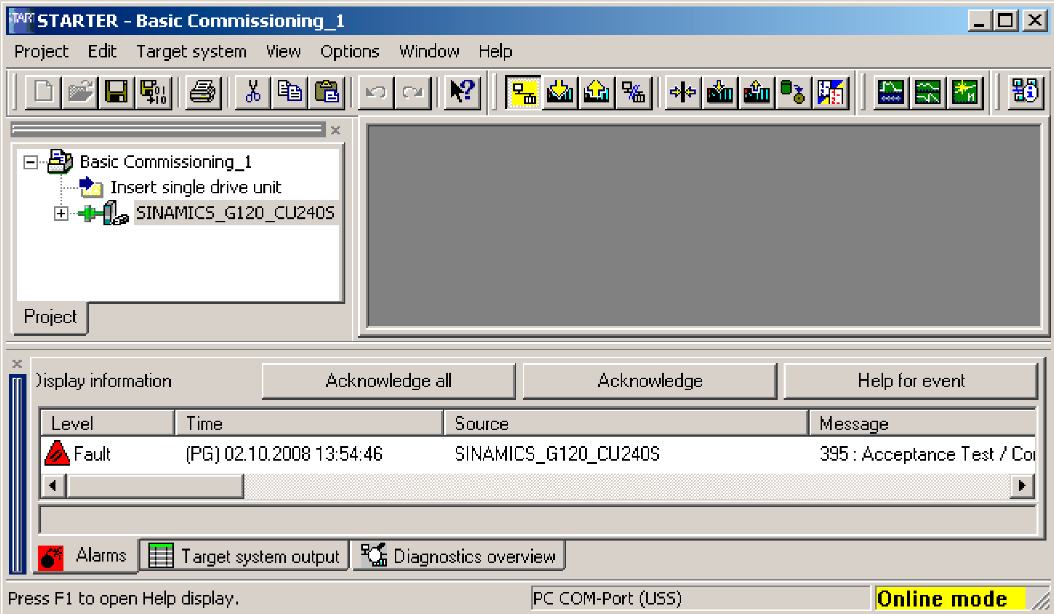
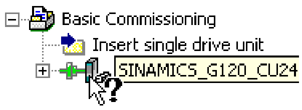


Figure 4-11 Going online with STARTER (example with SINAMICS G120)

- For modular frequency inverters that comprise a Control Unit and Power Module, when first powered-up and after replacing a control unit or a Power Module, message F0395 is output. This message is intentional and does not indicate that the inverter is faulty. This message monitors the individual frequency inverter components (CU and PM) against unauthorized replacement.
- Select and acknowledge message F0395 that is present as described in the Section "Initial coupling of the CU and PM".

Note

For information about the symbols used in STARTER, call up the online help. Press <Shift><F1> and choose the relevant symbol. For example:



- Open the drive unit ( ), by double clicking on the drive object ( )
- Click on "Wizard ..." for the (basic) commissioning, and let the Wizard guide you.

Carrying out commissioning

You Project Wizard navigates you step-by-step using pull-down menus through the basic settings for your application.

- You get to the next menu item by pressing, choose "Next".

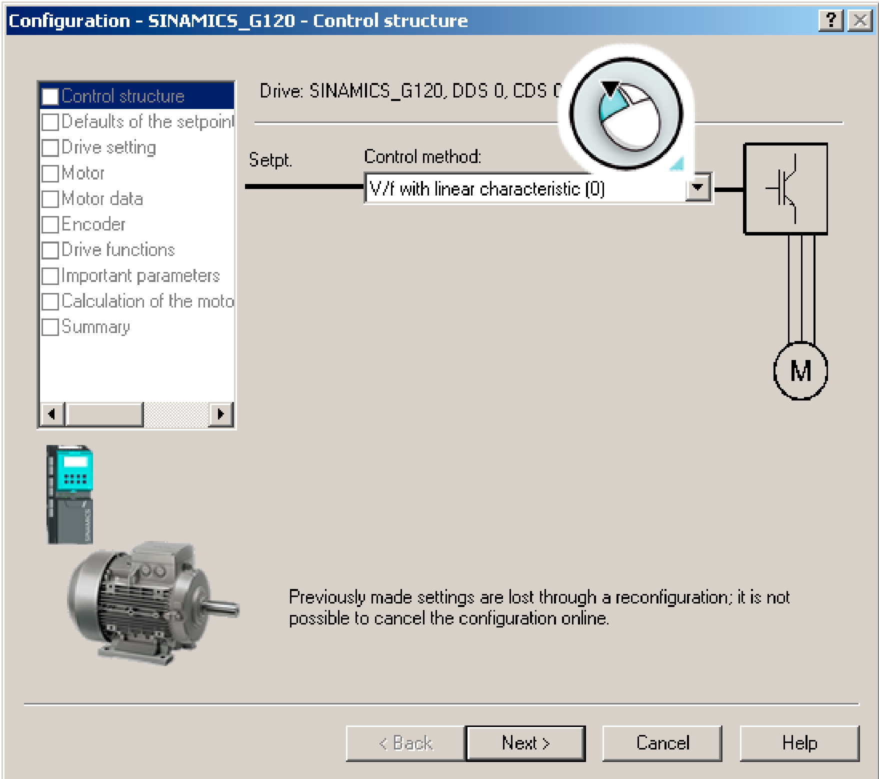


Figure 4-12 Start field: commissioning

- For the "Drive functions" menu item, we recommend that motor data identification: "Locked" should be selected.

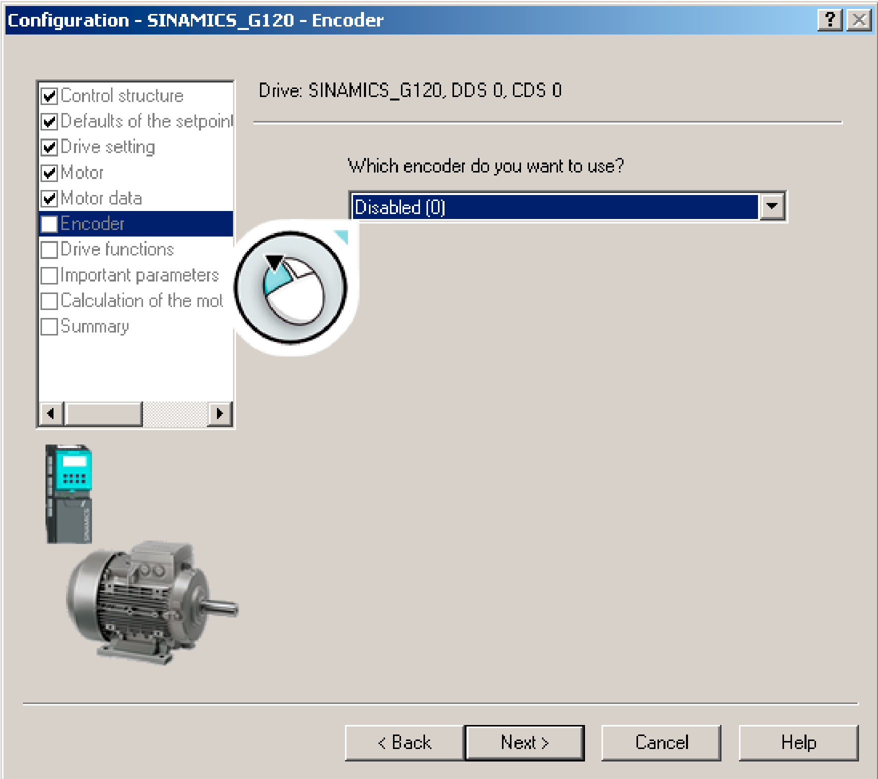


Figure 4-13 Deselecting motor data identification

Note

Motor data identification

Motor data identification is only required for vector control - and it is described there.

- For the menu item "Calculation of the motor data", we recommend that you select "Restore factory setting and calculate motor data".

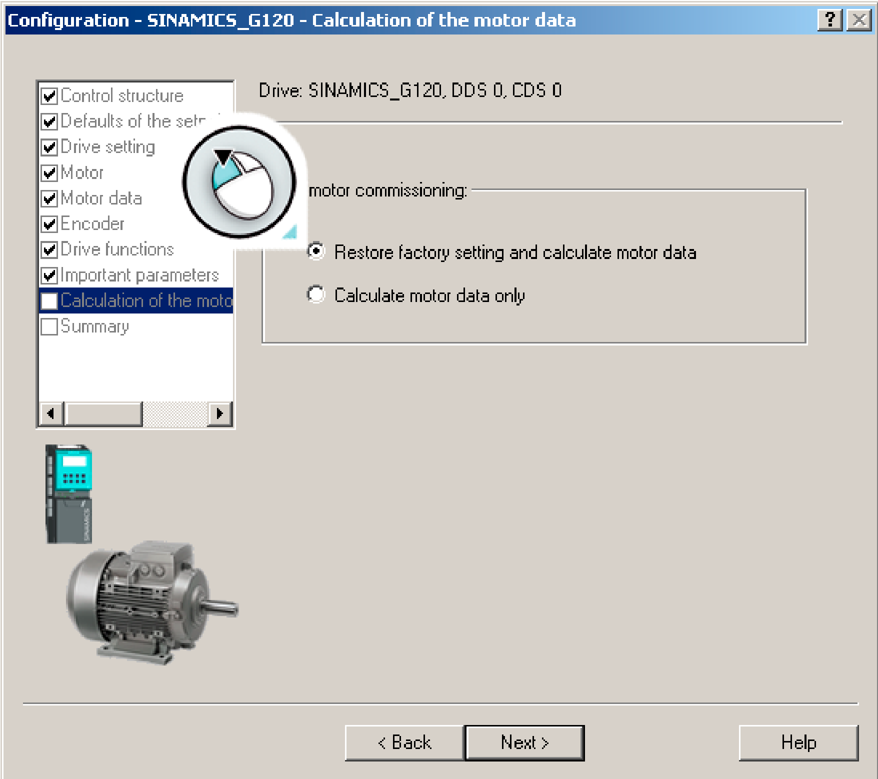


Figure 4-14 Calculating the motor data and restoring the factory setting

- The Project Wizard for the (first) commissioning is concluded with the following summary:

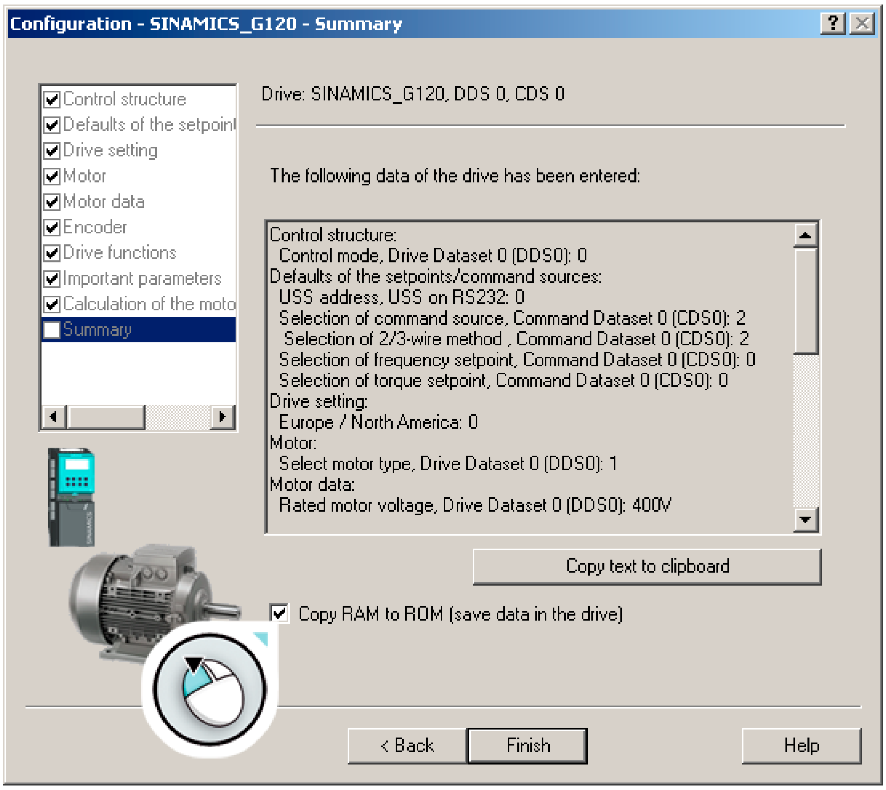


Figure 4-15 Completing commissioning

- Finally, choose "Finish".

4.5.4 Commissioning the application

Description

- You can now commission your application using the "Drive Navigator" screens or by using the functions available in the project tree.
- Save your settings so that they are protected against power failure (see below).
- Once you have commissioned your application, disconnect the online connection between the PC and converter by clicking on .

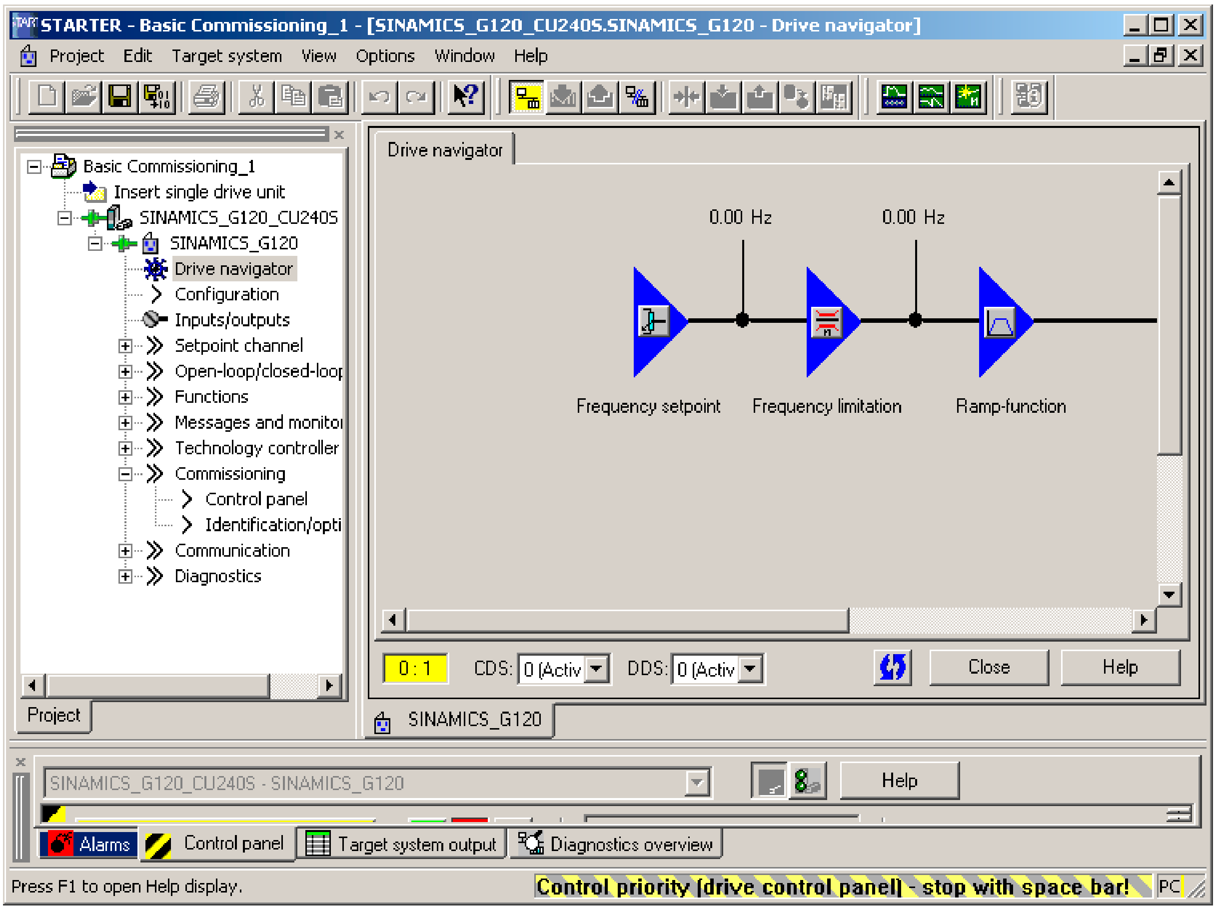


Figure 4-16 Application communication

Saving data so that it is protected against power failure

- In the project tree, select your SINAMICS project
- Double-click on "Drive Navigator".
- Select "Commissioning" in the working area
- In the dialog box, select "Save data in the drive (RAM to ROM)".

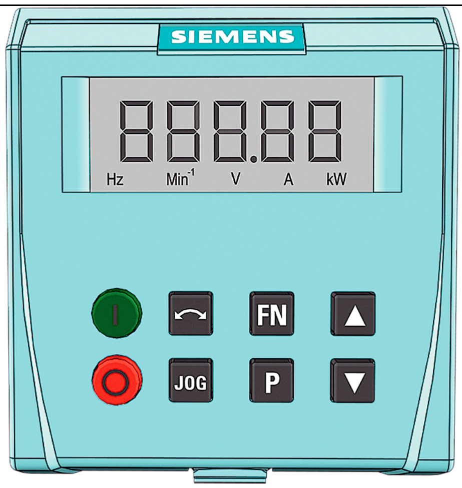
You can now disconnect the online connection with "Disconnect from target system"

4.6 Commissioning with the operator panel

4.6.1 Function of the Basic Operator Panel

The Basic Operator Panel (BOP) offers various commissioning options and ways of Saving and transferring data using the BOP (Page 77).

The Basic Operator Panel for 'local' operation and how to attach it to the Control Unit



How to attach the BOP to the Control Unit.

The Basic Operator Panel is an input and display instrument that allows you to operate inverters "locally". A BOP can be used for more than one inverter and is mounted directly on a Control Unit.

The Basic Operator Panel can be used to commission drives, monitor operation and set individual parameters. Parameter changes that are made using the BOP are saved so that they are protected against power failure.

It has eight keys and a two-line screen for displaying values and units.

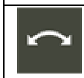
Line 1 shows a parameter number or value

Line 2 shows the corresponding physical unit

The keys can be used, for example, to set control signals and the speed setpoint.

4.6.2 BOP controls and displays

How to use the BOP

Key	Function	Function / result
r0000	Status LED	Shows parameter numbers, values, and physical units of measure.
P	Parameter access	This button allows you to access the parameter list. r _ _ _ _ read-only parameters: for display only P_ _ _ _ write parameters: these can be changed
▲	Increase displayed values	This button allows you to scroll forwards in the parameter list;
▼	Decrease displayed values	This button allows you to scroll backwards in the parmeter list.
FN	Function key	The function of this button varies depending on the data displayed: If a parameter **number** is displayed and you press this button once briefly, you can return to the start of the parameter list r0000. If a parameter **value** is displayed and you press this button once briefly, the cursor jumps to the next position (e.g. in a multi-digit number). This allows you to change a decimal number digit by digit, for example. If an alarm or a fault **message** is displayed and you press this button once briefly, this acknowledges the message.
I	Start motor	Press this button to start the motor. In the factory setting, this button is not active. To activate it, set P0700 = 1.
O	Stop motor	Press this button to stop the motor. OFF2 is always activated: Press twice briefly or press once for longer: The motor coasts to a standstill. In the factory setting, OFF1 is not active. To activate it, set P0700 = 1.
	Change direction of rotation	When you press this button, the direction of motor rotation is reversed (CW/CCW). In the factory setting, this button is not active. To activate it, set P0700 = 1.
JOG	Jog mode	Run the motor in jog mode. The motor rotates at a predefined speed for as long as this key is pressed (and kept down). In the factory setting, this button is not active. To activate it, set P0700 = 1.

4.6.3 Parameterization with the BOP (two examples)

All of the parameter changes, which are made using the BOP, are saved so that they are protected against power failure.

Changing a parameter value using the BOP

The following description is an example of how to change any parameter using the BOP.

Table 4- 3 Change P0003 (set user access level "3")

	Step	Result displayed
1	Press P to access the parameters.	r0000
2	Press ▲ until P0003 is displayed.	P0003
3	Press P to display the parameter value.	1
4	Press ▲ or ▼ to set the required value (to 3).	3
5	Press P to confirm and save the value.	P0003
6	The user can now view all parameters in steps 1 to 3.	

Using the BOP to change parameters with more than one index

The next example shows how the value of an indexed parameter can be changed.

Table 4- 4 Change index parameter P0700 (set command source "BOP" under index 1)

	Step	Result displayed
1	Press P to access the parameters.	r0000
2	Press ▲ as often or as long as required until P0700 is displayed.	P0700
3	Press P: index "in000" is displayed.	in000
4	Press ▲ or ▼ to select index 1.	in001
5	Press P to display the value that is currently set.	0
6	Press ▲ or ▼ until the required value is displayed.	1
7	Press P to confirm and save the value.	P0700
8	Press ▼ until r0000 is displayed.	r0000
9	Press P to reset the display to the standard drive display (as defined by the customer).	

Note

When parameter values are being changed, the BOP sometimes displays the message **"bUSY"**. This means that the inverter is currently processing a higher-priority task.

4.6.4 Commissioning steps

The following section provides a step-by-step guide to quick commissioning, which is sufficient for the majority of applications.

The first step in commissioning a drive train is to ensure that the converter and motor are harmonized. This converter-motor combination can then be adapted in line with the requirements of the drive machine

The frequency inverter is adapted to the requirements of an application by parameterizing it. A corresponding parameter list with explanations is provided on the following pages.

4.6.5 Commissioning V/f control

Since the load characteristic can be set as required, V/f control is sufficient for many drive trains. A drive train that operates with *V/f control with a linear characteristic* can be set by entering the following parameters.

Parameter settings for V/f control

Table 4- 5 **Setting the access level and parameter filter**

Parameter	Description
P0003 = 1	**User access level** 1: Standard: Allows access to the most frequently used parameters (factory setting) 2: Extended: Allows extended access, e.g. to inverter I/O functions 3: Expert: For experts only
P0010 = 1	**Commissioning parameter filter** 0: Ready (factory setting) 1: Quick commissioning 30: Factory setting To parameterize the motor rating plate data, set P0010 = 1.

Table 4- 6 **Data on the environmental conditions at the installation location**

Parameter	Description
P0100 = 0	**Europe / North America (line frequency of region)** 0: Europe [kW], standard frequency 50 Hz (factory setting) 1: North America [hp], standard frequency: 60 Hz 2: North America [kW], standard frequency: 60 Hz
P0230 = 0	**Shows the selected output filter** 0: No filter (factory setting)
P0233 = ...	**Filter inductance of the output filter used** 0.000 (factory setting)
P0234 = ...	**Filter capacitance of the output filter used** 0.000 (factory setting)

Table 4- 7 **Motor data in accordance with the specifications on the motor rating plate**

Parameter	Description
P0304 = …	**Rated motor voltage** (enter value as specified on the motor rating plate in Volt) 400 [v] (factory setting) The rating plate data entered must correspond to the motor connection type (star/delta) (i.e. with a delta motor connection, the delta rating plate data must be entered).
P0305 = …	**Rated motor current** (enter value as specified on the motor rating plate in Ampere) 1 [A] (factory setting)
P0307 = …	**Rated motor power** (enter value as specified on the motor rating plate in kW or hp) 0.37 [kW / hp] (factory setting) If P0100 = 0 or 2, the data is specified in kW If P0100 = 1, the data is specified in hp.
P0308 = ...	**Rated motor power factor [cos phi]** 0.820 (factory setting) This parameter is irrelevant when P0100 = 1 or 2.
P0310 = …	**Rated motor frequency** (enter value as specified on the motor rating plate in Hz) 50.00 [Hz] (factory setting) When this parameter is changed, the number of pole pairs for the motor is automatically recalculated.
P0311 = …	**Rated motor speed** (enter value as specified on the motor rating plate in rpm) 1395 [U / min]

Table 4- 8 **Specify command source and frequency setpoint source**

Parameter	Description
P0700 = 2 or 6	**Select the command source** 0: factory setting (restores factory settings for CU) 1: BOP (Basic Operator Panel keys) 2: Digital inputs (factory setting for 'stand-alone' CUs) 4: USS on RS 232 5: USS on RS 485 6: Fieldbus (factory setting for fieldbus-capable CUs)
P1000 = 2 or 6	**Select the setpoint source** 0: No main setpoint 1: MOP setpoint 2: Analog setpoint (factory setting for stand-alone CUs) 3: Fixed frequency 4: USS on RS 232 5: USS on RS 485 6: Fieldbus (factory setting for fieldbus-capable CUs) 7: Analog setpoint 2

Table 4- 9 **Parameters that must be set in every application**

Parameter	Description
P1080 = …	**Minimum frequency** 0.00 [Hz] factory setting Enter the minimum frequency (in Hz) at which the motor runs independently of the frequency setpoint. The value set here applies to CW and CCW rotation.
P1082 = …	**Maximum frequency** 50.00 [Hz] factory setting Enter the maximum frequency (in Hz) to which the motor is restricted independently of the frequency setpoint. The value set here applies to CW and CCW rotation.
P1120 = …	**Rampup time** 10.00 [s] Enter the time (in seconds) in which the motor is to accelerate from standstill to the maximum frequency (P1082). If the ramp-up time is too short, alarm A0501 (current limit value) may be output or the inverter is shut down with fault F0001 (overcurrent).
P1121 = …	**Rampdown time** 10.00 [s] Enter the time (in seconds) during which the motor is to be decelerated (braked) from the maximum frequency (P1082) to standstill. If the ramp-down time is too short, alarm A0501 (current limit value) or A0502 (overvoltage limit value) may be output or the inverter is shut down with fault F0001 (overcurrent) or F0002 (overvoltage).

Table 4- 10 **End quick commissioning (= start internal motor data calculation)**

Parameter	Description
P3900 = 1	**End quick commissioning** 0: No quick commissioning (factory setting) 1: Quick commissioning incl. restoring factory settings - Calculate the motor data with the quick commissioning parameters - Restore the factory settings for the I/O - Restore the factory settings for all other parameters 2: Quick commissioning incl. restoring the factory settings for the I/O. - Calculate the motor data with the modified quick commissioning parameters - Restore the factory settings for the I/O - All the other parameters remain unchanged 3: Quick commissioning with motor data only - Calculate the motor data with the quick commissioning parameters - I/O settings remain unchanged - All the other parameters remain unchanged When P3900 = 1, 2, or 3, the value for P1082 is written to P2000. When quick commissioning is being completed, the message **"bUSY"** is displayed on the BOP. This means that the system is in the process of calculating the control data and saving the parameter values in the EEPROM. Once quick commissioning has been carried out, P3900 and P0010 are set to 0. When you press "FN" and "P" on the BOP, the actual frequency is displayed.

4.7 Data backup with the operator panel and memory card

4.7.1 Saving and transferring data using the BOP

The Operator Panel as a medium to backup and transfer data

You can save a parameter set on the Operator Panel and transfer it to other frequency inverters, e.g. to identically parameterize several devices or to transfer the settings after a device has been replaced.

Prerequisites for transferring data sets from the Operator Panel to a different inverter

The Control Unit to which the parameter set is transferred must be of the same type and have the same firmware release as the source Control Unit. (Same 'type' means: The same Order No.)

Saving the parameters on the Operator Panel (upload)

Parameter	Description
P0003 = 3	3: Access level 3
P0010 = 30	30: Parameter transfer
P0802 = 1	1: Start data transfer from the EEPROM to the Operator Panel.
	• If the upload procedure is successful, P0010 and P0802 are set to 0 and the "RDY" LED lights up. • If the download procedure is unsuccessful, F0055 or F0057 is displayed and the LED "SF" (red) lights up. Make another attempt to transfer the data.

Transferring parameters from the Operator Panel into the frequency inverter (download)

Parameter	Description
P0003 = 3	3: Access level 3
P0010 = 30	30: Parameter transfer
P0803 = 1	1: Starting data transfer from the BOP to the EEPROM
	• If the upload procedure is successful, P0010 and P0803 are set to 0 and the "RDY" LED lights up. • If the download procedure is unsuccessful, F0055 or F0057 is displayed and the LED "SF" (red) lights up. In this case, make another attempt to transfer data.

4.7.2 Saving and transferring data using the MMC

The MMC memory card as a medium for backing up and transferring data

You can save a parameter set on the memory card and transfer it to other frequency inverters, e.g. to identically parameterize several devices or to transfer the settings after a device has been replaced.

Data backup

The MMC is a removable, non-volatile flash memory for the parameter set of a frequency inverter and does not require a power supply. For instance, this can be used to transfer parameter settings to a new frequency inverter after the previous one was replaced.

We recommend that memory card MMC (Order No.: 6SL3254-0AM00-0AA0) should be used.

Prerequisites for transferring data sets from the MMC to a different inverter

The Control Unit to which the parameter set is transferred must be of the same type and have the same firmware release as the source Control Unit. (Same 'type' means: The same Order No.)

Backup the parameters on the MMC memory card (upload)

Parameter	Description
Insert MMC	
A0564	This alarm means that the MMC was inserted while the device was in operation and that no MMC was inserted when the inverter was started.
P0003 = 3	3: Access level 3
P0010 = 30	30: Parameter transfer
P0802 = 2	2: Start data transfer from the EEPROM to the MMC. "RDY" LED flashes.
	• If the upload procedure is successful, P0010 and P0802 are set to 0 and the "RDY" LED lights up. • If the download procedure is unsuccessful, F0061 or F0062 is displayed and the LED "SF" (red) lights up. In this case, make another attempt to transfer data.

Note

Time it takes to save the data

It can take several minutes to transfer data to the MMC memory card.

Transferring the parameters from the MMC memory card into the frequency inverter (download)

Parameter	Description
P0003 = 3	3: Access level 3
P0010 = 30	30: Parameter transfer
P0803 = 2	2: Start data transfer from the MMC to the EEPROM in the CU. "RDY" LED flashes.
	• If the upload procedure is successful, P0010 and P0803 are set to 0 and the "RDY" LED lights up. • If the download procedure is unsuccessful, F0061 or F0062 is displayed and the LED "SF" (red) lights up. In this case, make another attempt to transfer data.

Functions

5

5.1 Overview of inverter functions

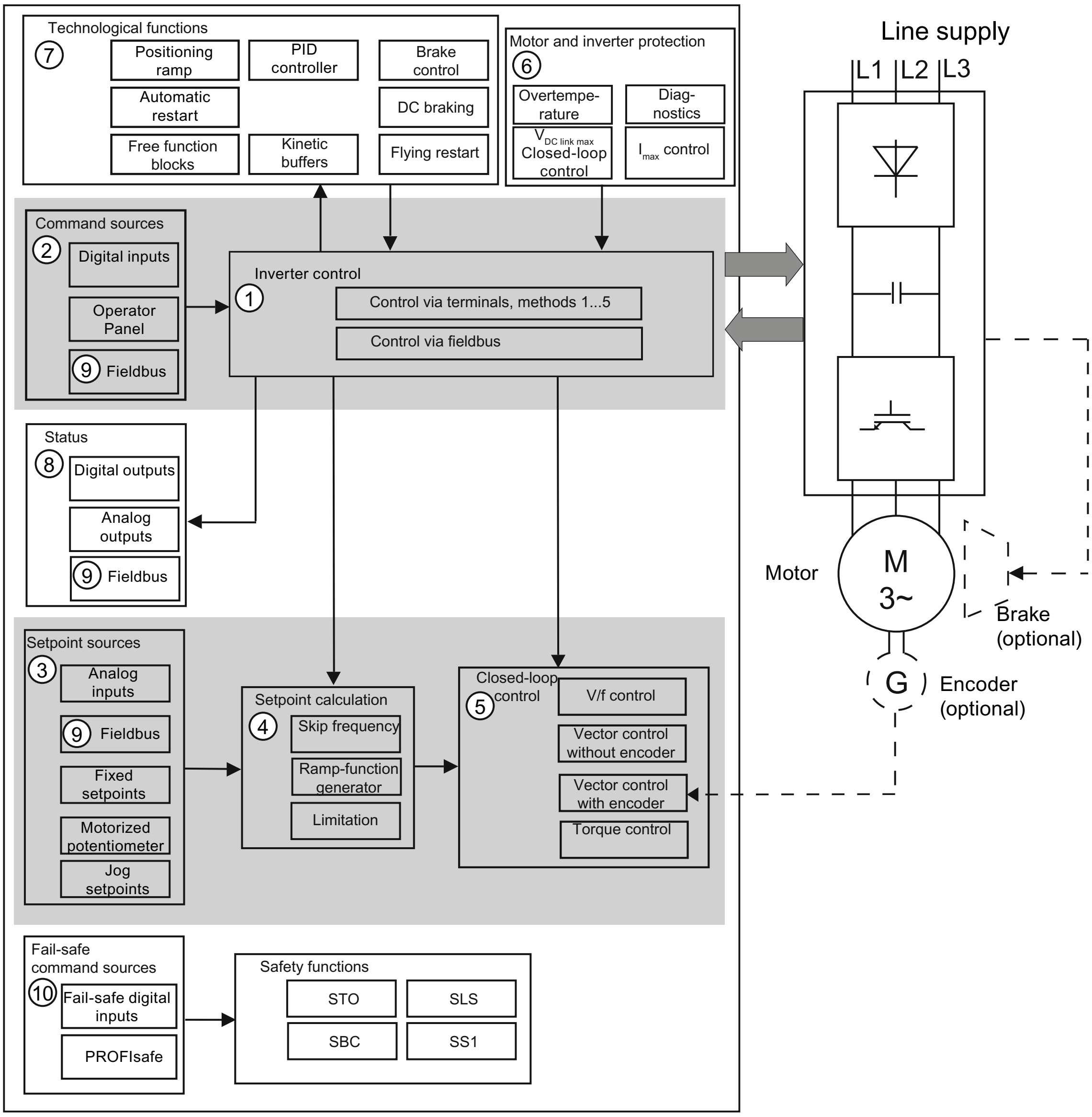


Figure 5-1 Overview of the functions in the frequency inverter
The functions that you need in each application have a gray background.

Functions relevant to all applications

① **Inverter control** is responsible for all of the other frequency inverter functions. Among other things, it defines how the inverter responds to external control signals.

② The **command source** defines whether the motor is powered-up and powered-down via terminals (digital inputs) or a fieldbus.

③ The **setpoint source** defines how the speed setpoint is entered, e.g. via terminals (analog input) or via a fieldbus.

④ The **setpoint calculation**uses a ramp-function generator to prevent speed steps occuring and to limit the speed to a permissible maximum value.

⑤ The **closed-loop control** ensures that the motor follows the speed setpoint. It offers both V/f control, which is easy to configure, and vector control, which is more complex.

Functions required in special applications only

⑥ The **motor and frequency inverter protection** avoids overloads and operating states that could cause damage to the motor and frequency inverter. The motor temperature monitoring is, e.g. set here.

⑦ The **technological functions** allow you to activate a motor holding brake or implement a higher-level pressure or temperature control using the technology controller, for example.

⑧ The **status messages** provide binary and analog signals at the terminals or via the fieldbus. Examples include the current speed of the motor or fault messages issued by the inverter.

⑨ A **connection to a fieldbus** can be established via software tools in the control systems. How this is carried out with a SIMATIC controller is described in a separate section.

⑩ The **safety functions** are only available for fail-safe frequency inverters.

5.2 Inverter control

5.2.1 Frequency inverter control using digital inputs (two/three-wire control)

Configuring start, stop and direction of rotation reversal using digital inputs

If the frequency inverter is controlled using digital inputs, using parameter P0727, you can define how the motor responds when it is started, stopped, and the direction of rotation is changed (reversing).

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

The wide range of setting options is especially intended to be able to emulate existing control methods on the plant or system side if the frequency inverter has to be integrated into an existing application. The two most common methods use the factory setting (P0727 = 0) and are available as standard in SINAMICS frequency inverters.

Note

When CW rotation is activated, the frequency inverter generates a CW voltage characteristic at its output terminals. Whether the connected motor actually rotates CW depends on the wiring between the frequency inverter and motor.

Factory setting for "start", "stop", and "direction reversal" control commands

In the factory setting (P0727 = 0), the motor is operated using two control commands. In this case, two variants are available

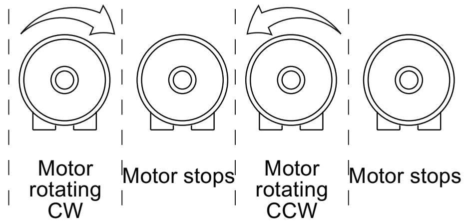
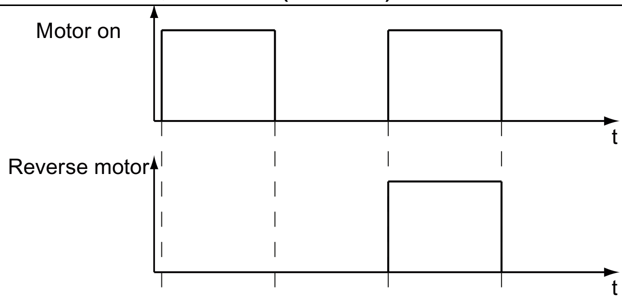
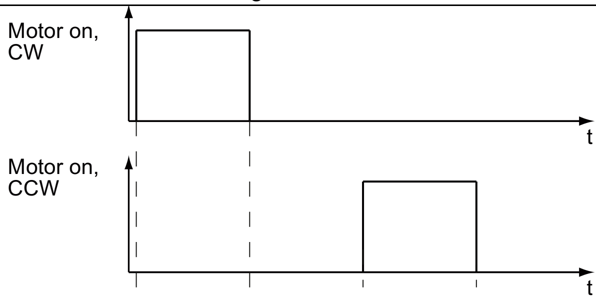
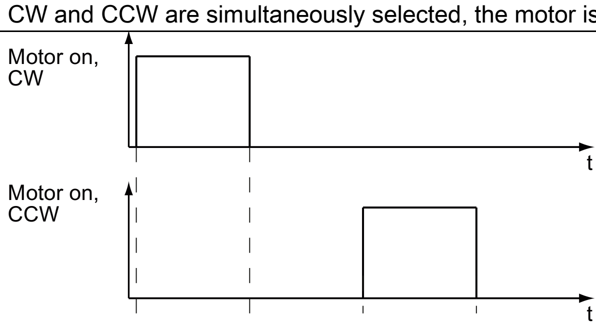
Further methods for "start", "stop", and "direction reversal" control commands

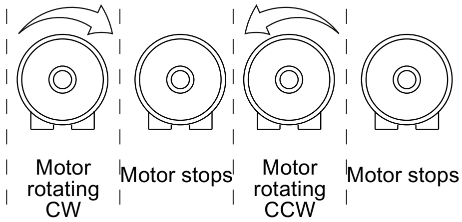
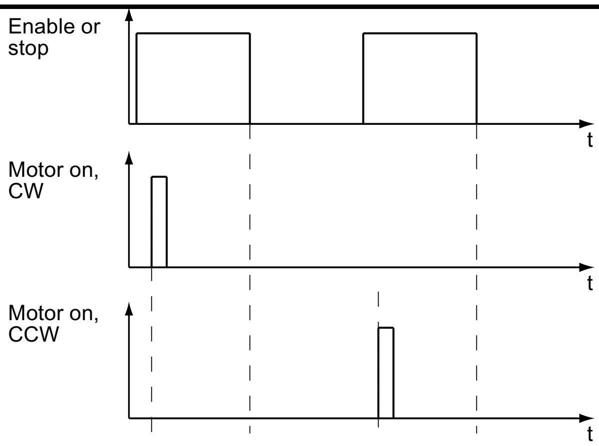
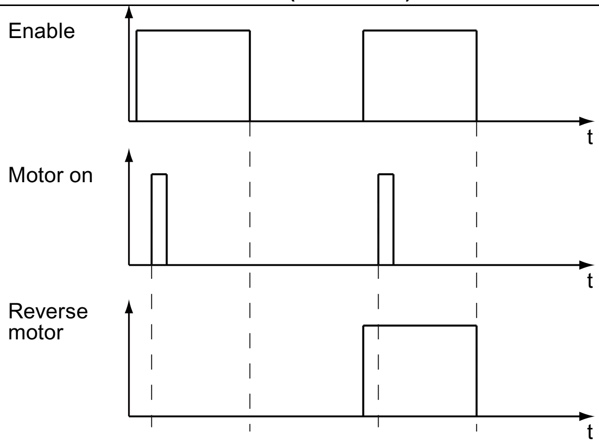
Parameter P0727 offers three additional methods for controlling the motor.

- Method 3 for controlling the motor is ideal for drives where the direction of rotation is manually changed, for instance, traction drives that are controlled from a master switch. It is similar to method 2, but differs with respect to how the motor responds when both control commands are present at the same time. In contrast to method 2, it also allows you to change the direction of rotation at any time.
- Two further methods are available for controlling motors, each of which use three control commands. With these methods, the motor is no longer controlled via the signal level only but also with the positive signal edges of certain commands.

  Just the same as method 3 of the two-wire control, the first three-wire control method is especially suitable for drives where the direction of rotation is manually reversed.

Table 5- 1 Comparison of the methods to control the motor using two-three wires

<table>
<tr><th>Control signals

</th><th>Description</th></tr>
<tr><td colspan="2">Two-wire control, method 1 (P0727=0)</td></tr>
<tr><td>
</td><td>1. Control command: Switch the motor on or off
2. Control command: Reverses the motor direction of rotation</td></tr>
<tr><td colspan="2">Two-wire control, method 2 (P0727=0)
If CW and CCW rotation are selected simultaneously, the signal that was issued first has priority. The signal that is received late is ignored.</td></tr>
<tr><td>
</td><td>1. Control command: Switch on or switch off the motor CW rotation
2. Control command: Switch on or switch off the motor CCW rotation
Reversing is not possible as long as the motor is still rotating</td></tr>
<tr><td colspan="2">Two-wire control, method 3 (P0727=1)
When CW and CCW are simultaneously selected, the motor is stopped.</td></tr>
<tr><td>
</td><td>1. Control command: Switch on or switch off the motor CW rotation
2. 2. Control command: Switch on or switch off the motor CCW rotation
Reversing is possible at any time</td></tr>
<tr><td colspan="2">Three-wire control, method 1 (P0727 = 2)</td></tr>
</table>

Control signals	Description
	
	1. Control command: Enable the motor so that it can be switched on or switched off 2. Control command: Switch on motor cw rotation 3. Control command: Switch on motor CCW rotation
Three-wire control, method 2 (P0727 = 3)	
	1. Control command: Enable the motor so that it can be switched on or switched off 2. Control command: Switch the motor on or off 3. Control command: Enter CW or CCW rotation of the motor

A detailed description of all of the methods to control a motor can be found in the following sections.

5.2.2 Two-wire control, method 1

Function description

This control method uses two control commands as permanent signals.

One control command starts/stops the motor, while the other control command changes the direction of rotation.

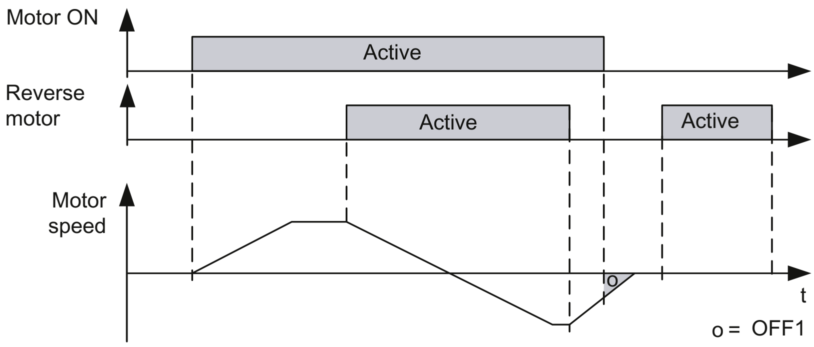


Figure 5-2 Two-wire control using digital inputs, method 1

Table 5- 2 Function table

Motor ON	Reverse motor	Function
0	0	OFF1: The motor decelerates to a standstill
0	1	OFF1: The motor decelerates to a standstill
1	0	The motor accelerates to the setpoint
1	1	The motor accelerates to the inverted setpoint

Table 5- 3 **Parameterizing the function**

Parameter	Description
P0700 = 2	Controls the motor using the digital inputs of the frequency inverter
P0727 = 0	Two-wire control, method 1 or 2
P0701 = 1	**The motor is power-up with digital input 0** Further options: The motor can be powered-up with any other digital input, e.g. with digital input 3 via P0704 = 1
P0702 = 12	**The motor is reversed with digital input 1** Further options: The motor can be reversed with any other digital input, e.g. with digital input 3 via P0704 = 12

5.2.3 Two-wire control, method 2

Function description

This control method uses two control commands as permanent signals.

CW and CCW rotation of the motor is started and stopped with one control command each. To change the direction, the drive must first decelerate to 0 Hz with OFF1 before the direction reversal signal is accepted.

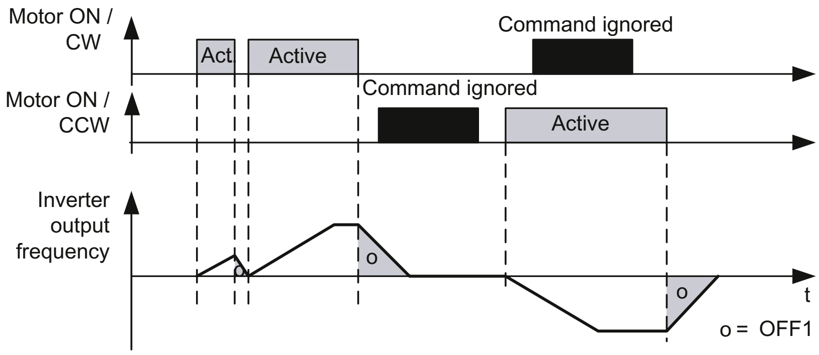


Figure 5-3 Two-wire control using digital inputs, method 2

Table 5- 4 Function table

Motor ON / CW	Motor ON / CCW	Function
0	0	OFF1: The motor decelerates to a standstill
0	1	The motor accelerates to the inverted setpoint
1	0	The motor accelerates to the setpoint
1	1	The first active signal has priority; the second signal is ignored.

Table 5- 5 **Parameterizing the function**

Parameter	Description
P0700 = 2	Controls the motor using the digital inputs of the frequency inverter
P0727 = 0	Two-wire control, method 1 or 2
P0701 = 1	**CW rotation is activated with digital input 0** Further options: CW rotation can be activated with any other digital input, e.g. with digital input 3 via P0704 = 1
P0702 = 2	**CCW rotation is activated with digital input 1** Further options: CCW rotation can be activated with any other digital input, e.g. with digital input 3 via P0704 = 2

5.2.4 Two-wire control, method 3

Function description

This control method uses two control commands as permanent signals.

Like method 2, CW and CCW rotation can be started/stopped by one control command each. In contrast to method 2, however, the control commands can be switched at any time regardless of the setpoint, output frequency, and direction of rotation. The motor does not have to coast to 0 Hz either before a control command is executed.

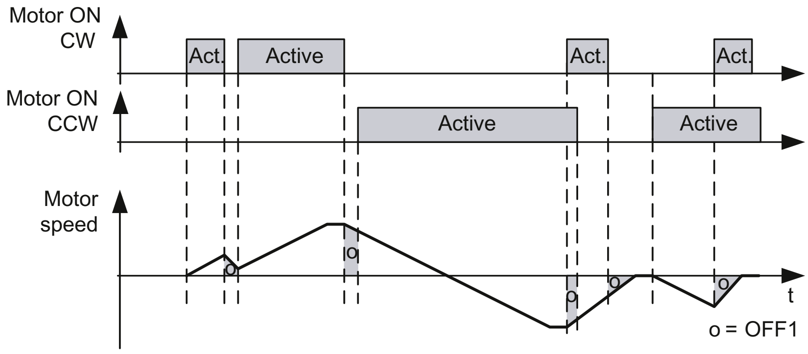


Figure 5-4 Two-wire control using digital inputs, method 3

Table 5- 6 Function table

Motor ON / CW	Motor ON / CCW	Function
0	0	OFF1: The motor decelerates to a standstill
0	1	The motor accelerates to the inverted setpoint
1	0	The motor accelerates to the setpoint
1	1	OFF1: The motor decelerates to a standstill

Table 5- 7 **Parameterizing the function**

Parameter	Description
P0700 = 2	Controls the motor using the digital inputs of the frequency inverter
P0727 = 1	Two-wire control, method 3
P0701 = 1	**CW rotation is activated with digital input 0** Further options: CW rotation can be activated with any other digital input, e.g. with digital input 3 via P0704 = 1
P0702 = 2	**CCW rotation is activated with digital input 1** Further options: CCW rotation can be activated with any other digital input, e.g. with digital input 3 via P0704 = 2

5.2.5 Three-wire control, method 1

Function description

- The first control command is a permanent enable signal for starting the motor. When this enable signal is canceled, the motor stops.
- CW rotation is activated with the positive edge of the second control command.
- CCW rotation is activated with the positive edge of the third control command.

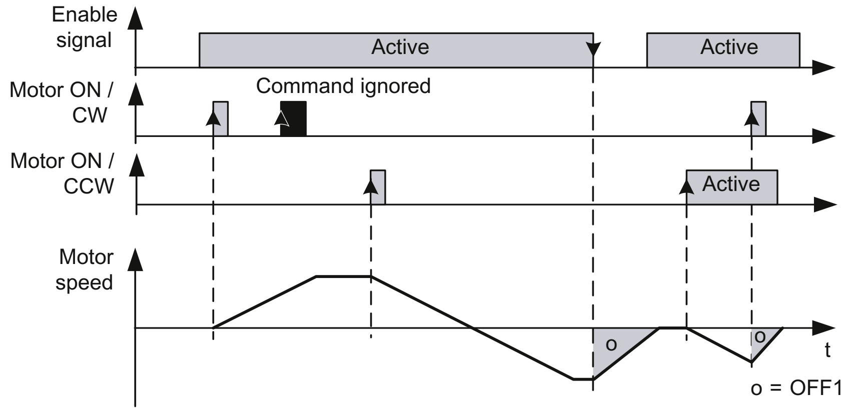


Figure 5-5 Three-wire control using digital inputs, method 1

Table 5- 8 Function table

Enable signal	Motor ON / CW	Motor ON / CCW	Function
0	Not relevant	Not relevant	OFF1: The motor decelerates to a standstill
1	0→1	0	The motor accelerates to the setpoint
1	0	0→1	The motor accelerates to the inverted setpoint
1	0	0	No effect on the direction of rotation.
1	1	1	OFF1: The motor decelerates to a standstill

Table 5- 9 **Parameterizing the function**

Parameter	Description
P0700 = 2	Controls the motor using the digital inputs of the frequency inverter
P0727 = 2	Three-wire control, method 1
P0701 = 1	**The enable signal to power-up the motor is issued with digital input 0** Further options: The enable signal can be issued with any other digital input, e.g. with digital input 3 via P0704 = 1
P0702 = 2	**CW rotation is activated with digital input 1** Further options: CW rotation can be activated with any other digital input, e.g. with digital input 3 via P0704 = 2
P0703 = 12	**CCW rotation is activated with digital input 2** Further options: CCW rotation can be activated with any other digital input, e.g. with digital input 3 via P0704 = 12

5.2.6 Three-wire control, method 2

Function description

- The first control command is a permanent enable signal for starting the motor. When this enable signal is canceled, the motor stops.
- The motor is started with the positive edge of the second control command.
- The third control command defines the direction of rotation.

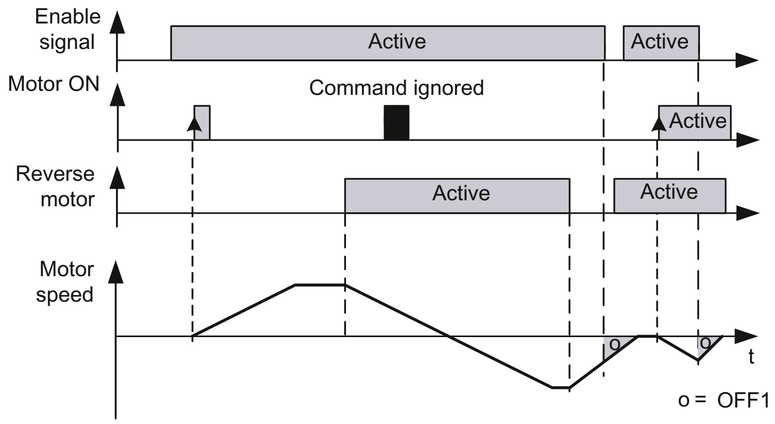


Figure 5-6 Three-wire control using digital inputs, method 2

Table 5- 10 Function table

Enable signal	Motor ON	Reverse motor	Function when motor is at a standstill	Function when motor is rotating
0	Not relevant	Not relevant	No effect	OFF1: The motor decelerates to a standstill
1	0→1	0	The motor accelerates to the setpoint.	No effect
1	0→1	1	The motor accelerates to the inverted setpoint.	No effect
1	0	1→0	No effect	The motor reverses to the setpoint.
1	0	0→1	No effect	The motor reverses to the inverted setpoint.

Table 5- 11 **Parameterizing the function**

Parameter	Description
P0700 = 3	Controls the motor using the digital inputs of the frequency inverter
P0727 = 3	Three-wire control, method 2
P0701 = 2	**The enable signal to power-up the motor is issued with digital input 0** Further options: The enable signal can be issued with any other digital input, e.g. with digital input 3 via P0704 = 2
P0702 = 1	**The motor is started with digital input 1** Further options: The motor can be started with any other digital input, e.g. with digital input 3 via P0704 = 1
P0703 = 12	**The direction of the motor is reversed with digital input 2** Further options: The direction of the motor can be reversed with any other digital input, e.g. with digital input 3 via P0704 = 12

5.3 Command sources

5.3.1 Selecting command sources

Selecting the command source [P0700]

The motor is switched on/off via external inverter control commands. The following command sources can be used to specify these control commands:

- Operator control / display instrument (Operator Panel)
- Digital inputs
- Fieldbus

The command sources available depend on the frequency inverter version.

- For frequency inverters with a fieldbus interface, the 'fieldbus' (P0700 = 6) is pre-selected as the command source,
- For frequency inverters without a fieldbus interface, the digital inputs (P0700 = 2) are pre-selected as command source.

Parameter	Description
P0700 = ...	**Select the command source** (allows you to select the digital command source) 0: Factory setting 1: OP (Operator Panel) 2: Digital inputs (P0701 … P0709), factory setting for a frequency inverter without fieldbus interface 4: USS on RS 232 5: USS on RS 485 (not available for all frequency inverters) 6: Fieldbus (P2050 … P02091), factory setting for frequency inverters with fieldbus interface.

5.3.2 Assigning functions to digital inputs

Assigning control commands to digital inputs as command sources [P0701…P071x]

The digital inputs are pre-assigned with certain control commands in the factory. However, these digital inputs can be freely assigned to a control command. Depending on the Control Unit version, SINAMICS frequency inverters are equipped with up to 9 digital inputs.

Table 5- 12 Factory setting of the digital inputs

Terminal no.: Digital input no.	Control command	Available in CU...
Terminal 5: Digital input 0 (DI0)	Switch motor on/off (ON/OFF1)	CU240S CU240S DP CU240S PN CU240S DP-F CU240S PN-F
Terminal 6: Digital input 1 (DI1)	Reverse direction of rotation	
Terminal 7: Digital input 2 (DI2)	Fault acknowledgment	
Terminal 8: Digital input 3 (DI3)	Selects fixed frequency 1	
Terminal 16: Digital input 4 (DI4)	Selects fixed frequency 2	
Terminal 17: Digital input 5 (DI5)	Selects fixed frequency 3	
Terminal 40: Digital input 6 (DI6)	Selects fixed frequency 4	CU240S CU240S DP CU240S PN
Terminal 41: Digital input 7 (DI7)	Blocked	
Terminal 42: Digital input 8 (DI8)	Blocked	

Table 5- 13 Changing the digital input settings

Terminal no.: Digital input no.	Parameter	Description
	P0003 = 2	Extended access to the parameters
Terminal 5: Digital input 0 (DI0)	P0701 = …	Possible values for P0701 to P0709: 0: Digital input disabled 1: Switch motor on/off (ON/OFF1) 2: Activate motor CW 3: Motor coasts to standstill (OFF2) 4: Rapid stop with ramp (OFF3) 9: Fault acknowledgement 10: Jog mode CW 11: Jog mode CCW 12: Change direction of rotation (reverse) 13: Increase frequency of motorized potentiometer 14: Increase frequency of motorized potentiometer 15: Select fixed frequencies (bit 0) 16: Select fixed frequencies (bit 1) 17: Select fixed frequencies (bit 2) 18: Select fixed frequencies (bit 3) 25: Enable signal for DC brake 27: Enable signal for PID technology controller 29: External fault 33: Disable additional frequency setpoint 99: The digital input can be freely used for the BICO technology
Terminal 6: Digital input 1 (DI1)	P0702 = …	
Terminal 7: Digital input 2 (DI2)	P0703 = …	
Terminal 8: Digital input 3 (DI3)	P0704 = …	
Terminal 16: Digital input 4 (DI4)	P0705 = …	
Terminal 17: Digital input 5 (DI5)	P0706 = …	
Terminal 40: Digital input 6 (DI6)	P0707 = …	
Terminal 41: Digital input 7 (DI7)	P0708 = …	
Terminal 42: Digital input 8 (DI8)	P0709 = …	

If you enable one of the digital inputs to be freely used for BICO technology (P701…P709 = 99), then you must interconnect this digital input to the required control command.

If value 99 is assigned to the digital input to define its function, this can only be reversed by restoring the factory settings.

5.3.3 Controlling the motor via the fieldbus

Control commands via the fieldbus

To control the motor via the fieldbus, the inverter must be connected to a higher-level controller via a PC tool. For more information, see "Operation in fieldbus systems".

5.4 Setpoint sources

5.4.1 Selecting frequency setpoint sources

Selecting the setpoint source [P1000]

The speed of the motor can be set via the frequency setpoint. The following sources can be used to specify the frequency setpoint:

- Analog inputs
- Fixed setpoints
- Motorized potentiometer
- Fieldbuses

The frequency setpoint sources available depend on the frequency inverter version.

- For frequency inverters with a fieldbus interface, the 'fieldbus' (P0700 = 6) is pre-selected as the frequency setpoint source.
- For frequency inverters without fieldbus interface, the analog input (P0700 = 2) is pre-selected as the frequency setpoint source.

Table 5- 14 The most important settings for selecting the frequency setpoint source

Parameter	Description
P0003 = 1	Access to the most frequently used parameters
P1000 = …	0: No main setpoint 1: MOP setpoint / motorized potentiometer (P1031 … P1040) 2: Analog setpoint (P0756 … P0762), factory setting for frequency inverters without fieldbus interface 3: Fixed frequency (P1001 … P1023) 4: USS on RS 232 6: Fieldbus (P2050 … P2091), factory setting for frequency inverters with fieldbus interface

Adding setpoints from different sources

You can add several setpoints via frequency setpoint source P1000. For more information, see the List Manual (P1000 in the parameter list and function diagram 5000).

5.4.2 Using analog inputs as a setpoint source

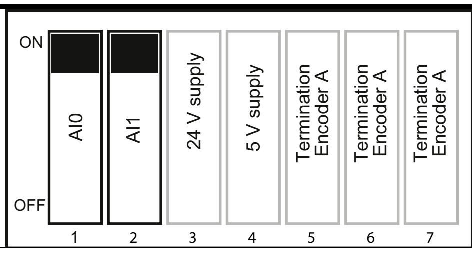
Frequency setpoint via analog input [for P1000 = 2]

Analog setpoints are read-in via the corresponding analog inputs. The setting specifying whether the analog input is a voltage input (10 V) or current input (20 mA) must be made via P0756 and in addition using the DIP switches on the Control Unit housing.

Note

Only analog input 0 (AI0) can be used as a *bipolar* voltage input.

Depending on the AI type of the source, a suitable connection must be established.

Terminal No. and Meaning		Parameter	Description
		Setting the DIP switch	
3	AI0+	P0756 [0]	Analog input 1
4	AI0-		
10	AI1+	P0756 [1]	Analog input 2
11	AI1-		
		P0756 = 0	**Analog input type (AI)** Defines the analog input type and enables analog input monitoring. 0: Unipolar voltage input (0 … +10 V) (factory setting) 1: Unipolar voltage input with monitoring (0 … +10 V) 2: Unipolar current input (0 mA …20 mA) 3: Unipolar current input with monitoring (0 … 20 mA) 4: Bipolar voltage input (-10 … +10 V)
		P0757 = 0	**Value x1 for AI scaling [V or mA]**
		P0758 = 0.0	**Value y1 of AI-scaling** This parameter shows the amount of x1 as a % of P2000 (reference frequency)
		P0759 = 10	**Value x2 for AI scaling [V or mA]**
		P0760 = 100	**Value y2 of AI-scaling** This parameter shows the amount of x2 as a % of P2000 (reference frequency)

5.4.3 Using a motorized potentiometer as a setpoint source

Frequency setpoint via motorized potentiometer (MOP) (when P1000 = 1 -> P1031)

The 'motorized potentiometer' function simulates an electromechanical potentiometer for entering setpoints. The value of the motorized potentiometer (MOP) can be set by means of the "up" and "down" control commands.

Table 5- 15 Example: Implementing the motorized potentiometer using the Operator Panel keys

Parameter	Description
P0700 = 1	**Select the command source** 1: Operator Panel keys; ON and OFF keys as well as "up" and "down" keys
P1000 = 1	**Selects the frequency setpoint source** 1: MOP setpoint
P1031 = 0	**Setpoint memory of the MOP** The last motorized potentiometer setpoint that was active prior to the OFF command or shutdown can be saved. 0: MOP setpoint is not saved (factory setting) 1: MOP setpoint is saved in P1040
P1032 = 1	**Disables the opposite direction of the MOP** 0: Reverse direction of rotation is permitted 1: Reverse direction of rotation is disabled (factory setting)
P1040 = 5	**MOP setpoint** Determines the setpoint [Hz] of the motorized potentiometer (MOP). Factory setting 5 Hz
P2000 = 50	**Reference frequency** (Hz); An MOP output value of 100% corresponds to the frequency setpoint of P2000. P2000 should be changed if a maximum frequency greater than 50 Hz is required.

5.4.4 Using the fixed frequency as a setpoint source

Frequency setpoint via fixed frequency (P1000 = 3)

The fixed frequencies are defined using parameters P1001 to P1004 and can be assigned to the corresponding digital inputs using P1020 to P1023.

Parameter	Description	
P1016 = 1	Fixed frequency mode, defines the procedure for selecting fixed frequencies. 1: Direct selection (factory setting) 2: Binary-coded selection	The fixed frequency can be selected using four digital inputs (factory setting: DI3 … DI6) and combined (e.g. summed). The factory settings support the following additional combinations:
P1001 = 0	Fixed frequency 1 (FF1) (FF values in Hz)	
P1002 = 5	Fixed frequency 2 ((FF2)	
P1003 = 10	Fixed frequency 3 (FF3)	
P1004 = 15	Fixed frequency 4 (FF4)	
P1020 = 722.3	FF1 selection using DI3	
P1021 = 722.4	FF2 selection using DI4	
P1022 = 722.5	FF3 selection using DI5	
P1023 = 722.6	FF4 selection using DI6	

Fixed Frequency selected via	FF- Par	FF [Hz]
DI3 (P1020 =722.3)	P1001 (default = 0 Hz)	0
DI4 (P1021 =722.4)	P1002 (default = 5 Hz)	5
DI5 (P1022 =722.5)	P1003 (default = 10 Hz)	10
DI6 (P1023 =722.6)	P1004 (default = 15 Hz)	15
DI3, DI4	P1001+P1002	5
DI3, DI5	P1001+P1003	10
DI3, DI6	P1001+P1004	15
DI4, DI5	P1002+P1003	15
DI5, DI6	P1003+P1004	25
DI3, DI4, DI5	P1001+P1002+P1003	15
DI3, DI4, DI6	P1001+P1002+P1004	20
DI3, DI5, DI6	P1001+P1003+P1004	25
DI3, DI4, DI5, DI6	P1001+P1002+P1003+P1004	30

Additional information about binary coded selection of the fixed frequencies (P1016 = 2) is provided in function chart 3210 of the List Manual.

5.4.5 Running the motor in jog mode (JOG function)

Run motor in jog mode [JOG function]

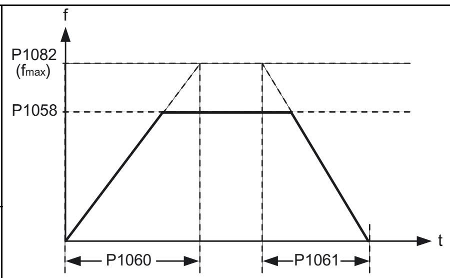
The JOG function enables you to carry out the following:

- Test the motor and converter after commissioning to ensure that they function properly (the first traverse movement, direction of rotation etc.)
- Move a motor or motor load to a specific position
- Run a motor (e.g. following program interruption)

This function allows the motor to start up or rotate with a specific jog frequency. This function can normally be activated via the JOG button on the Basic Operator Panel,

When this function is enabled, the motor starts up ("ready for operation" status) when the JOG button is pressed and rotates at the set JOG frequency. When the button is released, the motor stops. This button has no effect when the motor is already running.

Parameter	Description
P0003 = 2	User access level 2: Advanced mode
P1057 = 1	JOG enable 0: JOG function disabled 1: JOG function enabled (factory setting)
P1058 = 5	JOG frequency CW 0 Hz ... 650 Hz in JOG mode of motor in clockwise direction of rotation; 5 Hz (factory setting)
P1059 = 5	JOG frequency CCW 0 Hz ... 650 Hz in the motor JOG mode in the counter-clockwise direction; 5 Hz (factory setting)
P1060 = 10	JOG ramp-up time 0 s ... 650 s / 10 s (factory setting) Ramp-up time (in seconds) from 0 to maximum frequency (P1082). The ramp-up procedure in JOG mode is limited by P1058 or P1059.
P1061 = 10	JOG ramp-down 0 s ... 650 s / 10 s (factory setting) The ramp-down time (in seconds) from the maximum frequency (P1082) to 0.



Using BICO technology, you can also assign the JOG function to other keys.

Parameter	Description
P0003 = 3	User access level 3: Expert mode
P1055 = ...	Enable JOG CW Possible sources: 722.x (digital inputs) / 19.8 (JOG key on the Operator Panel) / r2090.8 (serial interface)
P1056 = ...	Enable JOG CCW Possible sources: 722.x (digital inputs) / 19.8 (JOG key on the Operator Panel) / r2090.9 (serial interface)

5.4.6 Specifying the motor speed via the fieldbus

Specifying the motor speed via the fieldbus

To specify the speed of the motor via the fieldbus, the inverter must be connected to a higher-level controller via a PC tool. For more information, see "Operation in fieldbus systems".

5.5 Changing over the command data sets (manual, automatic)

Switching operating priority

In some applications, the inverter is operated in different ways.

Example: switchover from automatic to manual operation

A central controller can switch a motor on/off or change its speed either via a fieldbus or via local switches. A key-operated switch close to the motor can be used to switch the operating priority of the inverter from "control via fieldbus" to "local control".

Command data set (CDS)

The inverter offers up to three different methods for parameterizing its command and setpoint sources as well as for switching between these different settings. This function allows the control priority of the frequency inverter to be changed over as described in the example above. The parameters for these functions are indicated with the index numbers 0, 1, and 2. Control commands define the switchover between the parameters by selecting one of these three indices.

The total of all switchable parameters with the same index is known as a "command data set".

Since all the switchable parameters have the same three indices (0, 1, and 2), the command and setpoint sources can only be switched together.

The following diagram shows which functions can be switched.

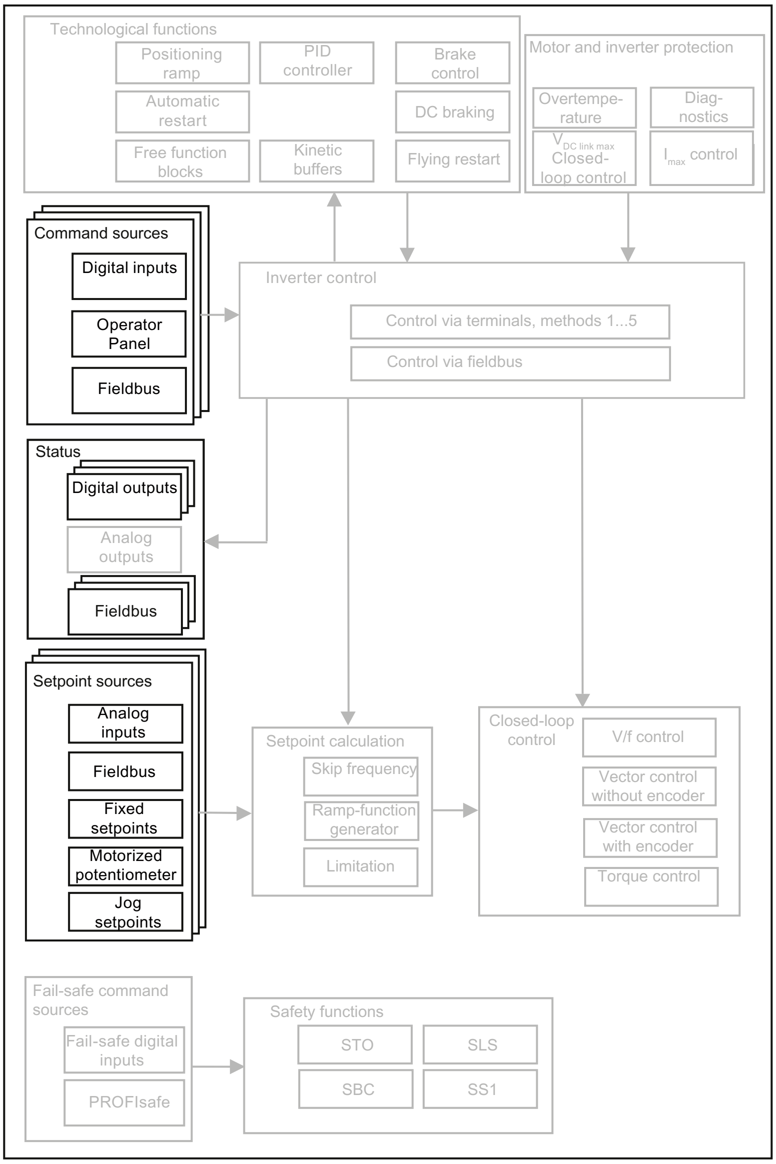
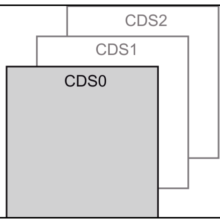
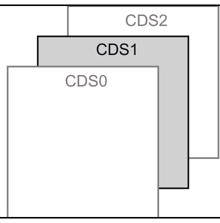
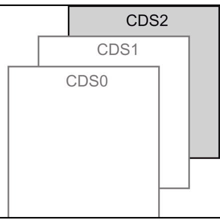


Figure 5-7 CDS switchover in the inverter

Note

Command data sets can be switched in the "ready for operation" and "operation" state. The switchover time is approx. 4 ms.

Table 5- 16 The command data sets are switched over with parameters P0810 and P0811

P0810	0	1	0 or 1
P0811	0	0	1
The CDS that is current active is gray.			
Examples	Fieldbus as setpoint source: The speed setpoint is specifed via the fieldbus.	Analog input as setpoint source: The speed setpoint is specifed via an analog input.	-
	Fieldbus as command source: The motor is switched on/off via the fieldbus.	Digital inputs as command source: The motor is switched on/off via digital inputs.	-

Parameters P0810 and P0811 are connected to control commands (e.g. the digital inputs of the inverter) by means of BICO parameterization.

Table 5- 17 Parameters for switching the command data sets:

Parameter	Description
P0810 = …	1st control command for switching the command data sets Example: When P0810 = 722.0, the system switches from command data set 0 to command data set 1 via digital input 0.
P0811 = …	2nd control command for switching the command data sets
r0050	Displaying the number of the CDS that is currently active
A copy function is available making it easier to commission more than one command data set:	
P0809.0 = …	Number of the command data set to be copied (source)
P0809.1 = …	Number of the command data set to which the data is to be copied (target)
P0809.2 = 1	Start copying

For an overview of all the parameters that belong to the drive data sets and can be switched, see the List Manual.

5.6 Setpoint preparation

Overview of setpoint preparation

The setpoint calculation 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.

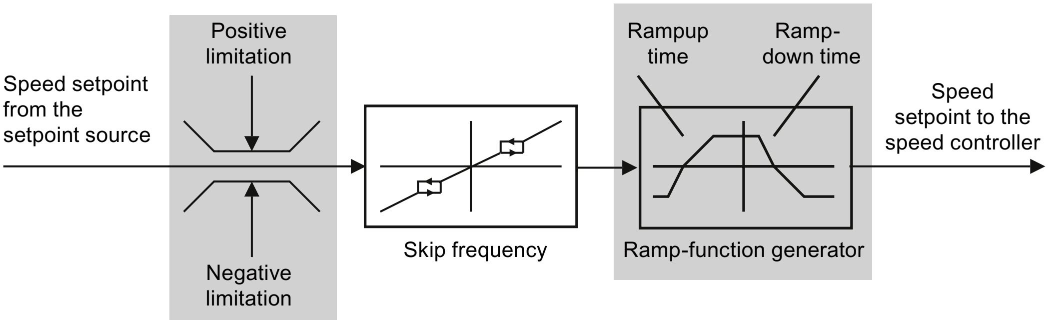


Figure 5-8 Setpoint calculation in the frequency inverter

5.6.1 Minimum frequency and maximum frequency

Limiting the speed setpoint

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

Minimum frequency

When the motor is switched on, it accelerates to the minimum frequency regardless of the frequency setpoint. The set parameter value applies to both directions of rotation. In addition to its limiting role, the minimum frequency can be used as a reference value for various monitoring functions (e.g. if a motor holding brake is engaged when the minimum frequency is reached).

Maximum frequency

The frequency setpoint is limited to the maximum frequency in both directions of rotation. A message is output if the maximum frequency is exceeded.

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

Table 5- 18 Parameters for minimum and maximum frequency

Parameter	Description
P1080 = ...	Minimum frequency
P1082 = ...	Maximum frequency

5.6.2 Parameterizing the ramp-function generator

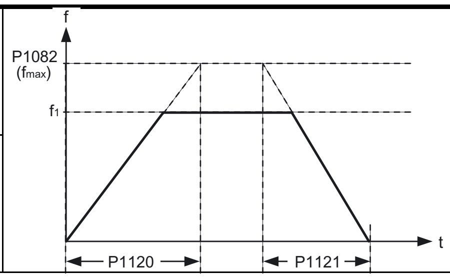
Parameterizing the ramp-function generator

The ramp-function generator in the setpoint channel limits the speed of setpoint changes. This causes the motor to accelerate and decelerate more smoothly, thereby protecting the mechanical components of the driven machine.

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.

Parameter	Description	
P1120 = …	**Ramp-up time** Duration of acceleration (in seconds) from zero speed to the maximum frequency (P1082).	
P1121 = …	**Ramp-down time** Duration of deceleration (in seconds) from the maximum frequency (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.

Rounding

Acceleration can be "smoothed" further by means of rounding. The jerk occurring when the motor starts and when it begins to decelerate can be reduced independently of each other. Rounding can be used to lengthen the motor acceleration/deceleration times. The ramp-up/down time parameterized in the ramp-function generator is exceeded.

Rounding does not affect the ramp-down time in the event of a quick stop (OFF3).

Table 5- 19 Rounding parameters

Parameter	Description
P1130 = …	**Initial rounding time for ramp up** (in seconds)
P1131 = …	**Final rounding time for ramp up** (in seconds)
P1132 = …	**Initial rounding time for ramp down** (in seconds)
P1133 = …	**Final rounding time for ramp down** (in seconds)
P1134 = …	**Rounding type**

For more information about this function, see the List Manual (function diagram 5300 and the parameter list).

5.7 Closed-loop control

Overview

There are two different open-loop and closed-loop control techniques for frequency inverters with synchronous and induction motors.

- Closed-loop control with V/f-characteristic (called V/f control)
- Field-oriented control technology (called vector control)

5.7.1 V/f control

5.7.1.1 Typical applications for V/f 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

Basic properties of 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 frequency inverter provides the two most important characteristics (linear and square-law). User-defined characteristic curves are also supported.

V/f control is not a high-precision method of controling the speed of the motor. The speed setpoint and the speed of the motor shaft are always slightly different. The deviation depends on the motor load. If the connected motor is loaded with the rated torque, the motor speed about the rated motor slip is below the speed setpoint. If the load is driving the motor (i.e. the motor is operating as a generator), the motor speed is above the speed setpoint.

5.7.1.2 V/f control with linear characteristic

V/f control with a linear characteristic is 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.

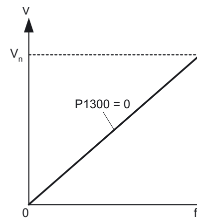


Table 5- 20 Setting the control type

Parameter	Description
P0003 = 2	Extended access to the inverter functions
P1300 = 0	Control type: V/f control with linear characteristic

Optimizing the linear characteristic for special applications

The linear characteristic of the V/f control assumes an ideal motor without resistive losses. The resistive losses in the motor stator resistance and in the motor cable reduce the available torque and must not be neglected in all applications. These losses play a more significant role the smaller the motor and the lower the motor speed.

The losses can be compensated by the V/f control by increasing the voltage at low speeds. Examples of applications where this is necessary, include:

- Holding a load
- Driven machines with a high breakaway torque
- Utilizing the brief overload capability of the motor when accelerating

Table 5- 21 Optimizing the linear characteristic

Parameter	Description
P0003 = 2	Extended access to the frequency inverter functions
P1310 = …	Voltage boost to compensate resistive losses The voltage boost is effective for all speeds below the rated speed and continually decreases as the speed increases. The maximum voltage boost is effective at zero speed and is in V: Rated motor current (P305) × stator resistance (P350) × P1310 /100
P1311 = …	Voltage boost when accelerating The voltage boost is effective from standstill up to the rated speed. The voltage boost is independent of the speed. The voltage boost in V is: Rated motor current (P305) × stator resistance (P350) × P1311 /100

Additional information about this function is provided in the parameter list and in the function diagrams 6100 and 6200 in the List Manual.

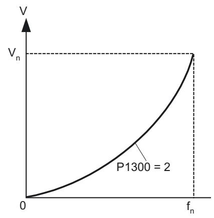
Note

Only increase the voltage boost in small steps until satisfactory motor behavior is reached. Excessively high values in P1310 and P1311 can cause the motor to overhead and switch off (trip) the frequency inverter due to overcurrent .

5.7.1.3 V/f control with parabolic characteristic

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

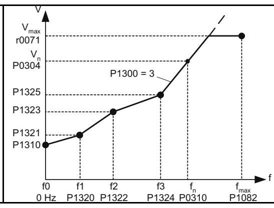
Table 5- 22 Setting the control type

Parameter	Description
P0003 = 2	Extended access to the inverter functions
P1300 = 2	**Control type:** V/f control with parabolic characteristic

5.7.1.4 Additional characteristics for the V/f control

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

Table 5- 23 Further V/f control methods (P1300)

Parameter value	Application
P1300 = 1	**Linear V/f characteristic with Flux Current Control (FCC)** 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.
P1300 = 3	**Freely adjustable V/f characteristic**, which supports the torque behavior of synchronous motors (SIEMOSYN motors) 
P1300 = 5 P1300 = 6	**Linear V/f characteristic for textile applications** where it is important that the motor speed is kept constant under all circumstances. This setting has the following effects: 1. When the maximum current limit is reached, the stator voltage is reduced but not the speed. 2. Slip compensation is inhibited.
P1300 = 19	**V/f control without characteristic.** The interrelationship between the frequency and voltage is not calculated in the frequency 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).

For more information about this function, see function diagrams 6100 and 6200 in the List Manual.

5.7.2 Vector control

5.7.2.1 Typical applications for vector control

The vector control can be used to control (closed-loop) the speed and the torque of a motor.

Vector control is mostly used without directly measuring the motor speed (vector control without encoder). The vector control is also used with a speed encoder in special applications.

Vector control in comparison to 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

Vector control must not be used in the following cases:

- If the motor is too small in comparison to the frequency inverter (the rated motor power may not be less than one quarter of the rated frequency inverter power)
- If the maximum frequency is more than 200 Hz
- If several motors are connected to one frequency inverter
- If a power contactor is used between the frequency inverter and motor and is opened while the motor is powered-up

Typical applications for sensorless vector control

Vector control without encoder is typically used for the following applications:

- Hoisting equipment and vertical conveyor belts
- Winders
- Extruders

5.7.2.2 Commissioning vector control

The vector control without encoder requires careful commissioning and therefore must only be performed by commissioning engineers that are experienced in handling this type of control.

Steps when commissioning vector control

1. Carry out quick commissioning (P0010 = 1)
   In order to ensure that the vector control functions perfectly, it is absolutely imperative that the motor data are correctly entered
2. Run the motor identification routine (P1900 = 2)
   The motor identification routine must be carried out with the motor in the cold state. Motor identification must be carried out after the quick commissioning as the quick commissioning supplies output data for the motor model and the motor identification makes these even more precise
3. Carry out the automatic speed controller optimization (P1960 = 1)
4. Manually optimize the speed controller

Table 5- 24 The most important vector control parameters

Parameter	Description
P0003 = 2	Extended access to the inverter functions
P1300 = 20	Control type: Vector control without speed encoder
P300 … P360	Motor data are transferred from the motor rating plate during the quick commissioning and calculated with the motor data identification
P1452 = …	Smoothing the actual speed
P1470 = …	Speed controller gain
P1472 = …	Speed controller integral time
P1496 = …	Speed pre-control scaling for the speed controller
P1511 = …	Additional torque
P1520 = …	Upper torque limit
P1521 = …	Lower torque limit
P1530 = …	Motoring power limit
P1531 = …	Regenerative power limit

For more information about this function, refer to the parameter list as well as the function diagrams 7000, 7500, 7700, 7800 and 7900 in the List Manual.

5.7.2.3 Torque control

Torque control is always part of the vector control and normally receives its setpoint from the speed controller output. By deactivating the speed controller and directly entering the torque setpoint, the closed-loop speed control becomes closed-loop torque control. The inverter then no longer controls the motor speed, but the torque that the motor generates.

Typical applications for torque control

The torque control is used in applications where the motor speed is specified by the connected driven load. Examples of such applications include:

- Load distribution between master and slave drives:
  The master drive is speed controlled, the slave drive is torque controlled
- Winding machines

Steps when commissioning the vector control

1. Carry out quick commissioning (P0010 = 1)
   In order to ensure that the vector control functions perfectly, it is absolutely imperative that the motor data are correctly entered
2. Run the motor identification routine (P1900 = 2)
   The motor identification routine must be carried out with the motor in the cold state. Motor identification must be carried out after the quick commissioning as the quick commissioning supplies output data for the motor model and the motor identification makes these even more precise

Table 5- 25 The most important torque control parameters

Parameter	Description
P0003 = 2	Extended access to the inverter functions
P1300 = 22	Control type: Torque control without speed encoder
P300 … P360	Motor data are transferred from the motor rating plate during the quick commissioning and calculated with the motor data identification
P1452 = …	Smoothing the actual speed
P1511 = …	Additional torque
P1520 = …	Upper torque limit
P1521 = …	Lower torque limit
P1530 = …	Motoring power limit
P1531 = …	Regenerative power limit

Additional information about this function is provided in the parameter list and in the function diagrams 7200, 7700 and 7900 in the List Manual.

5.7.2.4 Using a speed encoder

Higher accuracy by using a speed encoder

A speed encoder increases the accuracy of the speed or the torque of the vector control for speeds below approx. 10% of the rated motor frequency.

Commissioning the speed encoder

A speed encoder requires the following commissioning steps:

1. Connect the speed encoder (refer below)
2. Set the encoder voltage using the DIP switches on the CU (refer below)
3. Set the speed encoder parameters (refer below)
4. Set the frequency inverter to V/f control (P1300 = 0)
5. Power-up the motor with an average speed
6. Compare parameters r0061 (speed encoder signal in Hz) and r0021 (calculated speed in Hz) regarding the sign and absolute value
7. If the signs do not match, invert the speed encoder signal (P0410 = 1)
8. If the absolute value of the two values do not correspond, check P0408, the speed encoder wiring and the setting of the corresponding DIP switch
9. Change over to vector control with speed encoder (P1300 = 21 or P1300 = 23)

Connect the speed encoder

An encoder can only be connected to CU240S, CU240S DP, CU240S DP-F, CU240S PN or CU240S PN-F.

Only encoders with two pulse tracks A and B offset through 90° may be connected.

Table 5- 26 Terminals on the CU to connect the speed encoder

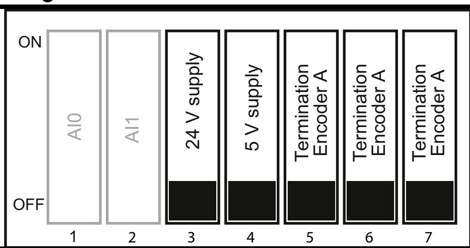
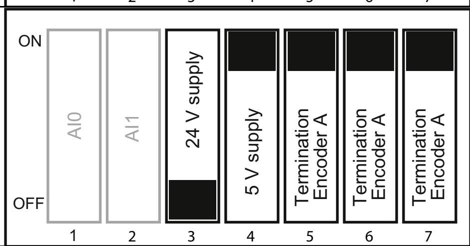
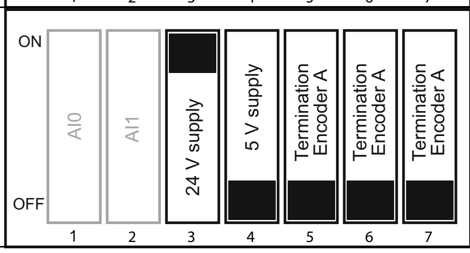
Terminal	Designation	Function
28	U0V OUT	Reference potential of the power supply voltage (terminal 9)
33	ENC+ SUPPLY	Encoder power supply (5 V or 24 V set via DIP switch, max. 300 mA, CU240S PN-F max. 200 mA)
70	ENC AP	Pulse track A, non-inverting input
71	ENC AN	Pulse track A, inverting input
72	ENC BP	Pulse track B, non-inverting input
73	ENC BN	Pulse track B, inverting input
74	ENC ZP	Zero signal, non-inverting input
75	ENC ZN	Zero signal, inverting input

> ⚠ **CAUTION**
>
> Use a shielded cable to connect the speed encoder. The shield must not be interrupted by terminal points between the encoder and frequency inverter.

Setting the encoder voltage

The encoder voltage is set using the DIP switches at the front of the CU. If you use either a BOP or a PC Connection Kit, you must remove this module in order to be able to access the switches.

Table 5- 27 Encoder voltage settings

Encoder type	Setting of the DIP switches at the front of the CU
No encoder	
TTL encoder Supply voltage: 5 V	
HTL encoder Supply voltage: 24 V	
DIP switches 1 and 2 are of no significance when setting the encoder voltage	

> ⚠ **WARNING**
>
> If DIP switch 3 is set to ON (24 V), a TTL encoder (voltage level 5 V) must not be connected to the frequency inverter.

Table 5- 28 The most important speed encoder parameters

Parameter	Description
P0003 = 2	Extended access to the inverter functions
P0400 = …	Encoder type • 0: Encoder signal is not evaluated • 2: Encoder with pulse tracks A and B without zero pulse • 12: Encoder with pulse tracks A, B and zero pulse
P0408 = …	Encoder pulses per revolution
P0410 = …	Inverts the encoder signal • 0: The encoder signal is not influenced • 1: The encoder signal is inverted
P0491 = …	Response when the speed signal is lost • 0: Motor is shut down with fault message F0090 • 1: Alarm and switch to SLVC, if in SVC
P0492 = …	Permissible speed difference for monitoring the encoder signal (F0090)
P0494 = …	Delayed response when the speed signal is lost
P1442 = …	Filter time for the speed encoder actual value
P1300 = 21 or P1300 = 23	Control type: Vector control with speed encoder

5.8 Motor and inverter protection

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.

The load torque monitoring functions provide effective plant and system protection.

5.8.1 Overtemperature protection for the frequency inverter and motor

Temperature monitoring for the converter (Power Module)

Parameter	Description
P0003 = 3	**User access level** 3: Expert
P0290 = 2	**Temperature monitoring of the Power Module** This therefore defines the response of the the frequency inverter to an **internal overtemperature**. 0: Reduce the output frequency 1: Shutdown (F0004) 2: Reduce pulse frequency and output frequency (factory setting) 3: Reduce pulse frequency, then shut down (F0004)
P0292	**Parameterizes the alarm threshold** for heatsink and module temperature monitoring (Power Module)
P0294	**Parameterize alarm threshold for:** I^2t monitoring (Power Module)

Temperature monitoring for the motor

Two options are available for implementing thermal motor protection:

- Temperature sensing in the motor with PTC sensor or KTY 84 sensor
- Temperature calculation without sensors by analyzing the rating plate data and ambient temperature of the motor (Only possible in the 'vector control' mode)

Temperature measurement using a temperature sensor (PTC or KTY 84 sensor)

Parameter	Description
P0003 = 2	**User access level** 2: Advanced
P0335 = 0	**Specify the motor cooling** 0: Self-cooling with shaft-mounted fan attached to the motor (factory setting) 1: Separate cooling by means of a separately-driven cooling fan 2: Self-cooling and internal fan 3: Separate cooling and internal fan
P0601 = 0	**Specify the motor temperature sensor** 0: No encoder (factory setting; → P0610) 1: PTC thermistor (→ P0604) 2: KTY84 (→ P0604)
P0604 = …	**Motor overtemperature alarm threshold** (0°C … 220°C, factory setting 130°C) Enter the alarm threshold for motor overtemperature protection. The shutdown temperature threshold (alarm threshold + 10 %) is the value at which either the converter is shut down or I_{max} is reduced (P0610).
P0610 = 2	**Response for motor overtemperature I^2t** Defines the behavior as soon as the motor temperature reaches the alarm threshold. 0: No response, alarm only 1: Alarm and reduction of I_{max} (reduces the output frequency) 2: Fault and shutdown (F0011) (factory setting)
P0640	**Motor overload factor** (entered in % referred to P0305: rated motor current)

Temperature measurement without temperature sensor

This temperature calculation is only possible in the vector control mode (P1300 = 20/21/22/23) and functions by calculating a thermal motor model.

Parameter	Description
P0621 = 1	**Motor temperature measurement after restarting** 0: No identification (factory setting) 1: Temperature measurement after the first "motor ON" 2: Temperature measurement after each "motor ON".
P0622 = …	**Magnetization time of the motor for temperature measurement after starting** *(set automatically as the result of motor data identification)*
P0625 = 20	**Ambient motor temperature** Enter the ambient motor temperature in°C at the instant that the motor data is acquired (factory setting: **20°C**). The difference between the motor temperature and motor environment (P0625) must lie within a tolerance range of approx. ± 5 °C.

5.8.2 Overcurrent protection

Method of operation

The maximum current controller (I_{max} controller) protects the motor and inverter against overload by limiting the output current. The I_{max} controller is only active with V/f control.

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 frequency is reduced with a lower load and at lower speeds (e.g. parabolic torque-speed characteristic of the motor load).

In the regenerative mode, the current only decreases if the torque decreases at a higher frequency.

Settings

NOTICE
The factory setting of the I_{max} controller only needs to be changed in exceptional cases by appropriately trained personnel.

Table 5- 29 I_{max} controller parameters

Parameter	Description
P0003 = 3	User access level 3: Expert
P0305 = …	Rated motor current
P0640 = …	Maximum permissible motor overload referred to P0305 rated motor current
P1340 = …	Proportional gain of controller for frequency reduction
P1341 = …	Integral time of controller for frequency reduction
P1345 = …	Proportional gain of controller for voltage reduction
P1346 = …	Integral time of controller for voltage reduction
r0056 bit13	Status: I_{max} controller active
r1343	Frequency output of I_{max} controller Shows the amount to which the I-max controller reduces the inverter output frequency.
r1344	Voltage output of I_{max} controller Shows the amount by which the I-max controller reduces the inverter output voltage.

For more information about this function, see function diagram 6100 in the List Manual.

5.8.3 Limiting the maximum DC link voltage

How does the motor generate overvoltage?

An induction motor can operate as a generator if it is driven by the connected load, whereby the motor converts mechanical energy to electrical energy. The motor feeds the regenerative energy back to the inverter.

As a consequence, the DC link voltage is increased. The frequency inverter can only reduce the increased DC link voltage if it is capable of regenerative feedback into the line supply or is equipped with a braking resistor.

Without being capable of regenerating into the line supply, only extremely low or brief regenerative loads – relative to the frequency inverter power – are possible because the frequency inverter may be damaged if the DC link voltage reaches critical levels. Before the voltage can reach critical levels, however, the inverter shuts down with the fault message "DC link overvoltage".

Protecting the motor and inverter against overvoltage

The V_{DCmax} controller prevents – as far as is technically possible – 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 subject to braking. For applications such as these, you must select an inverter that is equipped with a braking resistor or that can feed energy back into the line supply (e.g. PM250 and PM260)

Table 5- 30 V_{DCmax} controller parameters

Parameter	Description
P0003 = 3	User access level 3: Expert
P1240 = …	Enables the V_{DCmax} controller 1: Enables the V_{DCmax}controller 3: Enables the V_{DCmax} controller with kinetic buffering
r1242	Shows the value of the DC link voltage above which the V_{DCmax} controller is active
P1243 = …	Defines the extent to which the V_{DCmax} controller responds to excessively high DC link voltages
P1250 = …	Proportional gain of the V_{DCmax} controller
P1251 = …	Integral time of the V_{DCmax} controller
P1252 = …	Derivative time of the V_{DCmax} controller
P1253 = …	Limits the output of the V_{DCmax} controller
P1254 = …	Activates or deactivates automatic detection of the switch-on levels of the V_{DCmax} controller

For more information about this function, see function diagram 4600 in the List Manual.

5.8.4 Load torque monitoring

Applications with load torque monitoring

In many applications, it is advisable to monitor the motor torque:

- Applications in which the mechanical connection between the motor and load may be interrupted (e.g. if the drive belt in fan or conveyor belt systems tears).
- Applications that are to be protected against overload or locking (e.g. extruders or mixers).
- Applications in which no-load operation of the motor represents a critical situation (e.g. pumps).

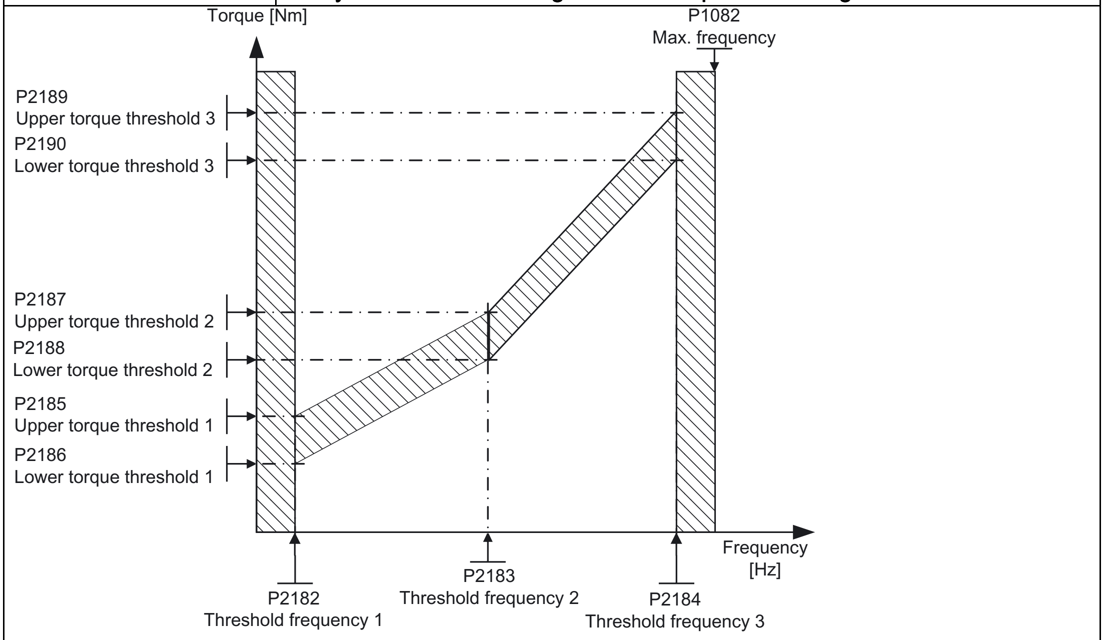
Load torque monitoring functions

The inverter monitors the torque of the motor in different ways:

1. No-load monitoring:
   The inverter generates a message if the motor torque is too low.
2. Lock protection:
   The inverter generates a message if the motor speed cannot match the speed setpoint despite maximum torque.
3. Stall protection:
   The inverter generates a message if the inverter controller has lost the orientation of the motor.
4. Frequency-dependent torque monitoring:
   The inverter measures the current torque and compares it with a parameterized frequency/torque characteristic.

Table 5- 31 Parameterizing the monitoring functions

Parameter	Description
No-load monitoring	
P2179 = …	Current limit for no-load detection If the frequency inverter current is below this value, the message "no load" is output.
P2180 = …	Delay time for the "no load" message
Lock protection	
P2177 = …	Delay time for the "motor locked" message
Stall protection	
P2178 = …	Delay time for the "motor stalled" message
P1745 = …	Deviation of the setpoint from the actual value of the motor flux as of which the "motor stalled" message is generated This parameter is only evaluated as part of encoderless vector control.
Frequency-dependent torque monitoring	
P2181 = …	Enable signal for function
P2182 = …	Frequency threshold 1
P2183 = …	Frequency threshold 2
P2184 = …	Frequency threshold 3
P2185 = …	Upper torque threshold for frequency threshold 1
P2186 = …	Lower torque threshold for frequency threshold 1
P2187 = …	Upper torque threshold for frequency threshold 2
P2188 = …	Lower torque threshold for frequency threshold 2
P2189 = …	Upper torque threshold for frequency threshold 3
P2190 = …	Lower torque threshold for frequency threshold 3
2192 = …	Delay time for the message "Leave torque monitoring tolerance band"



For more information about these functions, see the List Manual (function diagrams 4110, 4130, and 4140 as well as the parameter list).

5.9 Evaluating the frequency inverter status

Frequency inverter states, such as alarms or faults or different actual value quantities of the frequency inverter can be displayed using digital and analog outputs. The pre-assignments (default settings) can be adapted to the particular plant or system requirements as explained in the following descriptions.

5.9.1 Assigning specific functions to digital outputs

Assigning specific functions to digital outputs

Three digital outputs are available that can be programmed to display different frequency inverter states, e.g. faults, alarms, current limit value violations etc.

Table 5- 32 Factory setting of the digital outputs

Terminal No., significance			Function
18	NC	Digital output 0	Frequency inverter fault active
19	NO		
20	COM		
21	NO	Digital output 1	Frequency inverter alarm active
22	COM		
23	NC	Digital output 2	Digital output deactivated
24	NO		
25	COM		

Table 5- 33 Changing the digital output settings

Terminal No., significance			Parameter	Description
			P0003 = 2	Extended parameter access
18	NC	Digital output 0	P0731	Possible values for P0731, P0732 and P0732: 0 Deactivate digital output 52.0 Drive ready 52.1 Drive ready for operation 52.2 Drive running 52.3 Drive fault active 52.4 OFF2 active 52.5 OFF3 active 52.6 Switching on inhibited 52.7 Drive alarm active 52.8 Setpoint/actual value deviation 52.9 PZD control 52.10 f_act >= P1082 (f_max) 52.11 Alarm: Motor current/torque limiting 52.12 Brake active 52.13 Motor overload 52.14 Motor CW rotation 52.15 Inverter overload 53.0 DC brake active 53.1 f_act < P2167 (f_off) 53.2f_act > P1080 (f_min) 53.3 Current actual value r0027 ≥ P2170 53.6 f_act ≥ setpoint (f_set)
19	NO			
20	COM			
21	NO	Digital output 1	P0732	
22	COM			
23	NC	Digital output 2	P0733	
24	NO			
25	COM			
			P0748	Invert digital outputs Bit 0: Digital output 0 Bit 1: Digital output 1 Bit 2: Digital output 2

Further, the digital outputs can be interconnected with all binector outputs. A list of the binector outputs is provided in the List Manual.

5.9.2 Assigning certain functions to analog outputs

Assigning specific functions to analog outputs

Two analog outputs are available, which can be parameterized to display a multitude of variables, e.g. the actual speed, the actual output voltage or the actual output current.

Table 5- 34 Factory setting of the analog outputs

Terminal No., significance			Function
12	AO0+	Analog input 0	Actual speed
13	AO0-		
26	AO1+	Analog input 1	Actual speed
27	AO1-		

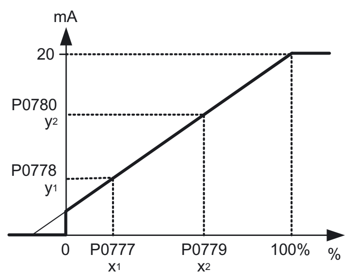
Table 5- 35 Changing the analog output settings

Terminal No., significance			Parameter	Description
12	AO0+	Analog input 0	P0771 [Ind 0]	Possible values for P0771, Ind 0 and Ind 1: 21:CO: Actual frequency (factory setting; scaled corresponding to P2000) 24:CO: Actual output frequency (scaled corresponding to P2000) 25:CO: Actual output voltage (scaled corresponding to P2001) 26:CO: Actual value of the DC link voltage (scaled corresponding to P2001) 27:CO: output current (scaled in line with P2002)
13	AO0-			
26	AO1+	Analog input 1	P0771 [Ind 1]	
27	AO1-			

The analog outputs can also be interconnected with all connector outputs. A list of the connector outputs is provided in the List Manual.

Table 5- 36 Additional analog output settings

Parameter	Description
P0775 = 0	**Permit absolute value** Specifies whether or not the absolute value of the analog output is used. If enabled, this parameter will use the absolute value of the value to be output. If the original value was negative, the corresponding bit is set in r0785.
P0776 = 0	**Analog output type** Scaling of r0774. 0: Current output (factory setting) 1: Voltage output **Note:** P0776 changes the scaling of r0774 (0 to 20 mA ⇔ 0 to 10 V). The scaling parameters P0778 and P0780 as well as the dead band are always entered with 0 to 20 mA. Analog output 0 can be switched as a voltage output between 0 and 10 V. Analog output 1 is a current output only. If it is to be used as a voltage output, it must be terminated with a 500 Ω resistor.
P0777 = 0.0	**Value x1 for analog output scaling** Defines output characteristic x1 (in %). This parameter is the minimum analog value expressed as a percentage of P200x (depending on how P0771 is set).
P0778 = 0	**Value y1 for analog output scaling** This parameter is the value of x1 (in mA).
P0779 = 100	**Value x2 for analog output scaling** This defines x2 of the output characteristic as a percentage. This parameter is the maximum analog value expressed as a percentage of P200x (depending on how P0771 is set).
P0780 = 20	**Value y2 for analog output scaling** This parameter is the value of x2 (in mA).
P0781 = 0	**Dead band width of the analog output** This can be used to set the width of the dead band for the analog output (in mA).



5.10 Technological functions

The frequency inverter offers the subsequently listed technological functions.

- Braking functions
- Automatic restart and flying restart
- Basic process control functions
- Positioning deceleration ramp
- Logical and arithmetic functions using function blocks that can be freely interconnected

Please refer to the following sections for detailed descriptions.

5.10.1 Braking functions of the frequency inverter

A differentiation must always be made between electrical braking of a motor and mechanical braking:

- The motor is electrically braked by the frequency inverter. 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.
- 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.

Different electrical braking methods for different applications

If an induction motor electrically brakes the connected load and the braking energy that is released exceeds the mechanical and electrical losses, then it operates as a generator. In this case, the motor converts mechanical energy to electrical energy. Examples of typical applications where regenerative operation briefly occurs include:

- Centrifuges
- Grinding disk drives
- Fans

For certain drive applications, the motor can operate in the regenerative mode for longer periods of time. Examples include:

- Cranes
- Conveyor belts with downward movement of load

Depending on the particular application and the frequency inverter type, there are different technologies to handle regenerative energy.

- The regenerative energy is converted into heat in the motor (DC and compound brake)
- The frequency inverter stores the regenerative energy in the DC link which means that the DC link voltage increases.
- The frequency inverter converts the regenerative energy in the voltage DC link using a braking resistor (dynamic braking).
- The frequency inverter feeds the regenerative energy back to the line supply (regenerative braking).

Braking methods depending on the drive inverter being used

Table 5- 37 Functions in relationship with the frequency inverters

	SINAMICS G120		
	PM240	PM250	PM260
DC and compound brake	X	---	---
Dynamic braking	X	---	---
Regenerative braking	---	X	X

Advantages and disadvantages of the braking methods

- DC brake
  - Advantage: The motor is braked without the frequency inverter having to convert the braking energy
  - Disadvantages: Is only used for an OFF1 command, excessive motor temperature rise, no defined braking response, no constant braking torque, braking energy dissipated as heat.
- Compound brake
  - Advantage: Defined braking response, the motor is braked without the frequency inverter having to convert any significant amount of braking energy
  - Disadvantages: Is only used for an OFF1 command, no constant braking torque, excessive motor temperature rise, braking energy is lost as heat.
- Dynamic braking
  - Advantages: defined braking response, no additional motor heating, constant braking torque
  - Disadvantages: A braking resistor is required, braking energy is lost as heat, the permissible load of the braking resistor must be taken into account
- Regenerative braking
  Advantages:
  - The regenerative energy is not converted into heat, but instead, is fed back into the line supply
  - Constant braking torque
  - The methods can be used in all applications
  - Constant regenerative operation is possible - e.g. when a crane load is being lowered

5.10.1.1 Parameterizing a DC & compound brake

Applications for a DC brake and compound brake

DC and compound brakes are especially used for centrifuges, saws, grinding machines, and conveyor belts.

⚠ CAUTION

With DC and compound brakes, the kinetic energy of the motor and motor load is partially converted into thermal energy. If the braking procedure lasts too long, this can cause the motor to overheat.

Note

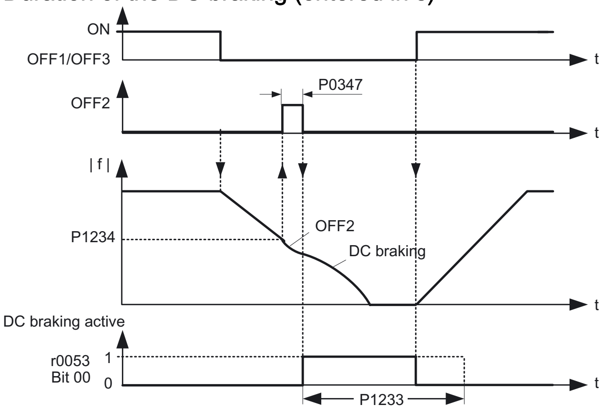
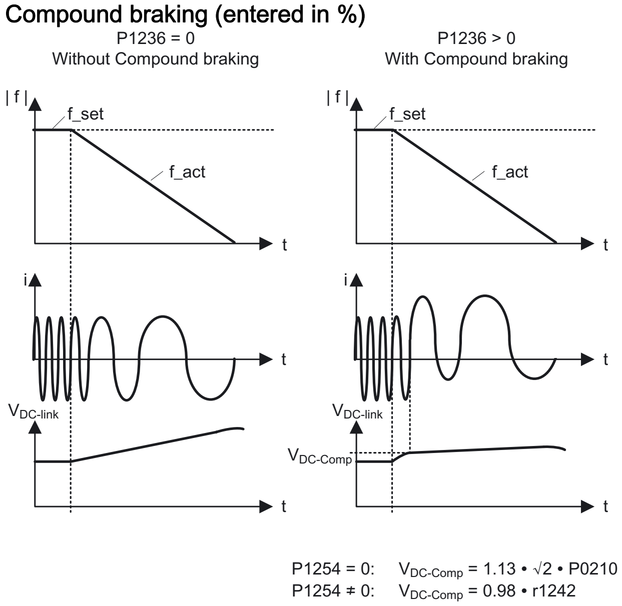
The compact brake is only active in conjunction with the V/f control.

The compound brake is deactivated, if:

- The "flying restart" function is active
- The DC brake is active
- Vector control is selected

The switch-on limit value for the compound brake $V_{DC\text{-}Comp}$ depends on P1254 (refer to V_{DCmax} control)

Parameterizing a DC & compound brake

Parameter	Description
P1230	**Enables the DC brake** Enables DC braking via a signal that was used by an external source (BICO). The function remains active as long as the external signal is active.
P1232=	**DC brake current (entered in %)** Defines the strength of the direct current in [%] with respect to the rated motor current (P0305)
P1233=	**Duration of the DC braking (entered in s)**  Defines the duration of DC brake in seconds after an OFF1 or OFF3 command
P1234=	**Starting frequency of the DC brake (entered in Hz)** Sets the starting frequency for DC brake.
P1236=	**Compound braking (entered in %)**  Parameter P1236 defines the direct current superimposed on the motor current after the DC link voltage threshold has been exceeded. P1236 = 0 Compound brake disabled P1236 = 1 - 250 Current level of braking direct current as a % of the rated motor current (P0305)

5.10.1.2 Dynamic brake

Parameterizing the dynamic brake

An internal closed-loop chopper control (braking chopper) in the frequency inverter, which can control an external braking resistor, is required for a dynamic brake

Dynamic braking converts the regenerative energy, which is released when the motor brakes, into heat.

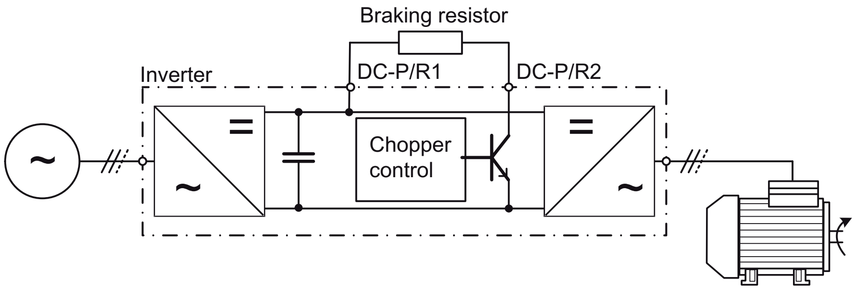


Figure 5-9 Braking chopper in the frequency inverter

Parameter	Description
P1237	**Enable signal and ON period of the dynamic brake** 0: Dynamic brake is blocked 1: 5% ON period 2: 10% ON period 3: 20% ON period 4: 50% ON period 5: 100% ON period The ON period set here is only effective if the braking resistor has reached its operating temperature. When required, a cold braking resistor is switched-in independent of this parameter

⚠ WARNING

If a braking resistor that is unsuitable is used, a fire could break out and severely damage the converter.

The temperature of braking resistors increases during operation. For this reason, avoid coming into direct contact with braking resistors. Make sure that the devices are located at sufficient distances from each other and that proper ventilation is provided.

5.10.1.3 Parameterizing regenerative braking

Regenerative braking helps save energy thanks to feedback

The frequency inverter can feed back up to 100% of its power (for HO base load) into the line supply. The magnitude of the regenerative energy depends on the motor speed and the current or voltage limit parameters.

If the energy fed back into the line supply exceeds the rated power of the frequency inverter, then the frequency inverter shuts down with fault message F0028.

Regenerative feedback for V/f control (P1300 < 20)

The regenerative power can be limited via P0640. If the regenerative power exceeds its limit value for longer than 5 s, the converter shuts down with fault code F0028.

Note

If regenerative feedback is required at the rated frequency, set the parameter for the maximum frequency (P1082) greater than P0310 (rated motor frequency).

5.10.1.4 Parameterizing a motor holding brake

The motor holding braking prevents the motor from rotating when the frequency inverter is powered-down, e.g. when a load is lowered in a hoisting gear application. The frequency inverter has internal logic to control a motor holding brake.

Commissioning the control logic of a motor holding brake

1. Before commissioning, secure any dangerous loads (e.g. suspended loads for crane applications)
   - Lower the load to the ground
   - Suppress the motor holding brake control, e.g. by disconnecting the control cables
2. For hoisting gear applications, set the starting torque
   Before the motor holding brake is opened, a torque must be established that prevents the load from briefly sagging.
   - Check the magnetizing time P0346; the magnetizing time is pre-assigned when calculating the motor data and must be greater than zero.
   - The minimum frequency P1080 should approximately correspond to the rated motor slip r0330
3. For hoisting gear applications, adapt the voltage boost to the load
   - Boost parameters P1310, P1311 - for V/f operation (P1300 = 0 to 3)
   - The mechanical brake is controlled using bit 12 ("Brake active") of status signal r0052 of the brake control. This signal is available at terminals A and B of the Power Module. It is not sufficient to simply select status signal r0052 bit 12 in P0731 to P0733 (relay outputs). To activate the motor holding brake, parameter P1215 must be additionally set to 1.
4. Parameterize the opening and closing times of the motor holding brake
   It is extremely important that electromechanical braking is controlled with the correct timing (brake release time, brake closing time, release time) to protect the brakes against long-term damage. The exact values are provided in the motor catalog. Typical values:
   - Brake release times are between 35 ms and 500 ms
   - Brake closing times are between 15 ms and 300 ms
   - Release times are between 25 ms and 230 ms

When a motor with a built-in holding brake is commissioned, a "clicking" sound in the motor indicates that the brake has been properly released.

Timing of the motor holding brake after an OFF1 and OFF3 command

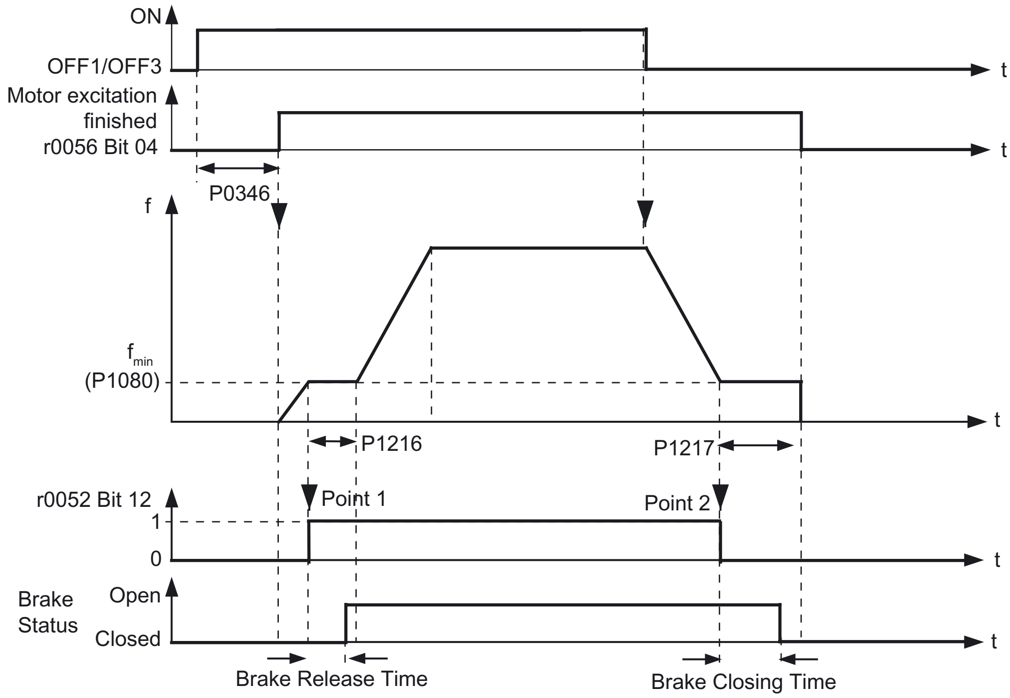


Figure 5-10 Function diagram, motor holding brake after an OFF1 or OFF3 command

Timing of the motor holding brake after an OFF2 or STO command

Contrary to a standard motor holding brake, after an OFF2 command, the brake is immediately closed. The normal timing sequence of the motor holding brake function is interrupted by the following signals, without taking into account the brake closing time:

- OFF2 command, or
- For fail-safe applications, in addition, after "Safe Torque Off" (STO)

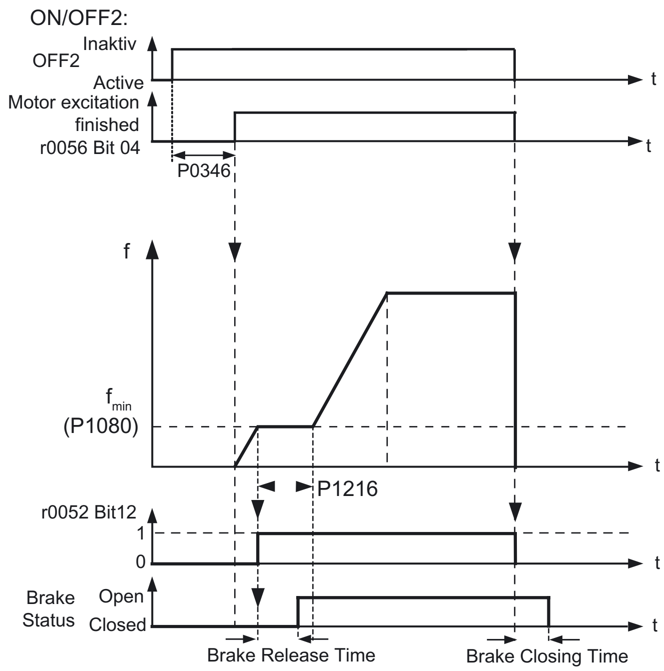


Figure 5-11 Function diagram, motor holding brake after an OFF2 command

Table 5- 38 Control logic parameters of the motor holding brake

Parameter	Description
P0003 = 2	Enables extended parameter access
P1215 = …	Enable motor holding brake 0 Motor holding brake disabled (factory setting) 1 Motor holding brake enabled
P0731= 52.C	BI: Function digital output 1 Note: To control the braking relay via the digital output, the following must apply for digital output 1: P0731 = 52.C = 52.12
P0346 = …	Magnetizing time time 0 ... 20 s, factory setting 1 s
P1080 = …	Minimum frequency 0 … 650 Hz, (0 Hz factory setting): minimum motor frequency, regardless of frequency setpoint
P1216 = …	Delay time for opening the brake 0 ... 20 s, factory setting 0.1 s Note: P1216> brake release time + relay opening time
P1217 = …	Holding time after runout 0 ... 20 s, factory setting 0.1 s Note: P1217> brake closing time + relay closing time
P1227 = …	Zero value detection monitoring time 0 ... 300 s, factory setting 4 s
r0052.12	"Brake active" status

Opening the motor holding brake via P1218

Using parameter P1218, you can force the brake to open, e.g. in order to be able to manually move a conveyor drive.

P1218 is ignored if the motor holding brake is closed because of an STO.

> ⚠ WARNING
>
> **Secure loads held by the brake!**
>
> Since this procedure cancels the "Brake active" signal which, in turn, causes the brake to be forced open, the user must ensure that, even when the motor has been powered-down, all loads held by the brake are secured before the signal is canceled.

Table 5- 39 Parameter to force open a motor holding brake

Parameter	Description
P0003 = 3	Enables expert access to parameters
P1218 = 1	Forcibly opens the motor holding brake

5.10.2 Automatic restart and flying restart

5.10.2.1 Flying restart: switching on the converter when the motor is running

Description

The "flying restart" function, which is activated by P1200, allows the converter to be switched to a rotating motor. The function must be used whenever a motor may still be running. This could be:

- After a brief line interruption
- When a converter is shut down but air currents cause a fan impeller to rotate (either CW or CCW)
- If the motor is driven by a load

This function is useful, therefore, with motors whose load exhibits a high moment of inertia since it can help prevent sudden loads in the mechanical components.

If this function is not used in such cases, this could cause the motor to shut down due to overcurrent (overcurrent fault F0001).

The "flying restart" function can be used to synchronize the converter and motor frequency.

> ⚠ WARNING
>
> **Drive starts automatically**
>
> When this function is enabled (P1200 > 0), all those working with the system must be informed of the following:
>
> - The drive starts automatically.
> - Although the drive is at a standstill, it can be started by the search current.

Input values

Table 5- 40 Main function parameters

Parameter	Description
P1200 = …	**Flying restart** 0: Inactive (factory setting), 1 - 6 Active

Table 5- 41 Overview: the "flying restart" function

P1200	Flying restart active	Search direction
0	Flying restart inactive (factory setting)	-
1	Flying restart always active	Search performed in both directions, startup in direction of setpoint
2	Flying restart active after: • Power ON • Faults • OFF2	Search performed in both directions, startup in direction of setpoint
3	Flying restart active after: • Faults • OFF2	Search performed in both directions, startup in direction of setpoint
4	Flying restart always active	Search performed in direction of setpoint only
5	Flying restart active after • Power ON • Faults • OFF2	Search performed in direction of setpoint only
6	Flying restart active after • Faults • OFF2	Search performed in direction of setpoint only

Table 5- 42 Additional commissioning parameters

Parameter	Description
P1202 = …	**Motor current: flying restart** (entered in %): 10 % ... 200 %, factory setting 100 % Defines the search current with respect to the rated motor current (P0305) that is present when the "flying restart" function is used.
P1203 = …	**Search rate/speed: Flying restart** (entered in %): 10 % ... 200 %, factory setting 100 % Sets the factor by which the output frequency changes during the flying restart to synchronize itself with the running motor.

Note

The higher the search rate (P1203), the longer the search time. The lower the search rate, the shorter the search time.

The "flying restart" function decelerates the motor slightly. The smaller the drive torque, the more the drive is decelerated.

The "flying restart" function should not be activated for motors in group drives due to the different coasting characteristics of the individual motors.

5.10.2.2 "Automatic restart" function after power failure

Restart after a power failure and/or faults within a few seconds.

This function is particularly useful when the frequency converter is operated as a stand-alone device.

The "automatic restart" function is used to restart the drive automatically once the power has been restored following a power failure. All faults are acknowledged automatically and the drive is switched on again.

Line undervoltage or power failure

The term "line undervoltage" describes a situation in which the line voltage fails momentarily and is then restored. The power failure is so short that the 400V power supply of the frequency inverter is briefly interrupted, but the electronics power supply is still maintained.

The term "power failure" describes a situation in which the power fails for a longer period, whereby the DC link collapses completely and the Control Unit of the converter is in a zero-current state.

An ON command prior to the power failure and when the system is powered-up is required for the "automatic restart" function.

Since the function is not restricted to line supply faults, it can also be used to automatically acknowledge faults and restart the motor after any tripping. To allow the drive to be switched to a motor shaft that is still rotating, the "flying restart" function must be activated via P1200.

> **⚠ WARNING**
>
> When the "automatic restart" function is active (P1210 > 1), a motor can restart automatically once the power has been restored. This is particularly critical if it is incorrectly assumed that the motors have been shut down after a long power failure.
>
> For this reason, death, serious injury, or considerable material damage can occur if personnel enters the working area of motors in this condition.

Automatic restart mode

Table 5- 43 Automatic restart mode

P1210 = 0: Disable automatic restart automatic restart inactive
P1210 = 1: acknowledge all faults without automatic restart When P1210 = 1, any faults that are present are acknowledged automatically once the cause has been rectified. If more faults occur once the previous faults have been acknowledged, these are also acknowledged automatically. If the ON/OFF1 signal (control word 1, bit 0) is set to HIGH, a period of P1212 + 1s must elapse between when a fault is acknowledged and another one occurs. If the ON/OFF1 signal is set to LOW, the time between when a fault is acknowledged and another one occurs must be at least 1 s. When P1210 = 1, fault F07320 is not generated if the attempt to acknowledge the fault is unsuccessful (e.g. due to frequent faults).

P1210 = 4: Automatic restart following power failure, no further startup attempts When P1210 = 4, an automatic restart is only carried out if fault F30003 has also occurred on the Power Module, a high signal is present at the binector input P1208[1], or if fault F06200 has occurred when an infeed drive object (x_Infeed) is used. If additional faults are present, these are also acknowledged and, if this is successful, the start attempt is continued. If the 24 V power supply for the CU fails, this is interpreted as a power failure.
P1210 = 6: Automatic restart after any fault with further start attempts When P1210 = 6, an automatic restart is carried out following any fault or when P1208[0] = 1. If the faults occur one after the other, the number of start attempts can be defined by means of P1211. Time monitoring can be set with P1213.

Commissioning

1. Activate the "automatic restart" function via P1210 and, if necessary, the "flying restart" function via P1200.
2. Set the number of start attempts via P1211.
3. Set the waiting times via P1212 and P1213.
4. Make sure that this functions properly.

Parameterizing the "automatic restart" function

Parameter		Meaning
P1210 =	0: "Automatic restart" function disabled (factory setting) 1: Acknowledges all faults without restart 2: 3: 4: Restart after power failure, no further start attempts 5: 6: Restart after any fault with further start attempts	
P1211 =		No. of start attempts
P1212 =		Waiting time for start attempts
P1213 =		Monitoring time for recovery of power supply

5.10.3 Technology controller

Technology controller for processing higher-level control functions

The technology controller supports all kinds of simple process control tasks. For example, it is used for controlling pressures, levels, or flow rates.

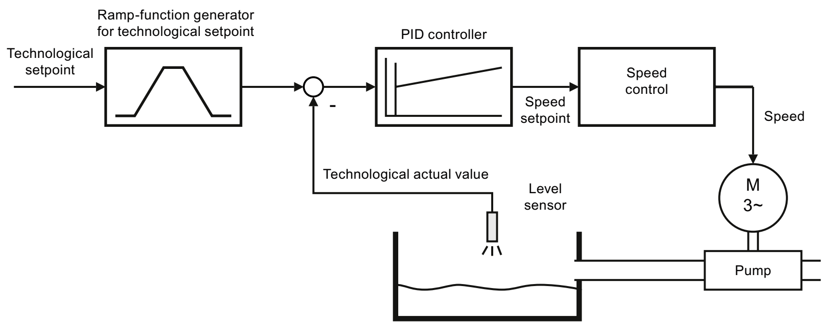


Figure 5-12 Example: technology controller as a level controller

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 can be supplied via the same setpoint sources as those available for the speed setpoint. The technology controller is also equipped with its own motorized potentiometer and fixed setpoints.

The setpoints, actual values, and control signals of the technology controller are defined by means of BICO technology.

Table 5- 44 Technology controller parameters

Parameter	Description
P2200 = …	Enable technology controller
P2251 = …	Control mode (correction or specification of speed setpoint)
P2253 = …	Setpoint selection
P2254 = …	Supplementary setpoint
P2255 = …	Setpoint scaling
P2256 = …	Supplementary setpoint scaling
P2257 = …	Ramp-up time for setpoint
P2258 = …	Ramp-down time for setpoint
P2263 = …	Technology controller with or without differential component
P2264 = …	Selection of source for the actual value
P2265 = …	Time constant for the setpoint filter
P2267 = …	Maximum value for feedback
P2268 = …	Minimum value for feedback
P2269 = …	Scaling for feedback
P2270 = …	Function selection for feedback
P2271 = …	Inversion of controller feedback
P2274 = …	Derivative time
P2280 = …	Proportional gain
P2285 = …	Integral time
P2291 = …	Maximum value for the output
P2292 = …	Minimum value for the output
P2293 = …	Ramp-up/ramp-down time for limit
P2295 = …	Output scaling

Parameter	Description
P2350 = …	Enable signal for self-optimization
P2354 = …	Monitoring time for self-optimization
P2355 = …	Offset for self-optimization
r2260	Setpoint after ramp-function generator
P2261	Time constant for the setpoint filter
r2262	Filtered setpoint after ramp-function generator
r2266	Filtered feedback
r2272	Feedback after smoothing and function processing
r2273	Controller deviation (difference between setpoint and feedback)
r2294	Output value of controller

For more information about this function, see function diagram 5100 in the List Manual.

5.10.4 Positioning down ramp - a basic positioning function

Description

In certain cases (e.g. when a conveyor belt is brought to a standstill), the belt may have to travel a defined deceleration distance after shutdown regardless of the speed so that it always stops in the same position.

Normally, the number of rotations that the motor requires to reach standstill depends on the motor speed at the instant that it is switched-off. Using the "positioning down ramp" function, the number of revolutions down to standstill can be defined independent of the speed. This is realized by extending the ramp-down time of the motor after it has been switched-off so that a specific number of motor revolutions is always reached. To realize this, the frequency inverter has a positioning function that is sufficient for many applications.

The accuracy of this function can be increased by means of a motor encoder.

Table 5- 45 Parameters for the simple positioning function

Parameter	Description
P2480 = …	Control command for the positioning function Example: When P2840 = 722.0, the positioning function is activated via digital input 0.
P2481 = …	Gear ratio = P2481/P2482
P2482 = …	
P2484 = …	Number of shaft revolutions at the gearbox output for one distance unit
P2488 = …	Number of distance units until the end position
P2487 = …	Additive compensation value for increasing accuracy

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

5.10.5 Logical and arithmetic functions using function blocks

Description

Additional signal connections in the inverter can be established by means of free function blocks. Every digital and analog signal available via BICO technology can be routed to the appropriate inputs of the free function blocks. The outputs of the free function blocks are also interconnected to other functions using BICO technology. The following free function blocks are available: Adders, subtracters, multipliers, dividers

Example:

You want to activate the motor via digital input 0 and digital input 1:

1. To do so, interconnect the status signals of digital inputs r722.0 and r722.1 with the inputs of a free OR block via BICO.
2. Now activate the OR block.
3. Finally, interconnect the OR block output with the internal ON command (P0840).

Table 5- 46 Parameters for using the free function blocks

Parameter	Description
P2800 = …	General enable signal for all function blocks 0: disabled 1: enabled
P2801 = …	Activation of the individual function blocks
P2802 = …	
P2803 = …	Activation of an 8 ms time slice for calculating the activated function blocks 0: All function blocks are calculated with a 128 ms time grid 1: Some of the function blocks can be calculated with an 8 ms time grid.

For more information about this function, see function diagrams 4800, 4810, 4820, and 4830 in the List Manual.

5.10.6 Changing over drive data sets (several motors connected to a frequency inverter)

Switching motor control

In certain applications, the inverter parameters need to be switched.

Example:

One inverter is to operate one of two different motors. Depending on which motor is to run at any given time, the motor data and the ramp-function generator times for the different motors must be adjusted accordingly in the inverter.

Drive data sets (DDS)

The inverter offers up to three different methods for parameterizing various functions and for switching between these different settings. The parameters for these functions are indicated with the index numbers 0, 1, and 2. Control commands define the switchover between the parameters by selecting one of these three indices.

The total of all switchable parameters with the same index is known as a "drive data set".

Since all the switchable parameters have the same three indices (0, 1, and 2), the functions can only be switched together.

The following diagram shows which functions can be switched.

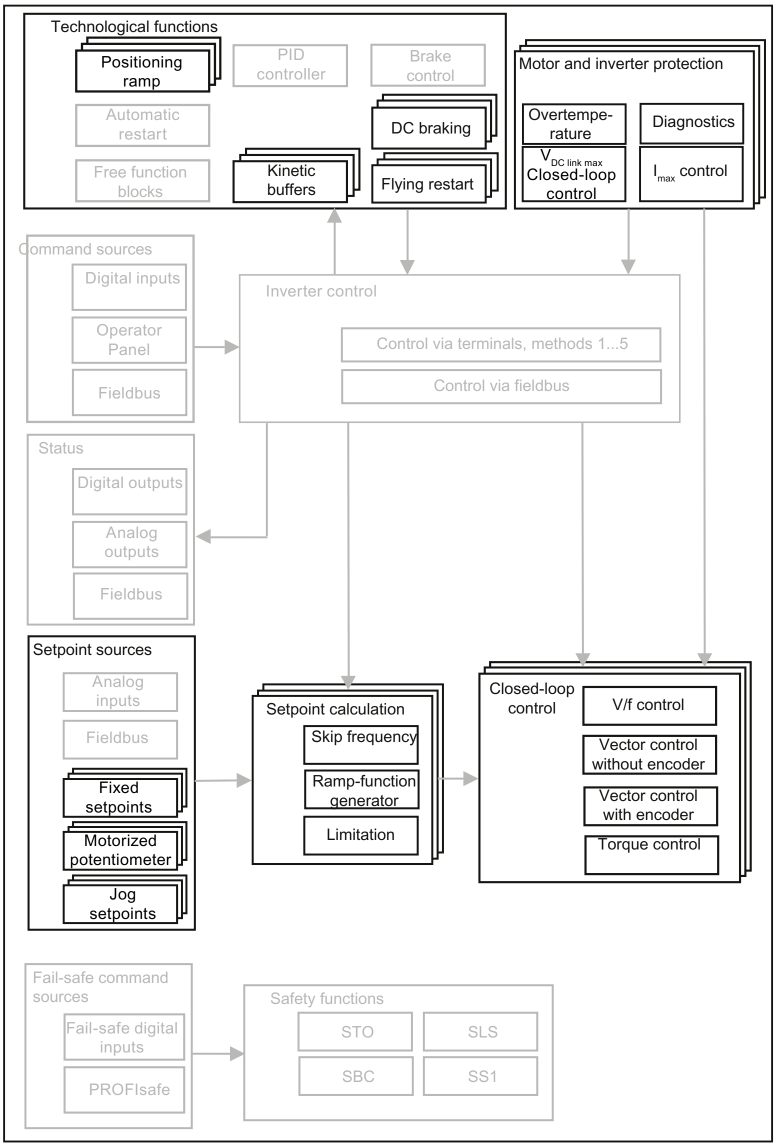


Figure 5-13 DDS switchover in the inverter

Note

Drive data sets can only be changed over in the "ready for operation" state. The switchover time is approx. 50 ms.

Exceptions: The ramp-function generator parameters, the ramp-down time for OFF3, and the speed controller gain can be switched during operation.

Table 5- 47 Parameters for switching the drive data sets:

Parameter	Description
P0820 = …	1st cntrol command for switching the drive data sets Example: When P0820 = 722.0, the system switches from drive data set 0 to drive data set 1 via digital input 0
P0821 = …	2nd control command for switching the drive data sets
r0051	Displaying the number of the DDS that is currently active
A copy function is available making it easier to commission more than one drive data set:	
P0819.0 = …	Number of the drive data set to be copied (source)
P0819.1 = …	Number of the drive data to which the data is to be copied (target)
P0819.2 = 1	Start copying

For an overview of all the parameters that belong to the drive data sets and can be switched, see the List Manual.

5.11 Operation in fieldbus systems

The frequency inverters are available in different variants for communication with higher-level controls with the subsequently listed fieldbus interfaces:

- CU240E and CU240S for USS via RS485
  - Control via PZD (process data channel)
  - Parameterizing using PKW (parameter channel)
- CU240S DP and CU240S DP-F for PROFIBUS DP
  - Control in cyclic operation using telegrams 1, 20, 350, 352 and 999
  - Control and parameterizing in cyclic operation using telegrams 353 and 354
  - Parameterizing using acyclic communication
- CU240S DP and CU240S DP-F for PROFINET
  - Control in cyclic operation using telegrams 1, 20, 350, 352 and 999
  - Control and parameterizing in cyclic operation using telegrams 353 and 354
  - Parameterizing via acyclic communication

5.11.1 Communication via USS

Universal serial interface (USS)

The USS protocol allows you to establish a serial point-to-point connection (RS 232 interface) and serial data connection between a higher-level master system and several slave systems (RS 485 interface). Master systems include programmable logic controllers (e.g. SIMATIC S7-200) or PCs. The converters are always slaves on the bus system.

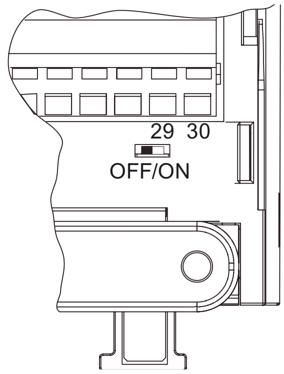
The USS protocol allows you to implement automation tasks with cyclic message frame transfer (fixed message frame length required) and visualization tasks. In this case, variable message frame lengths are better since texts and parameter descriptions can be transferred in a single message frame without the data being split up.

USS bus topology via RS 485

Communication networks with up to 31 frequency inverters (slaves) connected to a control can be established via the RS 485 interface. The topology must be configured as a path in which the first and last devices are terminated with terminating resistors.

USS communication network via RS 485 with a CU240E

The diagram shows the RS 485 terminals (29/30) and the DIP switches at the CU240E for the terminating resistor. The default position is OFF (no terminating resistor).



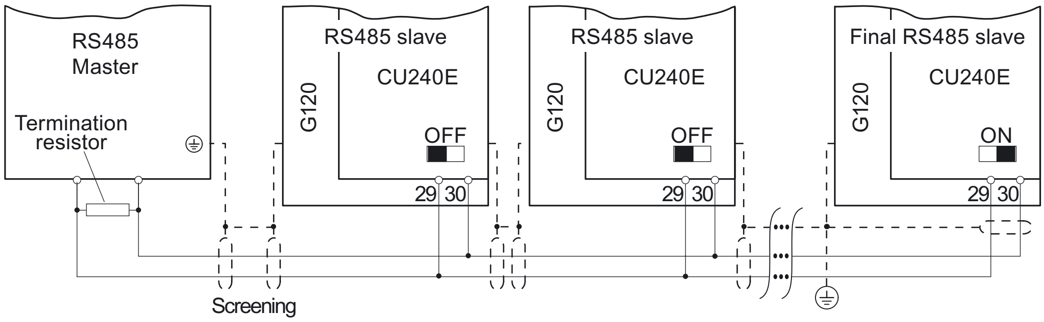
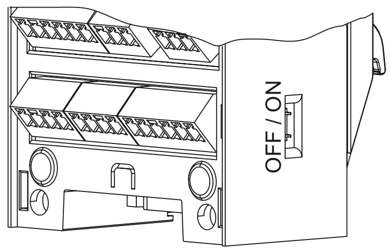


Figure 5-14 USS network via RS 485

USS communication network via RS 485 with a CU240S

The connection is established using the SUB D connector located on the lower side of the Control Unit.

The diagram shows the DIP switch for the terminating resistor at the CU240S. The default position is OFF (no terminating resistor).



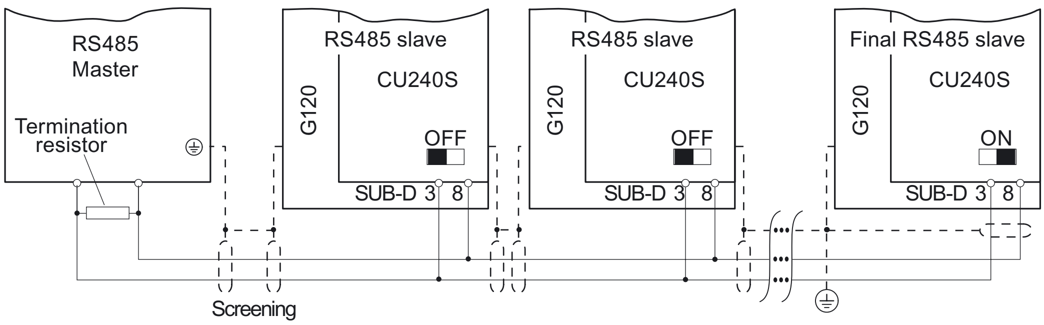


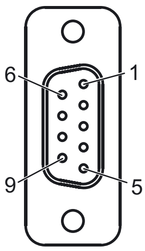
Figure 5-15 USS network via RS 485

> ⚠ **CAUTION**
>
> A difference in the ground potential between the master and slaves in an RS 485 network can damage the converter Control Unit. You must make absolutely sure that the master and slaves have the same ground potential.

SUB D connection on the CU 240S (pin assignment)

The CU240S Control Units are equipped with a 9-pole SUB D socket for connecting the inverter via an RS 485 interface. A standard 9-pole SUB D connector with a 180° cable outlet can be used for the USS connection via RS 485.

Table 5- 48 Contact assignment of the 9-pole SUB D socket

	Contact	Description	Description
	1	-	Unused
	2	-	Unused
	3	RS 485P	Receive and transmit signal (+)
	4	-	Unused
	5	0 V	Ground reference
	6	-	Unused
	7	-	Unused
	8	RS 485N	Receive and transmit signal (-)
	9	-	Unused
	X	Shield (housing)	Equipotential bonding

Cable lengths and number of devices

Table 5- 49 Max. no of devices and cable length

Baud rate in bit/s	Max. no. of devices	Max. cable length
9600	32	1200 m
19200	32	1200 m
38400	32	1200 m
57600	32	1200 m
115200 (max. baud rate)	30	1000 m

5.11.1.1 User data range of the USS message frame

Structure of the user data

The user data range of the USS protocol is used to transfer application data. The process data is exchanged cyclically between the converter and controller via the process data channel (PZD), while the parameter channel is used for transferring parameter values acyclically.

The following diagram shows the structure and sequence of parameter channel and process data (PZD).

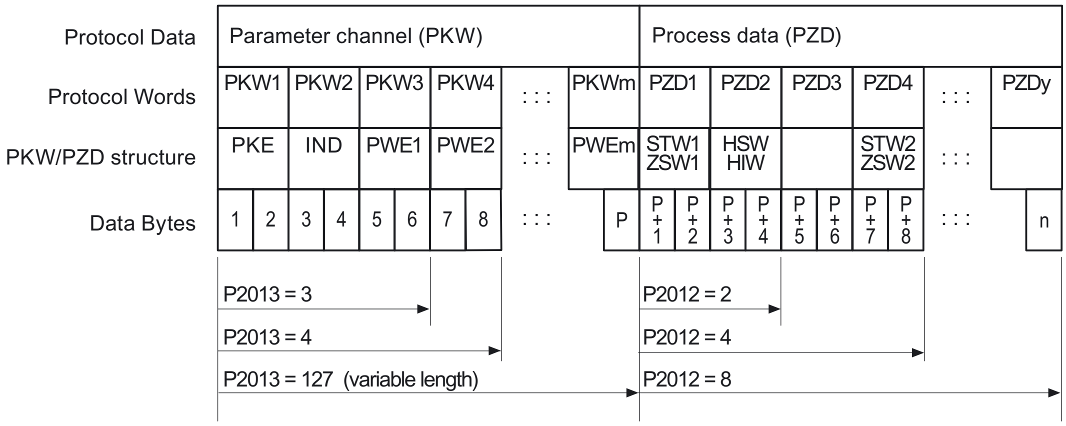


Figure 5-16 USS user data structure

The length of the parameter channel is defined via parameter P2013, while the length of the process data is defined via parameter P2012. If neither a parameter channel nor process data is required, the appropriate parameters can be set to zero ("PKW only" or "PZD only").

If both channels are required, they must be transferred together.

5.11.1.2 Data structure of the USS parameter channel

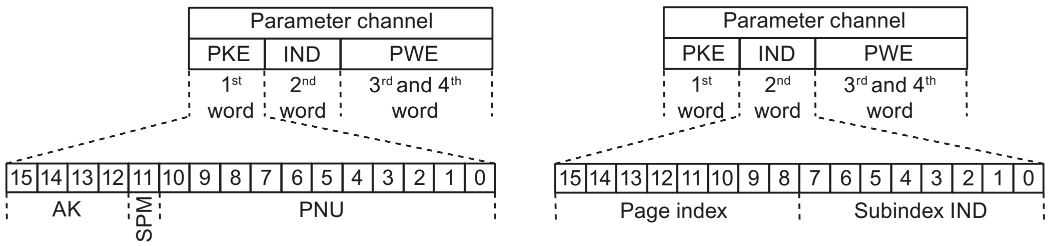
Description

The parameter channel is used to monitor and/or change parameters in the converter. Every time data is transferred, the parameter ID and associated parameter value are sent. The parameter channel can be set to a fixed length (3 or 4 data words) or variable length.

- The first data word always contains the parameter ID (PKE)
- The second data word contains the parameter index (IND)
- The third and fourth data word contain parameter values, text, and descriptions (PWE)

Parameter ID (PKE) and parameter index (IND)

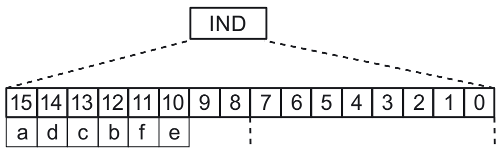
The parameter ID (PKE) is always a 16 bit value. In conjunction with the index (IND), it defines the parameter to be transferred.



PKE structure IND structure

- The parameter number is encoded in the lower 11 bits (PNU) of the PKE. Since the PNU can only contain values up to 2000, an offset must also be encoded for parameter numbers above 2000. The offset is set in the first word of the index (IND) as shown in the table below.
- Bit 11 (SPM) is reserved and is always 0.
- Bits 12 to 15 (AK) contain the request or response ID.

The meaning of the request ID for request message frames (master → converter) is explained in the following table.



IND page index

Table 5- 50 Regulations for setting the PNU

Parameter range	Page index						Bit		Hex value	+ PNU
	a	b	c	d	f	e	9	8		
0000 … 1999	0	0	0	0	0	0	0	0	0x00	0 – 7CF
2000 … 3999	1	0	0	0	0	0	0	0	0x80	0 – 7CF
4000 … 5999	0	0	0	1	0	0	0	0	0x10	0 – 7CF
6000 … 7999	1	0	0	1	0	0	0	0	0x90	0 – 7CF
8000 … 9999	0	0	1	0	0	0	0	0	0x20	0 – 7CF
…	…	…	…	…	…	…	…	…	…	…
32.000 … 33.999	0	0	0	0	1	0	0	0	0x8	0 – 7CF
…	…	…	…	…	…	…	…	…	…	…
64.000 … 65.999	1	1	1	1	0	1	0	0	0xF4	0 – 7CF

Table 5- 51 Sample coding of a parameter number in PKE and IND for P8820, index 16

	PKE		IND	
decimal	xx	820	32	16
hex	xx	334	20	10

The parameter index is encoded in the second word of the index (IND).

Example: Coding of a parameter number in PKE and IND for P2016, index 3

PKE		IND		PWE1		PWE2	
xx	10	80	03				

The master and slave exchange data via the request ID and response ID (AK), a process that is to take place with the parameter specified in the PKE. The transfer status is communicated with the response ID.

Table 5- 52 Request ID (master → converter)

Request ID	Description	Response ID	
		positive	negative
0	No request	0	7 / 8
1	Request parameter value	1 / 2	7 / 8
2	Change parameter value (word)	1	7 / 8
3	Change parameter value (double word)	2	7 / 8
4	Request descriptive element 1)	3	7 / 8
6	Request parameter value (field) 1)	4 / 5	7 / 8
7	Change parameter value (field, word) 1)	4	7 / 8
8	Change parameter value (field, double word) 1)	5	7 / 8
9	Request no. of field elements	6	7 / 8
11	Change parameter value (field, double word) and save in EEPROM 2)	5	7 / 8
12	Change parameter value (field, word) and save in EEPROM 2)	4	7 / 8
13	Change parameter value (double word) and save in EEPROM	2	7 / 8
14	Change parameter value (word) and save in EEPROM	1	7 / 8

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

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

The meaning of the response ID for response message frames (converter → master) is explained in the following table. The request ID determines which response IDs are possible.

Table 5- 53 Response ID (converter → master)

Response ID	Description
0	No response
1	Transferred parameter value (word)
2	Transferred parameter value (double word)
3	Transfer descriptive element 1)
4	Transfer parameter value (field, word) 2)
5	Transfer parameter value (field, double word) 2)
6	Transfer no. of field elements
7	The request cannot be processed and the task cannot be executed (with fault number)
8	No master controller mode / no authorization to change parameters of the PARAMETER CHANNEL interface
1) The required element of the parameter description is specified in IND (second word). 2) The required element of the indexed parameter is specified in IND (second word).	

If the response ID is 7 (request cannot be processed), one of the fault numbers listed in the following table is stored in parameter value 2 (PWE2).

Table 5- 54 Fault 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 is read only
2	Min./max. not reached or exceeded	–
3	Incorrect sub-index	–
4	No field	One parameter was addressed with a field request and sub-index > 0
5	Incorrect parameter/data type	Word and double word mixed up
6	Set not permitted (reset only)	–
7	The descriptive element cannot be changed	Description can never be changed
11	Not in "master controller" mode	Change request without "master controller" mode (see P0927)
12	No key word	–
17	Request cannot be processed due to the operating status	The current converter operating status is not compatible with the request received.
101	Parameter number currently deactivated	Depends on the operating status of the converter
102	Insufficient channel width	Communication channel too narrow for response
104	Impermissible parameter value	The parameter only permits certain values.
106	No request / task not supported	After request ID 5, 10, 15
200/201	Modified min./max. not reached or exceeded	The maximum or minimum value can be limited further during operation.
204	The current access authorization does not cover parameter changes.	–

Parameter value (PWE)

When communication takes place via the USS, the number of PWEs can vary. One PWE is required for 16 bit values. If 32 bit values are exchanged, two PWEs are required.

Note

U8 data types are transferred as U16, whereby the upper byte is zero. U8 fields, therefore, require one PWE for each index.

A parameter channel for 3 words is a typical data message frame for exchanging 16 bit data or alarm messages. The mode with a fixed word length of 3 is used when P2013 = 3.

A parameter channel for 4 words is a typical data message frame for exchanging 32 bit data variables and requires P2013 = 4.

A parameter channel allowing a flexible word length is used when P2013 = 127. The message frame length between the master and slave can have a different number of PWEs.

When the length of the parameter channel is fixed (p2013 = 3 or 4), the master must always transmit either 3 or 4 words in the parameter channel, otherwise the slave will not respond to the message frame. The response from the slave will also contain either 3 or 4 words. When the length is fixed, 4 should be used because 3 is insufficient for many parameters (i.e. double words). When the parameter channel is of a variable length (P2013 = 127), the master transmits only the amount of words required for the task in the parameter channel. The length of the response message frame is also restricted to the required size.

Rules for processing requests/responses

- A request or response can only refer to one parameter.
- The master must repeat a request until it receives a suitable response.
- The master recognizes the response to a request by:
  - Evaluating the response ID
  - Evaluating the parameter number (PNU)
  - Evaluating the parameter index IND (if required)
  - Evaluating the parameter value PWE (if required)
- The request must be transmitted in full in a message frame. Request message frames cannot be split up. The same applies to responses.
- If response message frames contain parameter values, the drive always returns the current parameter value when it repeats response message frames.

5.11.1.3 Timeouts and other errors

Process timeouts

Parameter P2014 defines the permissible timeout in ms. Value zero prevents timeout monitoring. Parameter P2014 checks the cyclic update of bit 10 in control word 1.

If the USS is configured as a command source for the drive and P2014 is not zero, bit 10 of the received control word 1 is checked. If the bit is not set, an internal timeout counter is incremented. If the threshold defined in P2014 is reached, the drive sets a process timeout error.

Other errors

P2025 = USS rejected

P2026 = USS character frame error

P2027 = USS overflow error

P2028 = USS parity error

P2029 = USS start not recognized

P2030 = USS BCC error

P2031 = USS length error

5.11.1.4 USS process data channel (PZD)

Description

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

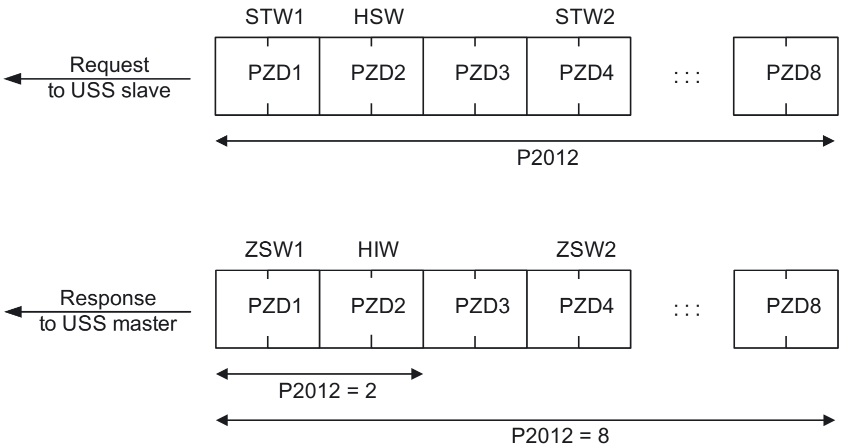


Figure 5-17 USS process data channel

The number of PZD words in a USS message frame is defined by parameter P2012. The first two words are:

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

If P2012 is greater than or the same as 4, the additional control word (STW2) is transferred as the fourth PZD word (default setting).

The sources of all the other PZDs are defined with parameter P2019 for an RS 485 interface and with P2016 for an RS 232 interface.

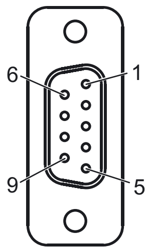
5.11.2 Communication via PROFIBUS and PROFINET

5.11.2.1 Connect the frequency inverter to PROFIBUS

Assignment of the SUB-D connector to connect to the PROFIBUS-DP network

Control Units CU240S DP and CU240S DP-F of the frequency converter are equipped with a SUB D connection for the PROFIBUS cable.

Table 5- 55 Contact assignment of the 9-pole SUB D connection

	Contact	Designation	Description	Area
	1	Shielding	Ground connection	
	2	U0V	Floating and reference point for user supply	
	3	RxD/TxD-P	Receive/transmit data P (B/B')	RS 485
	4	CNTR-P	Control signal	TTL
	5	DGND	Reference potential for PROFIBUS data (C/C')	
	6	VP	Plus pole for supply voltage	5 V ± 10 %
	7	U24V	Floating user supply +24 V at 100 mA	
	8	RxD/TxD-N	Receive/transmit data N (A/A')	RS 485
	9	-	Not assigned	
	Housing	Cable shield	Cable shield	

The SUB D connection is suitable for the SIMATIC RS 485 bus connector.

Recommended PROFIBUS connectors

We recommend one of the following connectors for the PROFIBUS cable:

1. 6GK1500-0FC00
2. 6GK1500-0EA02

Both connectors are suitable for all SINAMICS G120 Control Units with respect to the angle of the outgoing cable.

Note

PROFIBUS communication when the 400 V supply for the frequency inverter is switched off

If the frequency inverter is only supplied via the 400 V line connection for the Power Module, the PROFIBUS connection for the Control Unit is interrupted as soon as the power supply is disconnected. To prevent this, the Control Unit must be connected to a separate 24 V power supply via terminals 31 (+24 V I_n) and 32 (0 V I_n).

Permissible cable length / installing and shielding the PROFIBUS cable

For information about this, see http://support.automation.siemens.com/WW/view/de/1971286.

5.11.2.2 Example: configuring the frequency converter on PROFIBUS

Task

A drive with a SINAMICS G120 frequency converter is to be controlled from a central SIMATIC controller via PROFIBUS, whereby the control signals and speed setpoint are to be transferred from an S7-300 CPU to the drive. In the other direction, the drive is to transfer its status messages and actual speed value to the central controller via PROFIBUS.

Using a suitable example, the following section provides step-by-step instructions explaining how to connect a frequency converter to a higher-level SIMATIC controller via PROFIBUS. To extend the PROFIBUS network to include additional frequency converters, simply repeat the relevant steps.

What prior knowledge is required?

This section does not explain how to use S7 controllers or the STEP 7 engineering tool.

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 G120 Control Unit	CU240S DP	6SL3244-0BA21-1PA0	1
SINAMICS G120 Power Module	PM240	6SL3224-0BE21-5UA0	1
Basic Operator Panel	BOP	6SL3255-0AA00-4BA1	1
Motor	Three-phase induction motor	1LA7060-4AB10	1
PROFIBUS connector	PROFIBUS connector	6GK1500-0FC00	1

Note

The description provided in this manual uses the hardware listed above. Other similar products not listed above can also be used.

Software components

Component	Type	Order no.	Qty
SIMATIC STEP 7	V5.3 + SP3	6ES7810-4CC07-0YA5	1
Drive ES Basic	V5.4	6SW1700-5JA00-4AA0	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.

Setting the PROFIBUS address of the frequency converter

Two DIP switch blocks are located on the Control Unit. The PROFIBUS address of the frequency inverter is set using one of these. The DIP switch for the PROFIBUS address is, depending on the firmware release, either located on the front of the CU below the operator and display instrument (Operator Panel) or at the side of the CU.

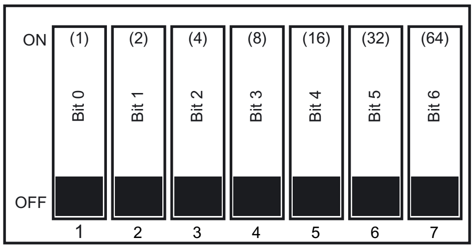


Figure 5-18 PROFIBUS DIP switches

Alternatively, the PROFIBUS address can be set via parameter P0918, although you should only use this method if you cannot set the address via the DIP switches.

CAUTION
When the PROFIBUS address is changed, the Control Unit needs to be switched off and on again to activate the new address. This must be carried out by switching the power supply off and then on again, regardless of whether the interface is supplied by the power supply for the converter or via its own 24 V power supply.

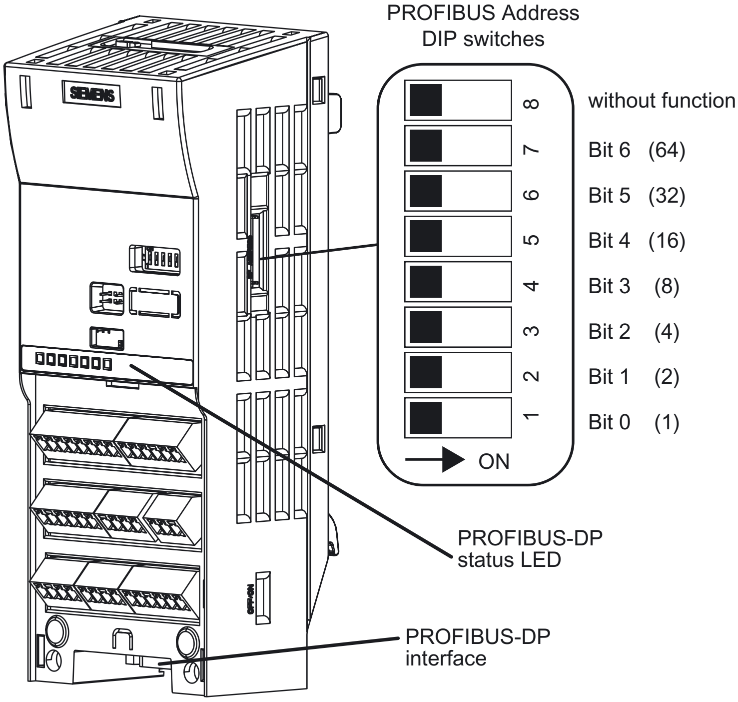
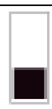
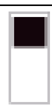
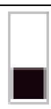
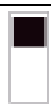
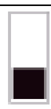
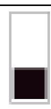
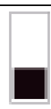
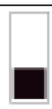
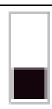
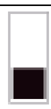
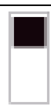
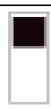
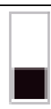
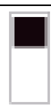


Figure 5-19 PROFIBUS interface, diagnostics, and address setting on the Control Unit

Set the DIP switch to address 10 (as shown in the following table).

Table 5- 56 Examples of setting the PROFIBUS address

DIP switch	1	2	3	4	5	6	7
The figure specified in this row must be added to the address.	1	2	4	8	16	32	64
Example 1: Address = 10 = 2 + 8							
Example 2: Address = 88 = 8 + 16 + 64							

The valid address range is specified in the table below:

Table 5- 57 Valid PROFIBUS addresses

DIP switch settings	Meaning
0	PROFIBUS address defined via P0918
1 … 125	Valid PROFIBUS address
126, 127	Invalid PROFIBUS address

Integrating the frequency converter in a higher-level SIMATIC controller

Once you have set the PROFIBUS address of the frequency converter, all the remaining settings required for integrating it in the SIMATIC controller are carried out in STEP 7 with HW Config.

Creating a STEP 7 project

Create a new STEP 7 project and assign a project name (e.g. "G120_in_S7").

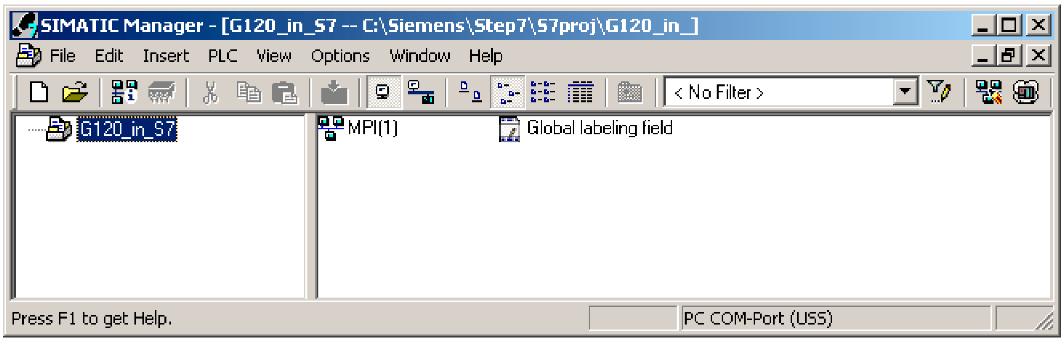


Figure 5-20 Create a new project in STEP 7

Configuring SIMATIC 300 and creating the PROFIBUS network

Add an S7 300 CPU.

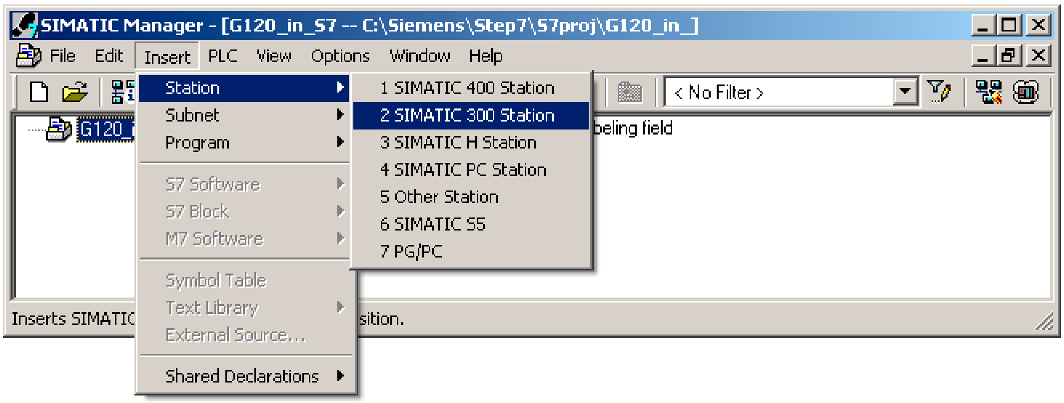


Figure 5-21 Add a SIMATIC 300 station

Open the hardware configuration (HW Config) in Step 7.

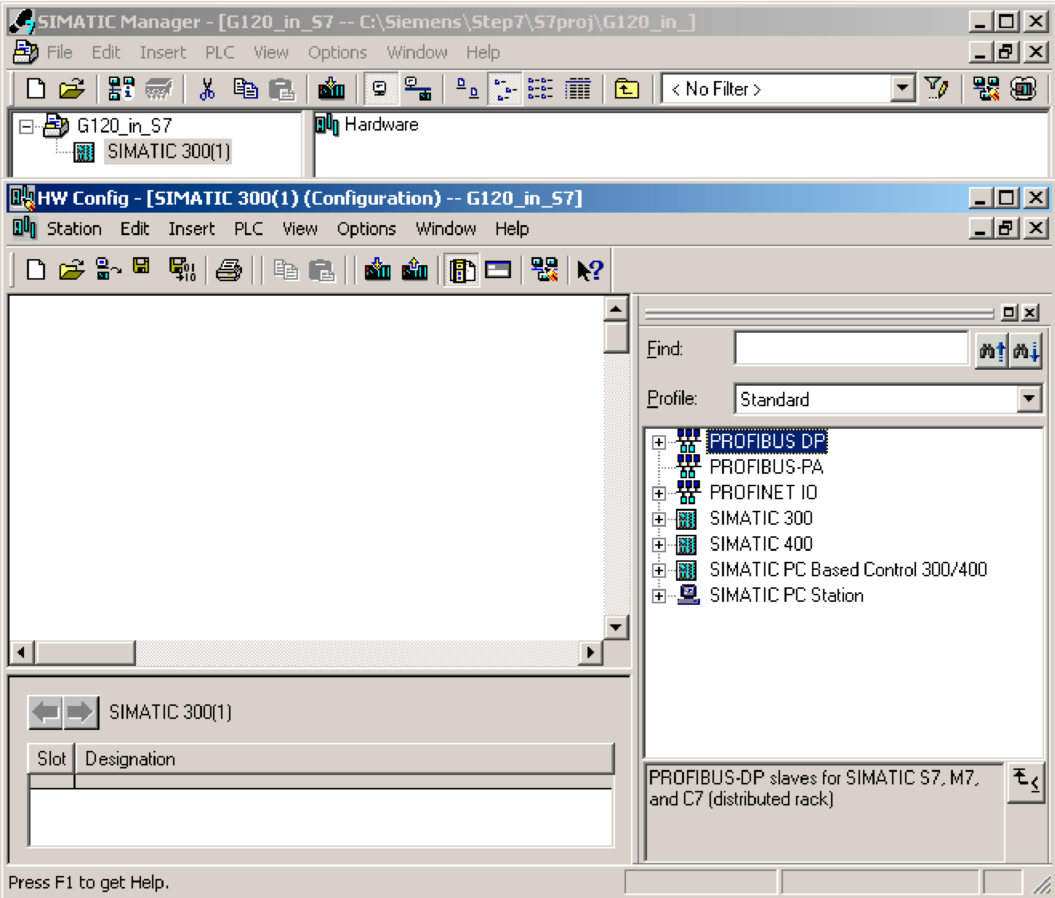


Figure 5-22 Open HW Config

Add an S7 300 subrack to your project by dragging and dropping it from the "SIMATIC 300" hardware catalog. Connect a power supply to slot 1 of the subrack and a CPU 315-2 DP to slot 2.

When you add the SIMATIC 300, a window is displayed in which you can define the network. Create a PROFIBUS DP network.

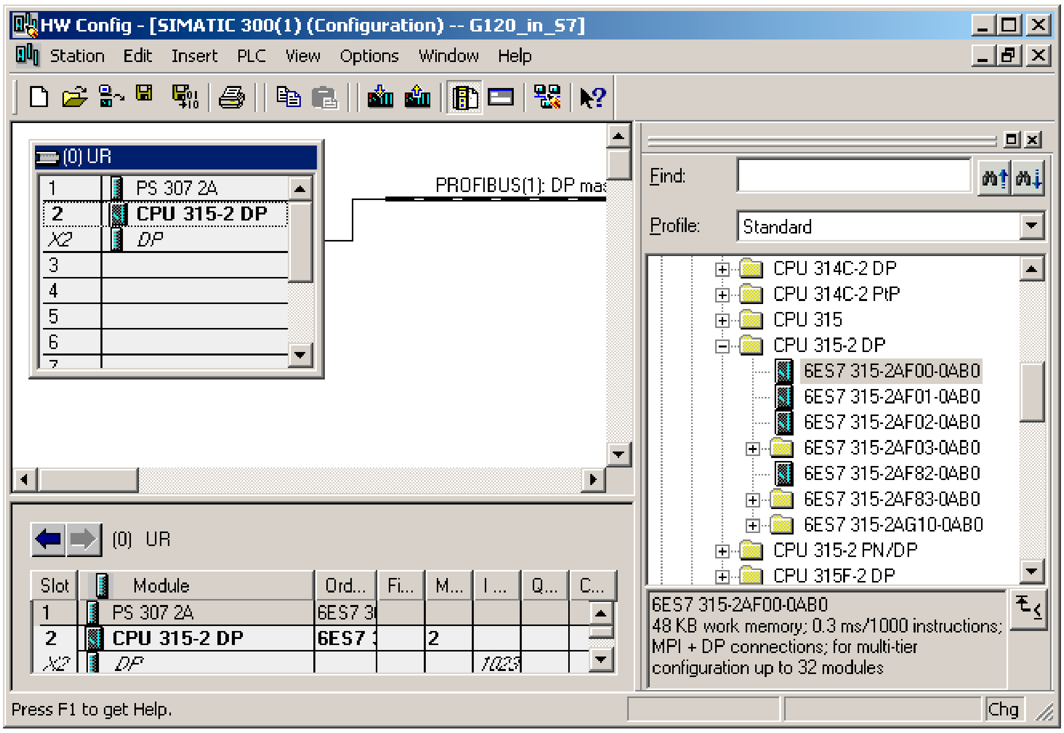


Figure 5-23 Add a SIMATIC 300 station with the PROFIBUS DP network

Configuring the frequency converter and integrating it in the PROFIBUS network

In STEP 7, the frequency converter can be connected to an S7 controller in two ways:

1. Via the GSD of the frequency converter

   The GSD is a standardized description file for a PROFIBUS slave. It is used by all controllers that are PROFIBUS masters.

2. Via the STEP 7 object manager

   This somewhat more user-friendly method is only available for S7 controls and installed Drive_ES_Basic.

The following section describes how to configure the frequency converter using the GSD.

Installing the GSD in STEP 7

The GSD for SINAMICS frequency converters can be downloaded from the Internet.

It is integrated in STEP 7 via HW Config.

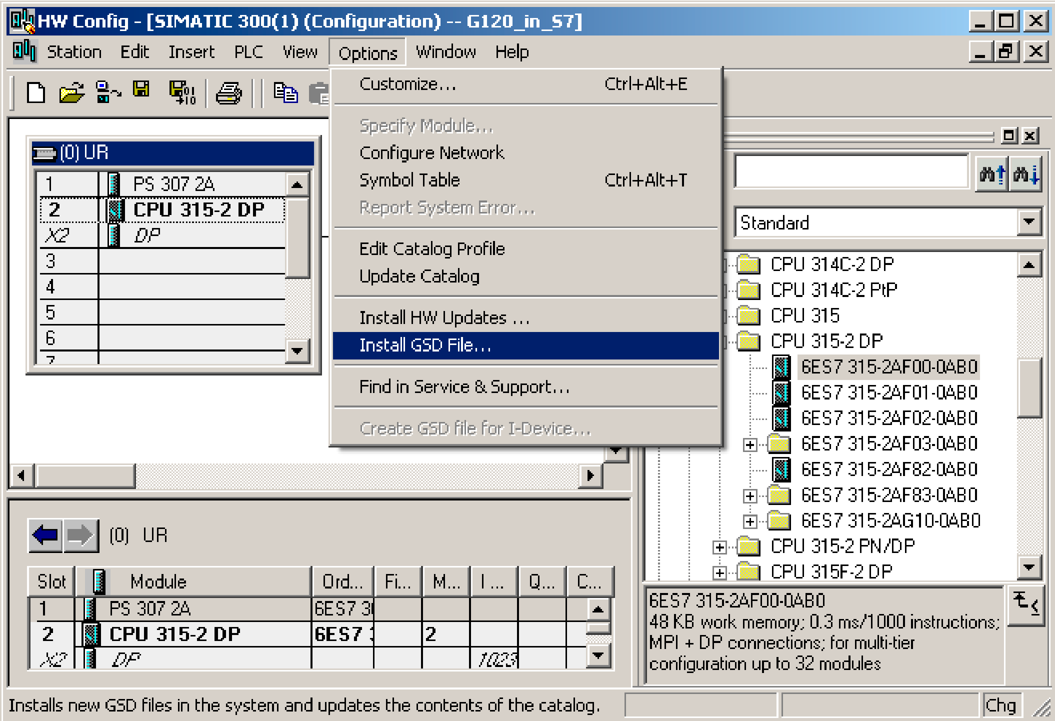


Figure 5-24 Install the GSD in STEP 7 with HW Config

Once the GSD has been installed, the frequency converter appears as an object under "PROFIBUS DP" in the HW Config product catalog.

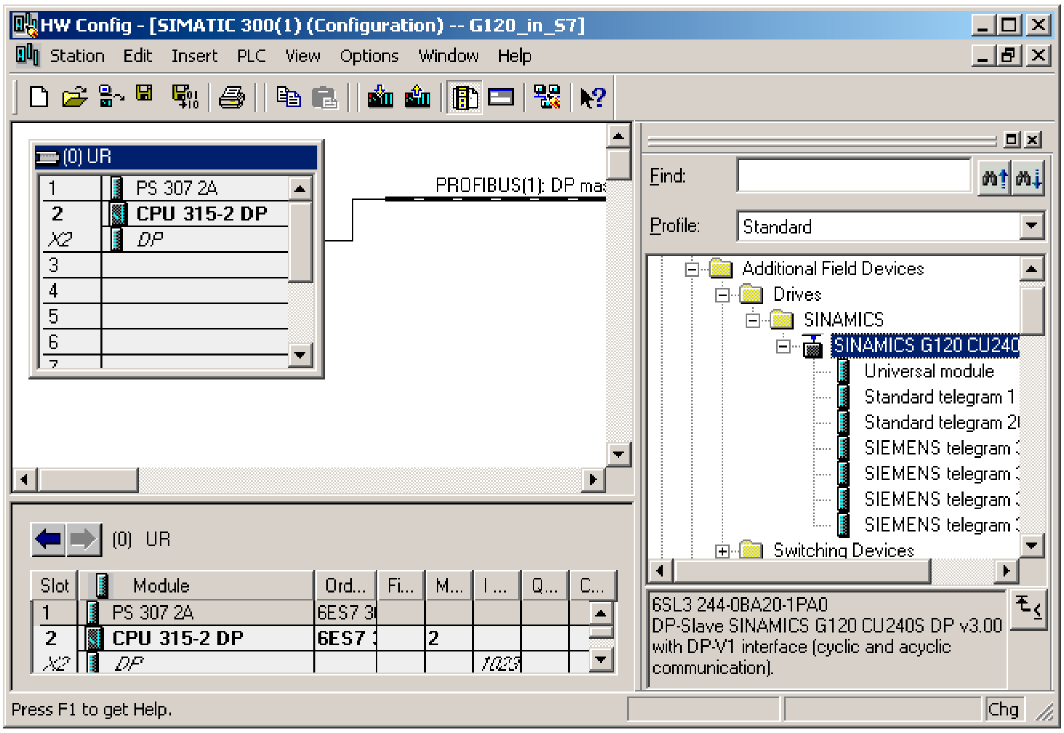


Figure 5-25 G120 in the HW Config product catalog

Drag and drop the frequency converter to the PROFIBUS network. Enter the PROFIBUS address set on the frequency converter in HW Config.

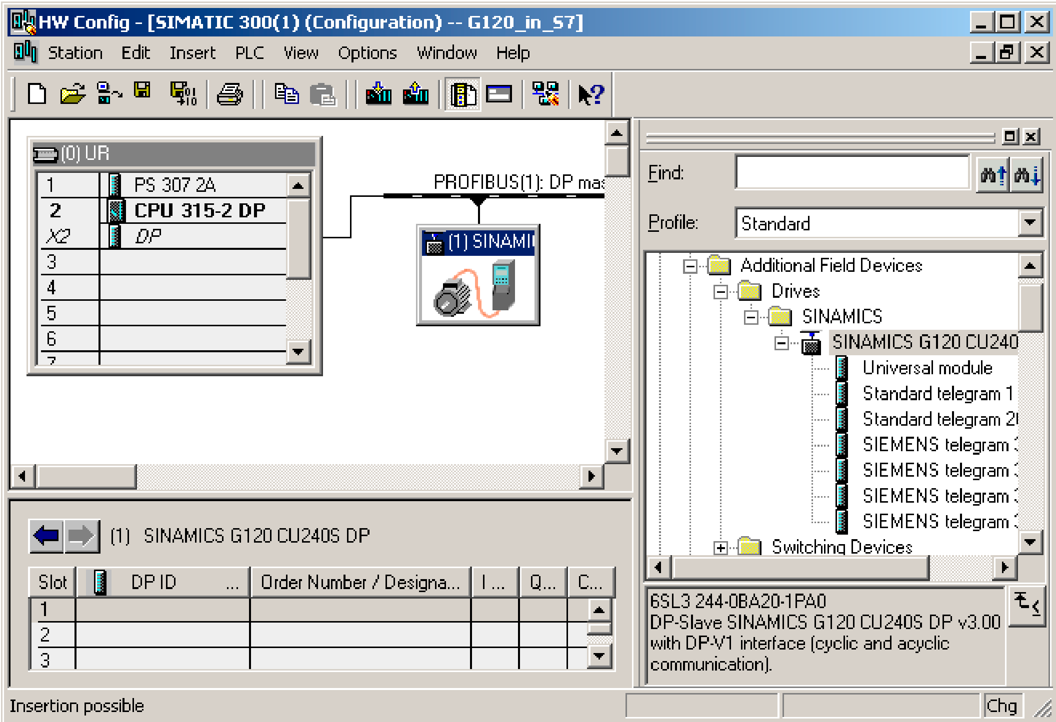


Figure 5-26 Connect G120 to the PROFIBUS network

The frequency converter object in the HW Config product catalog contains a number of message frame types. The message frame type defines which cyclic data (= process data (PZD)) is exchanged between the controller and frequency converter. With standard message frame 1, for example, the frequency inverter receives the process data for the speed setpoint and control word from the control system and returns its actual speed value and status word in the process data.

Add the required message frame type to slot 1 of the frequency converter by dragging and dropping it from the HW catalog.

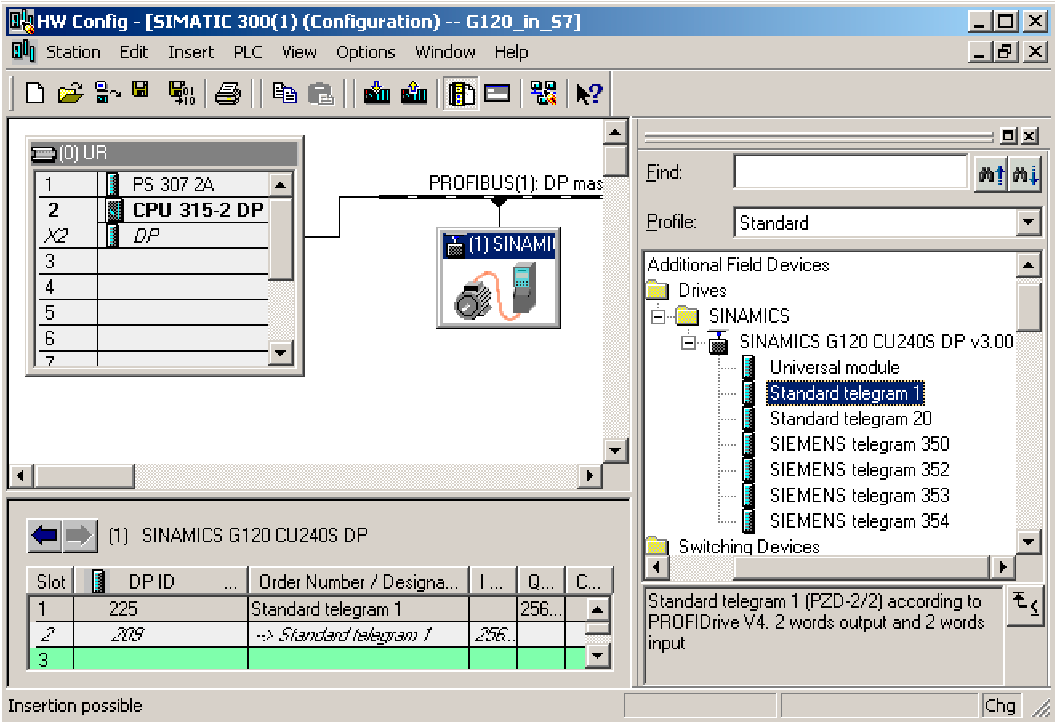


Figure 5-27 Define the message frame type of the SINAMICS G120 frequency converter in the controller

STEP 7 automatically assigns the address range containing the process data for the frequency converter. Standard message frame 1 occupies four bytes of input data and four bytes of output data.

Note

Defining the message frame type in the frequency converter

The message frame type setting in HW Config only applies to the controller side. In the frequency converter, the same message frame type must be set by means of STARTER or the BOP via parameter P0922.

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.

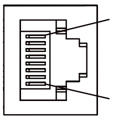
The frequency converter is now connected to the S7 CPU. The communications interface between the CPU and frequency converter is defined via the PROFIdrive profile. An example of how you can supply this interface with data can be found in this manual.

5.11.2.3 Integrating a frequency inverter in PROFINET

Assignment of the RJ45 connector to integrate a frequency inverter into PROFINET

The CU240S PN and CU240S PN-F Control Units are equipped with an Ethernet switch for two connections in the form of RJ45 sockets. Connections with optical networks are established via switches, which are equipped with an electrical and optical port. The drive is then connected to an electrical port, which means that no power supply is available for an external electrical/optical converter.

Table 5- 58 Contact assignment of the RJ45 sockets

	Contact	Designation	Meaning	Wire color
	1	TX+	Transmit data +	Yellow
	2	TX	Transmit data -	Orange
	3	RX+	Receive data +	White
	4	-		
	5	-		
	6	RX -	Receive data -	Blue

For information about assembling the SIMATIC NET Industrial Ethernet FastConnect RF45 plug 180, see "Assembly Instructions for SIMATIC NET Industrial Ethernet FastConnect RJ45 Plug". The document can be downloaded from the following page:

http://support.automation.siemens.com/WW/view/en/23175326/130000

Recommended PROFINET connectors

We recommend the following connector for the PROFINET cable:

6GK1901-1BB10-2Ax0

Permissible cable length / installing and shielding the PROFINET cable

For information about this, see http://support.automation.siemens.com/WW/view/de/25571355.

Note

SINAMICS does not support routing between PROFIBUS and PROFINET (and vice versa).

5.11.2.4 Example: configuring the frequency converter on PROFINET

Differences between PROFIBUS and PROFINET

The procedure for operating the frequency inverter on PROFINET differs only slightly from the above description for PROFIBUS. The following section covers only the key differences between PROFIBUS and PROFINET.

Hardware components (example)

In comparison to PROFIBUS, the S7 CPU, the Control Unit of the frequency inverter and the communication cable must be configured for PROFINET.

Component	Type	Order no.	Qty
Central controller			
Power supply	PS307 2 A	6ES7307-1BA00-0AA0	1
S7 CPU	CPU 315-2 PN/DP	6ES7315-2EG10-0AB0	1
Memory card	MMC 2MB	6ES7953-8LL11-0AA0	1
DIN rail	DIN rail	6ES7390-1AE80-0AA0	1
PROFINET connector	PROFINET connector	6GK1901-1BB10-2Ax0	1
PROFINET cable	PROFINET cable	6XV1840-2AH10	1
Drive			
SINAMICS G120 Control Unit	CU240S PN	6SL3244-0BA21-1PA0	1
SINAMICS G120 Power Module	PM240	6SL3224-0BE21-5UA0	1
Basic Operator Panel	BOP	6SL3255-0AA00-4BA1	1
Motor	Three-phase induction motor	1LA7060-4AB10	1
PROFINET connector	PROFINET connector	6GK1901-1BB10-2Ax0	1

Note

The description provided in this manual uses the hardware listed above. Other similar products not listed above can also be used.

Software components

Component	Type	Order no.	Qty
SIMATIC STEP 7	V5.4 SP2	6ES7810-4CC07-0YA5	1
Drive ES Basic	V5.4	6SW1700-5JA00-4AA0	1

Integrating the frequency converter in a higher-level SIMATIC controller

All settings required for integrating the frequency converter in the SIMATIC controller are carried out in STEP 7 with HW Config.

Creating the STEP 7 project and configuring SIMATIC 300

The procedure here is very similar to that described for PROFIBUS. The main differences are:

1. In the module catalog, choose a PROFINET-capable S7 controller (e.g. CPU 315-2 PN/DP).
2. Once you have added the SIMATIC 300, create a PROFINET network.

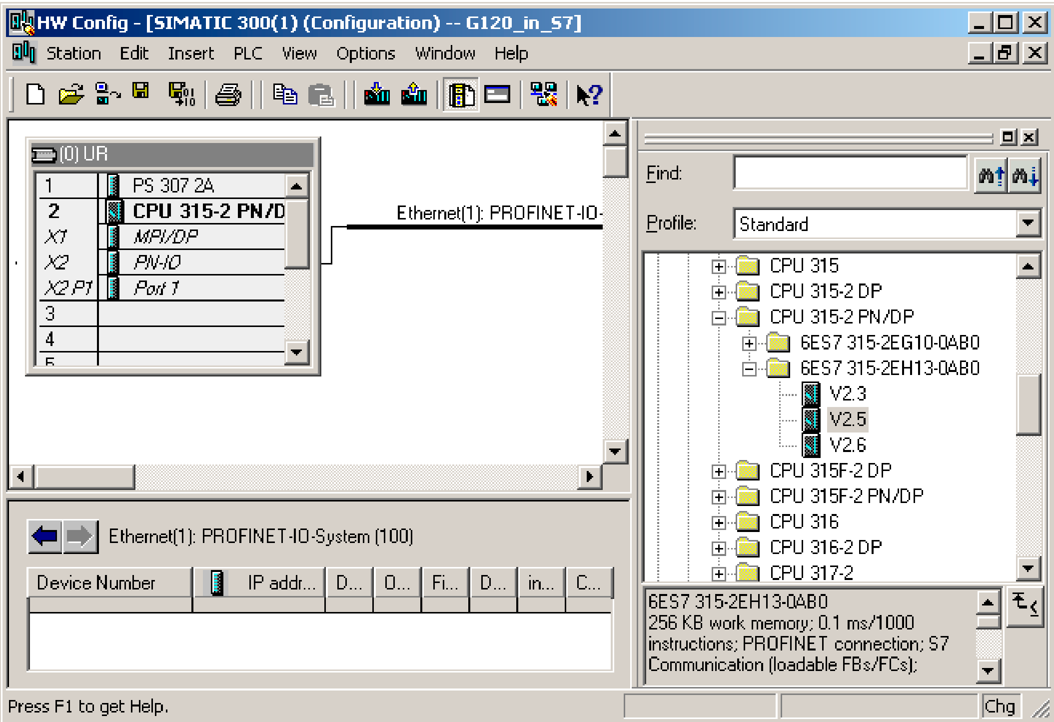


Figure 5-28 Add SIMATIC 300 station with the PROFINET network

Configuring the frequency converter and integrating it in the PROFINET network

The frequency converter is integrated in the higher-level controller with its GSDML via PROFINET. The GSDML for SINAMICS frequency converters can be downloaded from the Internet. Once the GSDML has been installed (see "Communication via PROFIBUS"), the frequency converter appears as an object under "PROFINET IO" in the HW Config product catalog.

Drag and drop the frequency converter to the PROFINET network and then choose the standard message frame 1 as the message frame type.

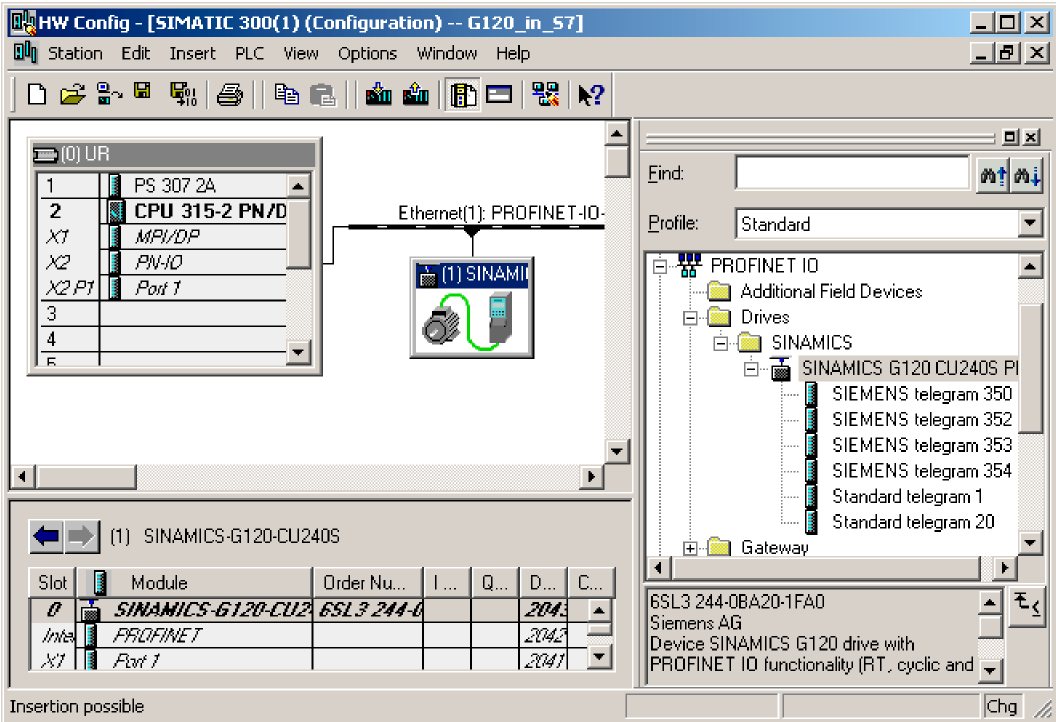


Figure 5-29 G120 with standard message frame 1 in STEP 7 on PROFINET

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.

The frequency converter is now connected to the S7 CPU. The communications interface between the CPU and frequency converter is defined via the PROFIdrive profile. An example of how you can supply this interface with data can be found in this manual.

5.11.2.5 The PROFIdrive profile

User data structure in the PROFIdrive profile

PROFIdrive as a frequency inverter interface on PROFIBUS or PROFINET

The SINAMICS G120 frequency converters are controlled via the PROFIdrive profile (version 4.1). The PROFIdrive profile defines the user data structure with which a central controller communicates with the frequency converter by means of cyclic or acyclic data transfer.

The PROFIdrive profile is a cross-vendor standard. A complete description of this standard is available under /P5/ PROFIdrive Profile Drive Technology.

Cyclic communication

Description

The PROFIdrive profile defines different message frame types. Message frames contain the data packages for cyclic communication with a defined meaning and sequence. The SINAMICS G120 frequency converter supports the message frame types listed in the table below.

Table 5- 59 SINAMICS G120 message frame types

Message frame type	Parameter channel (PKW) parameter data	Process data (PZD) - control and status words, actual values							
		PZD01 STW1 ZSW1	PZD02 HSW HIW	PZD03	PZD04	PZD05	PZD06	PZD 07	PZD 08
Message frame 1 speed control, 2 words	No	STW1	NSOLL_A	⇐ The frequency converter receives this data from the controller					
		ZSW1	NIST_A	⇒ The frequency converter sends this data to the controller					
Message frame 20 speed control, VIK/NAMUR 2 or 5 words	No	STW1	NSOLL_A						
		ZSW1	NIST_A_ GLATT	IAIST	MIST	PIST			
Message frame 350 speed control, 4 words	No	STW1	NSOLL_A	M_LIM	STW2				
		ZSW1	NIST_A_ GLATT	IAIST_	ZSW2				
Message frame 352 speed control, PCS7	No	STW1	NSOLL_A	<1>	<1>	<1>	<1>		
		ZSW1	NIST_A_ GLATT	IAIST	MIST	FAULT_ CODE	WARN_ CODE		
Message frame 353 speed control, PKW 4/4 and PZD 2/2	Yes	STW1	NSOLL_A						
		ZSW1	NIST_A_ GLATT						
Message frame 354 speed control, PKW 4/4 and PZD 6/6	Yes	STW1	NSOLL_A	<1>	<1>	<1>	<1>		
		ZSW1	NIST_A_ GLATT	IAIST	MIST	FAULT_ CODE	WARN_ CODE		
Message frame 999 free interconnection via BICO	No	STW1	Message frame length on receipt is max. 8 words. The central configuration is user defined (e.g. HW Config (universal module in GSD))						
		ZSW1	Message frame length on transmission is max. 8 words. The central configuration is user defined (e.g. HW Config (universal module in GSD))						

Message frame type	Parameter channel (PKW) parameter data	Process data (PZD) - control and status words, actual values							
		PZD01 STW1 ZSW1	PZD02 HSW HIW	PZD03	PZD04	PZD05	PZD06	PZD 07	PZD 08
<1> Placeholder for PCS7 process data									

STW1/2	Control word 1/2
ZSW1/2	Status word 1/2
NSOLL_A	Speed or frequency setpoint
NIST_A_GLATT	Smoothed speed or actual frequency value
IA_IST	Current output current
MIST	Current torque
PIST	Current active power
M_LIM	Toque limit value
FAULT_CODE	Fault number
WARN_CODE	Alarm number

The following sections explain the content of this table in more detail.

Data structure of the parameter channel

Parameter channel

The parameter channel can be used to process and monitor process data (write/read) as described below. The parameter channel always comprises four words.

Parameter channel		
PKE	IND	PWE
1st word	2nd word	3rd and 4th word

Abbreviations:
PKE : Parameter identifier
IND : Index
PWE: Parameter value

Figure 5-30 Structure of the parameter channel in the message frame structure

Parameter ID (PKE), first word

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

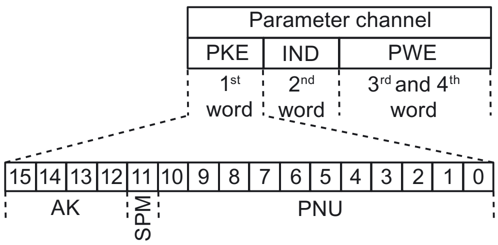


Figure 5-31 PKE structure

- Bits 0 to 10 (PNU) contain the rest of the parameter number (value range 1 to 61999).

An offset must be added, which is defined by IND with the upper bits (acyclic) or the lower bits (cyclic) of the byte, for parameter numbers ≥ 2000.

- Bit 11 (SPM) is reserved and is always 0
- Bits 12 to 15 (AK) contain the request or response ID

The meaning of the request ID for request message frames (master → converter) is explained in the following table.

Table 5- 60 Request ID (master → converter)

Request ID	Description	Response ID	
		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 1)	3	|
6	Request parameter value (field) 1)	4 / 5	|
7	Change parameter value (field, word) 1)	4	|
8	Change parameter value (field, double word) 1)	5	|
9	Request number of field elements	6	|
11	Change parameter value (field, double word) and save in EEPROM 2)	5	|
12	Change parameter value (field, word) and save in EEPROM 2)	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 (second word). 2) The required element of the indexed parameter is specified in IND (second word).			

The meaning of the response ID for response message frames (converter → master) is explained in the following table. The request identifier determines which response identifiers are possible.

Table 5- 61 Response ID (frequency inverter → master)

Response identifier	Description
0	No response
1	Transfer parameter value (word)
2	Transfer parameter value (double word)
3	Transfer descriptive element [1)]
4	Transfer parameter value (field, word) [2)]
5	Transfer parameter value (field, double word) [2)]
6	Transfer number of field elements
7	Request cannot be processed, task cannot be performed (with error number)
8	No master controller mode / no authorization to change parameters of the PARAMETER CHANNEL interface
1) The required element of the parameter description is specified in IND (second word). 2) The required element of the indexed parameter is specified in IND (second word).	

If the response ID is 7 (request cannot be processed), one of the fault numbers listed in the following table is stored in parameter value 2 (PWE2).

Table 5- 62 Fault 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	Word and double word mixed-up
6	Setting is not permitted (only resetting)	–
7	The descriptive element cannot be changed	Description can never be changed
11	Not in the "master control" mode	Change request without "master controller" 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
101	Parameter number is currently deactivated	Dependent on the operating mode of the inverter
102	Channel width is insufficient	Communication channel is too small for response
104	Impermissible parameter value	The parameter can only assume certain values
106	Request not included / task is not supported	After request identifier 5, 10, 15
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), second word

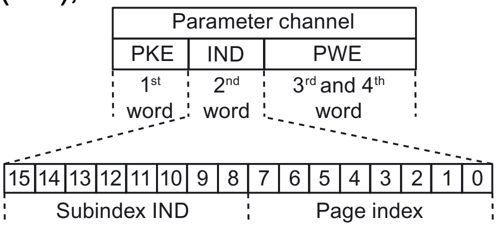


Figure 5-32 IND structure (cyclic)

- The field sub-index is an 8 bit value which, in cyclic data transfer mode, is transferred in the more-significant byte (bits 8 to 15) of the parameter index (IND).
- In this case, the least-significant byte (bits 0 to 7) in the parameter index selects the parameter page for additional parameters.

Rules for the parameter range

The bit for selecting the parameter page functions as follows:

When it is set to 1, an offset of 2000 is applied in the converter to the parameter number (PNU) transferred in the parameter channel request before the data is transferred.

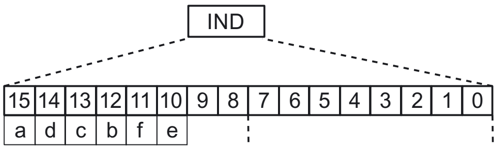


Figure 5-33 IND page index (acyclic)

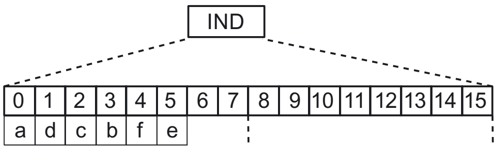


Figure 5-34 IND page index (cyclic)

Table 5- 63 Regulations for setting the PNU

Parameter range	Page index						Bit		Hex value	+ PNU
	a	d	c	b	f	e	9	8		
0000 … 1999	0	0	0	0	0	0	0	0	0x00	0 – 7CF
2000 … 3999	1	0	0	0	0	0	0	0	0x80	0 – 7CF
4000 … 5999	0	0	0	1	0	0	0	0	0x10	0 – 7CF
6000 … 7999	1	0	0	1	0	0	0	0	0x90	0 – 7CF
8000 … 9999	0	0	1	0	0	0	0	0	0x20	0 – 7CF
…	…	…	…	…	…	…	…	…	…	…
32.000 … 33.999	0	0	0	0	0	1	0	0	0x04	0 – 7CF
…	…	…	…	…	…	…	…	…	…	…
64.000 … 65.999	0	0	0	0	1	0	0	0	0x08	0 – 7CF

Table 5- 64 Sample coding of a parameter number in PKE and IND for P8820, index 16

	PKE		IND	
decimal	xx	820	32	16
hex	xx	334	20	10

Parameter value (PWE) third and fourth word

When data is transferred via PROFIBUS or PROFINET, the parameter value (PWE) is transferred as a double word (32 bit). Only one parameter value can be transferred in a single message frame.

A 32 bit parameter value includes PWE1 (high-order word, third word) and PWE2 (low-order word, fourth word).

A 16 bit parameter value is transferred in PWE2 (low-order word, fourth word). In this case, PWE1 (high-order word, third word) must be set to 0 in the PROFIBUS DP master / PROFINET I/O controller.

Note

When communication takes place via USS, the word length can be configured in P2013. For more information, see "Communication via USS".

Rules for editing requests/responses

- A request or a response can only be referred to one parameter.
- The master must constantly repeat a request until it receives a suitable response.
- The master recognizes the response to a request that it sent by:
  - Evaluating the response identifier
  - Evaluating the parameter number (PNU)
  - Evaluating the parameter index (IND), if necessary, or
  - Evaluating the parameter value PWE, if necessary.
- The complete request must be sent in a telegram. Request telegrams cannot be subdivided. The same applies to responses.
- If response telegrams contain parameter values, the drive always returns the current parameter value when it repeats response telegrams.

Control and status words

Description

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

Table 5- 65 Assignment of control word 1

Bit	Value	Meaning	Comments
0	0	OFF1	Shutdown, deceleration on the RFG ramp, pulse inhibit when $f < f_{min}$.
	1	ON	Switches the converter to "ready for operation" mode. The direction of rotation must be specified via bit 11.
1	0	Coast to standstill (OFF2)	Immediate pulse inhibit, drive coasts to standstill.
	1	No coasting to standstill	All "coast to standstill" (OFF2) commands are canceled.
2	0	Quick stop (OFF3)	Quick stop: Shut down with the deceleration ramp that can be additionally set.
	1	No quick stop	All "quick stop" (OFF3) commands are canceled.
3	0	Disable operation	Control and converter pulses are disabled.
	1	Enable operation	Control and converter pulses are enabled.
4	0	Reset ramp-function generator (RFG)	RFG output is set to 0 (quickest possible deceleration), converter remains ON.
	1	Enable ramp-function generator (RFG)	
5	0	Inhibit ramp-function generator (RFG)	The setpoint currently provided by the ramp-function generator is "frozen".
	1	Enable ramp-function generator (RFG)	
6	0	Deactivate setpoint	The value selected at the ramp-function generator input is set to 0 (zero).
	1	Enable setpoint	The value selected at the ramp-function generator input is enabled.
7	1	Fault acknowledgment	Fault is acknowledged with a positive edge; the converter then switches to "starting inhibit" mode.
8	0	JOG 1 OFF	Drive brakes along the ramp.
	1	JOG 1 ON	The drive ramps-up to the setpoint for the jog mode (direction of rotation: CW = clockwise).
9	0	JOG 2 OFF	Drive brakes along the ramp.
	1	JOG 2 ON	The drive ramps-up to the setpoint for the jog mode (direction of rotation: CCW = counter-clockwise).
10	0	No PLC control	Process data invalid, "sign of life" expected.
	1	PLC control	Control via interface; process data valid

Bit	Value	Meaning	Comments
11	0	No setpoint inversion	Motor runs clockwise in response to a positive setpoint.
	1	Setpoint inversion	Motor runs counter-clockwise in response to a positive setpoint.
12		Not used	
13	1	Motorized potentiometer UP	
14	1	Motorized potentiometer LOWER	
15	1	Data set changeover	Dependent on protocol: with SINAMICS G120 converters, you can switch between the command data sets (CDS) 0 and 1 in control word 1, bit 15 using the local/remote operation function. This triggers a data set changeover. Command data set 0 is active for local operation, while command data set 1 is active for remote operation. You can now set the application-specific parameters for command and target value sources in both command data sets.

Default assignment of control word 2 (STW2)

The settings for control word 2 are defaulted as follows. These can be changed by means of BICO.

Table 5- 66 Default setting for control word 2 (not defined for VIK/NAMUR)

Bit	Value	Meaning
0	1	Fixed frequency selection bit 0
1	1	Fixed frequency selection bit 1
2	1	Fixed frequency selection bit 2
3	1	Fixed frequency selection bit 3
4	–	Not used
5	–	Not used
6	–	Not used
7	–	Not used
8	1	Enable technology controller
9	1	Enable DC brake
10	–	Not used
11	1	Enable droop speed controller
12	1	Torque control
	0	Speed control
13	0	External fault 1
14	–	Not used
15	–	Not used

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 5- 67 Bit assignments for status word 1 (for all PROFIdrive and VIK/NAMUR message frames)

Bit	Value	Meaning	Comments
0	1	Ready for switching on	Power supply switched on; electronics initialized; pulses disabled.
	0	Not ready for switching on	--
1	1	Ready for operation	Converter is switched on (ON command present), no active fault, converter can start as soon as "enable operation" command is issued. See control word 1, bit 0.
	0	Not ready for operation	--
2	1	Operation enabled	Drive follows setpoint. See control word 1, bit 3.
	0	Operation disabled	--
3	1	Fault present	Drive is faulty. The drive is faulty, which means that it is not in operation and switches to "starting inhibit" mode once the fault has been successfully rectified and acknowledged.
	0	No fault	--
4	1	"Coast to standstill" not activated	--
	0	"Coast to standstill" activated	"Coast to standstill" (OFF 2) command present.
5	1	"Quick stop" not activated	--
	0	Quick stop activated	"Quick stop" (OFF 3) command present.
6	1	Switch-on disabled	The drive only switches to the ON state when the "No coast down" AND "No quick stop" commands (followed by "ON") are issued.
	0	Switch-on not disabled	--
7	1	Alarm present	Drive still in operation; alarm in service/maintenance parameter; no acknowledgement; see alarm parameter r2110.
	0	No alarm	No alarm is present or the alarm has disappeared.
8	1	Speed deviation within tolerance range	Setpoint/actual value deviation within tolerance range.
	0	Speed deviation outside of tolerance range	--
9	1	Master control requested	The automation system is requested to assume control.
	0	No control requested	The master is not currently the master controller.
10	1	Maximum frequency reached or exceeded	Converter output frequency is greater than or equal to the maximum frequency.
	0	Maximum frequency not reached	--
11	1	--	--
	0	Alarm: Motor current/torque limit reached	--
12	1	Motor holding brake active	Signal can be used to control a holding brake.
	0	--	--

Bit	Value	Meaning	Comments
13	1	--	Motor data displays overload status.
	0	Motor overload	--
14	1	Clockwise rotation	--
	0	Counter-clockwise rotation	--
15	1	--	--
	0	Converter overload	E.g. current or temperature

Status word 2 (ZSW2)

Status word 2 has the following default assignment. This can be changed by means of BICO.

Table 5- 68 Default setting for status word 2 (not defined for VIK/NAMUR)

Bit	Value	Meaning	Description
0	1	DC brake active	DC brake active
1	1	n_act < P2167	Converter frequency < shutdown limit
2	1	n_act ≧ P1080	Actual frequency > minimum frequency
3	1	i_act ≧ P2170	Current ≥ limit value
4	1	n_act > P2155	Actual frequency > reference frequency
5	1	n_act ≦ P2155	Actual frequency < reference frequency
6	1	Speed setpoint reached	Actual frequency ≥ setpoint
7	1	DC link voltage < P2172	Voltage < threshold value
8	1	DC link voltage ≧ P2172	Voltage > threshold value
9	1	Speed ramp ended	--
10	1	Technology controller output ≦ P2292	PI frequency < threshold value
11	1	Technology controller output > P2291	PI saturation
12	1	Vdc_max controller	--
13	1	Kinetic buffering and flexible response	--
14	1	Not used	--
15	1	Not used	--

Acyclic communication

Overview of Acyclic communication

The content of the transferred data block corresponds to the structure of the acyclic parameter channel according to PROFIdrive Profile, version 4.1 (http://www.profibus.com/organization.htm)

Acyclic data transfer mode allows in general:

- Large quantities of use data (up to 240 bytes) to be exchanged. A parameter request/response must fit in a data block (max. 240 byte). The requests/responses are not split-up over several data blocks.
- Transmission of complete arrays or parts of them, or the entire parameter description.
- Transmission of different parameters in one access (multi-parameter requests).
- To read out the profile-specific parameters by an acyclic channel
- Acyclic data transmission in parallel to cyclic data transmission.

Always just one request is being processed at a time (no pipelining). No spontaneous messages will be transmitted.

Acyclic communication via PROFIBUS DP (DPV1)

The PROFIBUS DP extensions DPV1 include the definition of an acyclic data exchange.

It allows simultaneous accessing by other PROFIBUS masters (class 2 master, e.g. start-up tool).

Conversion of extended PROFIBUS DP functionality

The different masters, or different modes of data exchange, are represented by appropriate channels in the SINAMICS G120 range of inverters:

- Acyclic data exchange with the class 1 master uses the DPV1 functions READ and WRITE (with data block 47 (DS47)).
- Acyclic data exchange using a SIEMENS start-up tool (class 2 master) (e.g. STARTER). The start-up tool can acyclically access parameter and process data in the inverter.
- Acyclic data exchange with a SIMATIC HMI (second class 2 master). The SIMATIC HMI can acyclically access parameters in the inverter.
- Instead of a SIEMENS start-up tool or SIMATIC HMI, an external master (class 2 master) as defined in the acyclic parameter channel according to PROFIdrive Profile version 4.1 (with DS47) can access the inverter.

Acyclic communication via PROFInet (Base mode parameter access)

In the base mode parameter access, the requests and the replies are transmitted acyclically by use of the "Acyclic Data Exchange" mechanism of the Communication System.

It allows simultaneous accessing by other PROFInet IO Supervisors (e.g. start-up tool).

Acyclic PROFInet functions

The different communication devices, or different modes of data exchange, are represented by appropriate channels in the SINAMICS G120 range of inverters:

- Acyclic data exchange with the IO controller uses the functions READ and WRITE (with 0xB02E)).
- Acyclic data exchange using a SIEMENS start-up tool (IO supervisor, e.g. STARTER). The start-up tool can acyclically access parameter and process data in the inverter.
- Acyclic data exchange with a SIMATIC HMI (second IO supervisor). The SIMATIC HMI can acyclically access parameters in the inverter.
- Instead of a SIEMENS start-up tool or SIMATIC HMI, an external IO supervisor as defined in the acyclic parameter channel according to PROFIdrive Profile version 4.1 (with 0xB02E) can access the inverter.

5.11.2.6 STEP 7 program examples

STEP 7 program example for cyclic communication

S7 program for controlling the frequency inverter

The S7 program, which supplies data for cyclic communication between the frequency converter and the central controller, can be used for PROFIBUS and PROFINET.

In the example provided below, communication between the controller and frequency converter is handled via standard message frame 1. The control specifies control word 1 (STW1) and the speed setpoint, while the frequency inverter responds with status word 1 (ZSW1) and its actual speed value.

```
Network 1 : Create control word 1 and speed setpoint

STW1: 0x47E
Freq: 0x2500

          L     W#16#47E
          T     MW     1
          L     W#16#2500
          T     MW     3


Network 2 : Acknowledge fault

Comment:

          U     E      0.6
          =     M      2.7


Network 3 : Start and stop

Comment:

          U     E      0.0
          =     M      2.0


Network 4 : Write process data

Comment:

          L     MW     1
          T     PAW  256
          L     MW     3
          T     PAW  258
```

Figure 5-35 Controlling the G120 via PROFIBUS or PROFINET

```
Network 5 : Read process data

Comment:

        L     PEW  256
        T     MW     5
        L     PEW  258
        T     MW     7
```

Figure 5-36 Evaluating the status of G120 via PROFIBUS or PROFINET

Information about the S7 program

The hexadecimal numeric value 047E is written to control word 1. The bits in control word 1 are listed in the following table.

Table 5- 69 Assignment of the control bits in the frequency converter to the SIMATIC flags and inputs

HEX	BIN	Bit in STW1	Meaning	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		

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.

The hexadecimal numeric value 2500 specifies the setpoint frequency of the frequency converter. The maximum frequency is the hexadecimal value 4000.

The process data is written to logical address 256 of the frequency converter in the cyclic time slice of S7 (e.g. OB1) and read from logical address 256 of the frequency converter. The logical addresses for field bus communication were defined in HW Config.

STEP 7 sample program for acyclic communication

Simple S7 program for parameterizing the frequency inverter

The S7 program, which supplies data for acyclic communication between the frequency inverter and the central controller, can be used for PROFIBUS and PROFINET.

```
OB1 :  "Main Program Sweep (Cycle)"

Kommentar:

Netzwerk 1 : Define Read or write

Kommentar:

    // Read parameter
          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 parameter
          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
          CALL  FC    3
```

Figure 5-37 STEP 7 program example for acyclic communication - OB1

Flags 9.0 to 9.3 specify whether parameters are read or written:

- M9.0: request to read parameters
- M9.1: request to write parameters
- M9.2: displays the read process
- M9.3: displays the write process

FC1 to read parameters from the frequency inverter

Frequency inverter parameters are read via SFC 58 and SFC 59.

```
FC1 : PAR_RD

Kommentar:

Netzwerk 1 : Parameters for reading

Kommentar:

      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   20
//---------------------------------------------
      L     MW    56
      T     DB1.DBW   24
      L     MB    61
      T     DB1.DBB   23
      L     MW    69
      T     DB1.DBW   26
```

Netzwerk 2 : Read request

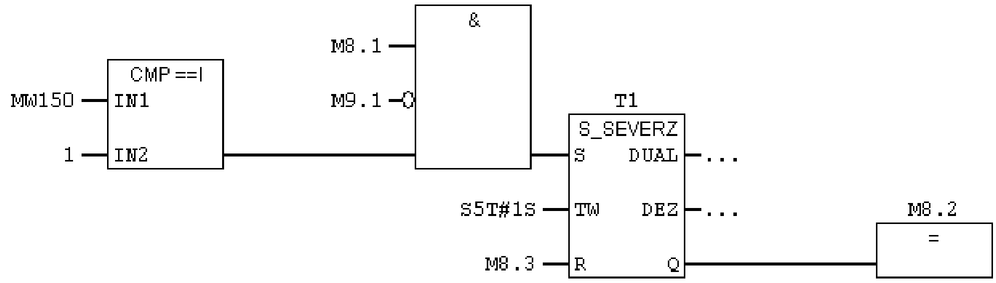
Kommentar:

```
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
```

Netzwerk 3 : Read delay after sending the read request

Kommentar:



Netzwerk 4 : Read request

Kommentar:

```
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 5-38 Function block for reading parameters

You first have to define how many parameters (MB62), which parameter numbers (MW50, MW52, etc.), and how many parameter indices (MW58, MB59, etc.) are read for each parameter number. The specifications are saved in DB1.

SFC 58 copies the specifications for the parameters to be read from DB1 and sends them to the frequency inverter as a read request. No other read requests are permitted while this one is being processed.

Once the read request has been issued and a waiting time of one second has elapsed, the parameter values are copied from the frequency inverter via SFC 59 and saved in DB2.

FC3 to write parameters to the frequency inverter

```
FC3 : PAR_WR

Kommentar:

Netzwerk 1 : Parameter for writing

Kommentar:

        L     MW    21
        T     DB3.DBW    6
        L     MW    23
        T     DB3.DBW    8
        L     MW    35
        T     DB3.DBW   12

Netzwerk 2 : Write request

Kommentar:

        CALL  SFC   58
         REQ    :=M9.1
         IOID   :=B#16#54
         LADDR  :=W#16#170
         RECNUM :=B#16#2F
         RECORD :=P#DB3.DBX0.0 BYTE 14
         RET_VAL:=MW10
         BUSY   :=M8.1

        U     M      8.1
        R     M      9.1
        S     M      9.3
```

Figure 5-39 Function block for writing parameters

You first have to define which value (MW35) is written to which parameter index (MW23) of which parameter (MW21). The specifications are saved in DB3.

SFC 58 copies the specifications for the parameters to be written from DB3 and sends them to the frequency inverter. No other write requests are permitted while this one is being processed.

For more information about SFC 58 and SFC 59, consult the STEP 7 online help.

5.12 Safety-related applications

5.12.1 Overview

Functional safety

Machine components operated by electrical drives are intrinsically hazardous. If a drive is incorrectly used or acts in an unexpected manner in the event of a malfunction, not only can this damage the machine but it can also cause severe injury or death. Functional safety reduces this risk of accidents caused by machines to an acceptable residual risk.

Integrated safety functions in SINAMICS G120

The CU240S DP-F and CU240S PN-F Control Units feature a range of integrated safety functions, which are certified in accordance with Cat. 3 to EN 954-1 and SIL 2 to IEC 61508:

Abbreviation	Description (DE/EN)	Function
STO	Sicher abgeschaltetes Moment Safe Torque Off	The motor is switched safely to zero torque.
SS1	Sicherer Stopp 1 Safe Stop 1	The motor is brought to a controlled standstill.
SLS	Sicher begrenzte Geschwindigkeit Safely Limited Speed	The speed of the motor is restricted in a controlled manner.
SBC	Sichere Bremsenansteuerung Safe Brake Control	The motor holding brake is safely controlled.

Basic prerequisites for using fail-safe functions

1. The machine risk assessment (e.g. in compliance with EN ISO 1050, "Safety of machinery - Risk assessment - Part 1: Principles") allows the use of frequency converter safety functions in accordance with SIL 2 or category 3.
2. The speed controller of the frequency converter must function properly. Each fail-safe drive (drive = converter + motor + brake + driven machine) must be set up in such a way that all operating procedures performed by the driven machine can be properly monitored and that the converter operates below its limit values (for current, temperature, voltage, etc.). The performance and parameters of the converter must be compatible with both the connected motor and the application in question.
3. Once the machine has been successfully commissioned, you must review the typical operating conditions and operate the machine close to the permissible limit values. The fail-safe drive must not malfunction under any circumstances.

Permissible control modes for using fail-safe functions

When the prerequisites mentioned above are fulfilled, the fail-safe functions can be used for both V/f and vector control.

Restrictions regarding SLS and SS1

⚠ CAUTION

Safety functions SS1 and SLS must not be used when the motor can still be accelerated by the mechanical elements of the connected machine component once the frequency converter has been shut down.

Whether or not a mechanical brake is installed is irrelevant.

Examples:

1. With lifting gear, a vertical load can accelerate the motor as soon as the frequency converter is shut down. In this case, safety functions SS1 and SLS are not permitted.
2. A horizontal conveyor is always brought to a standstill due to friction as soon as the frequency converter is shut down. In this case, safety functions SS1 and SLS can be used without restriction.

Examples of how the safety functions can be applied

Description of problem	Suitable safety function	Solution
When the EMERGENCY STOP button is pressed, a stationary motor must not start unintentionally.	STO	Control the frequency converter via terminals by means of an EMERGENCY STOP button.
A central EMERGENCY STOP button is designed to prevent more than one drive from starting unintentionally.	STO	Evaluate the EMERGENCY STOP button in a central controller; control the frequency converter via PROFIsafe.
A short-circuit and cable break occurring when the motor holding brake is activated are to be signaled.	SBC	Connect the motor holding brake to the optional "Safe Brake Module" of the frequency converter.
Having opened a protective door, the machine operator must enter the hazardous zone around a machine and run a conveyor belt at low speed.	SLS	Control the frequency converter via terminals by means of a button for moving the conveyor belt.
When a protective door is opened, the motor must be stationary.	SS1	Activate the SS1 function in the frequency converter and enable the protective door as soon as the frequency converter returns "STO".

Controlling the safety functions

The safety functions in the frequency inverter can be controlled via fail-safe digital inputs as well as over safe bus communication PROFIsafe via PROFIBUS or PROFINET in conjunction with a fail-safe CPU.

Safe feedback from the frequency converter

When fail-safe functions are used, feedback is generally required as to whether or not the drive is in a safe state.

With the SLS function, for example, this is the case if the frequency inverter has decelerated the motor to below the speed monitoring limit. This safe state is signaled by the frequency inverter via fail-safe channels. On the basis of this, a higher-level controller can trigger further actions (e.g. enable a protective door).

Fail-safe feedback signals from the frequency inverter are realized using PROFIsafe.

5.12.2 Restoring safety-related parameters to the factory setting

Before starting to commission the safety functions, you should know whether the safety-relevant parameters of the frequency inverter have already been changed. If you do not precisely know the setting of the safety-relevant parameters, then reset these parameters to the factory setting.

Which parameters are reset to the factory setting?

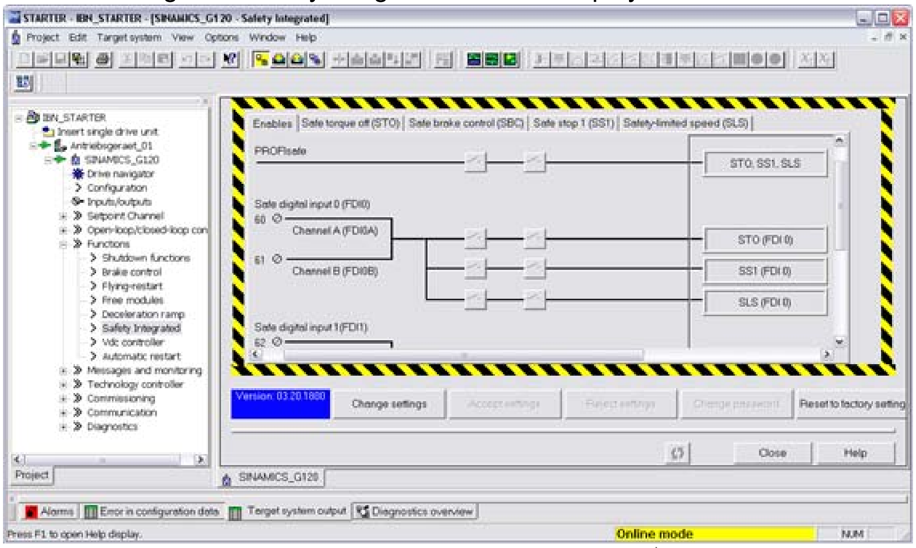
Resetting the safety-relevant parameters to the factory setting does not change the setting of the other parameters, e.g. the motor data or the significance of these terminals.

Resetting to factory settings sets all of the safety-relevant parameters back to their standard values. Exceptions:

- P9761 SI password input
- P9762 SI password change
- P9763 SI confirmation of password change

Procedure

1. Connect the PC and the frequency inverter using the PC Connection Kit or via the fieldbus
2. Go online by clicking on the button  and call the screen of the safety functions by double clicking. The Safety Integrated menu is displayed in the main screen.



3. With the mouse, click on the button Reset to factory setting at the lower edge of the screen.
4. Enter the safety password in the following screen and confirm with OK.

The safety-relevant parameters of the frequency inverter have now been reset to the factory setting.

5.12.3 Controlling the safety functions via fail-safe inputs

Connecting sensors to fail-safe inputs

The fail-safe inputs of the frequency inverter are designed for connecting electromechanical 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).

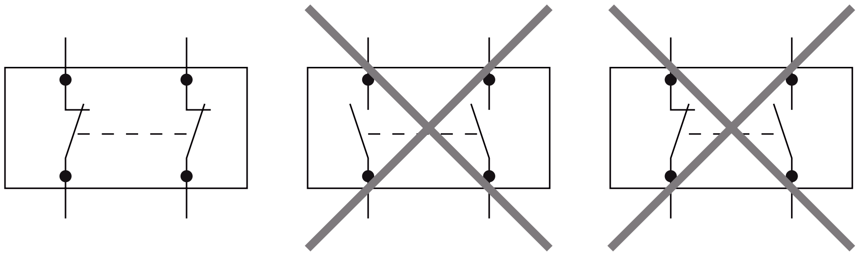


Figure 5-40 Sensors that can be connected to the fail-safe inputs

The following diagrams show the principle possibilities of connecting-up fail-safe inputs:

- Connecting sensors with electromechanical contacts, e.g. Emergency Stop mushroom pushbuttons and end position switches
- Connecting electronic sensors, e.g. SIMATIC FS-400 light curtains
- Connecting safety relays, e.g. SIRIUS 3TK28.
- Connecting fail-safe outputs, e.g. SIMATIC F digital output modules

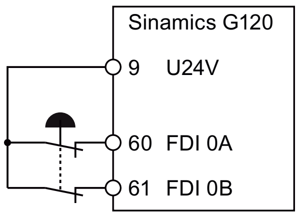


Figure 5-41 Connecting an electromechanical sensor

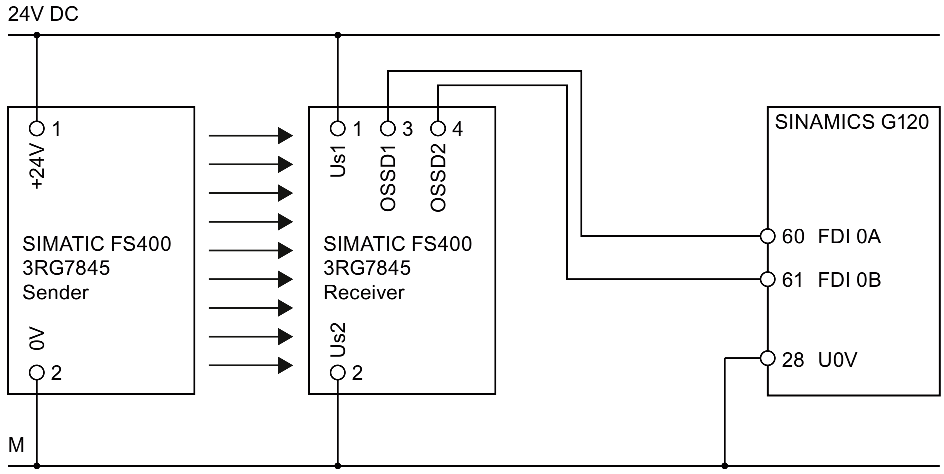


Figure 5-42 Connecting an electronic sensor

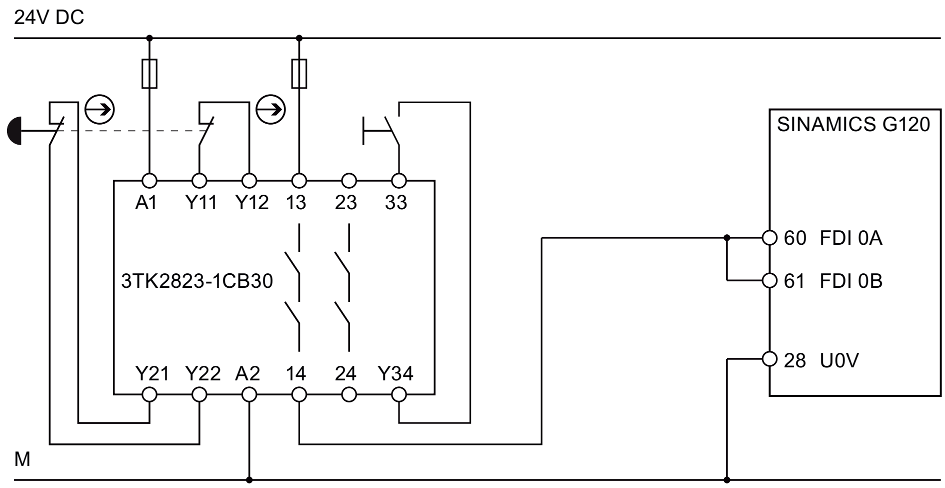


Figure 5-43 Connecting a safety relay

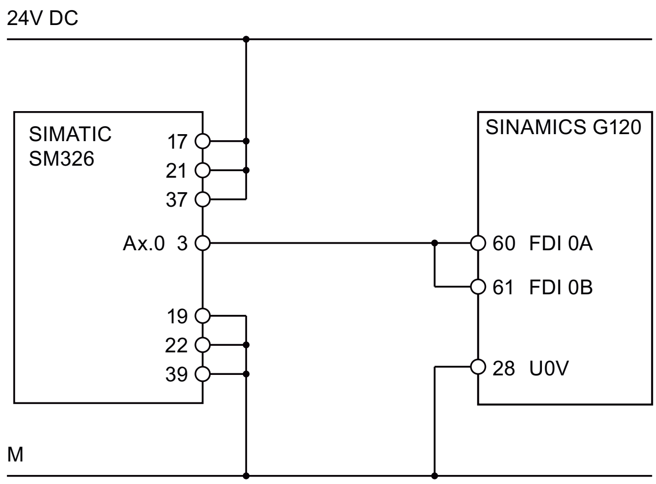


Figure 5-44 Connecting an F digital output module

Additional interconnection possibilities are under
http://support.automation.siemens.com/WW/view/de/27231237

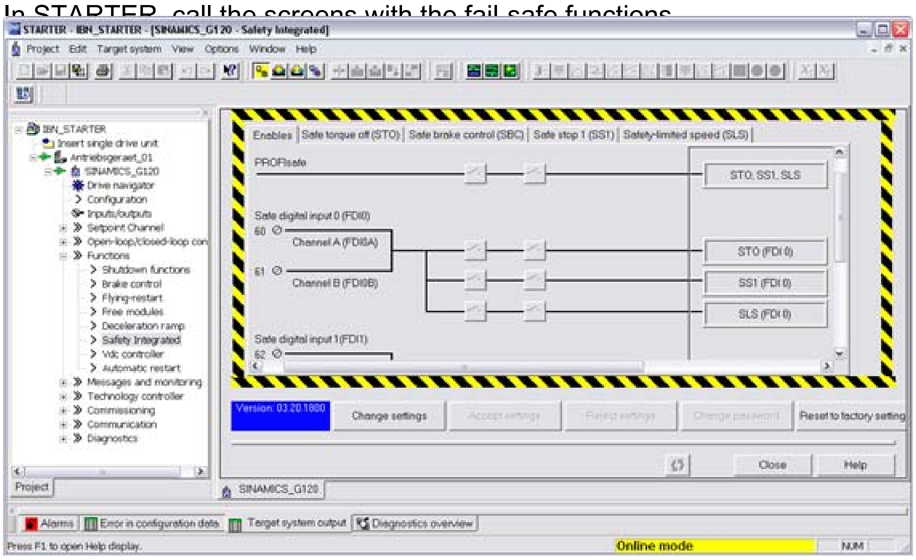
5.12.4 Settings for the "STO" function

Activating fail-safe inputs

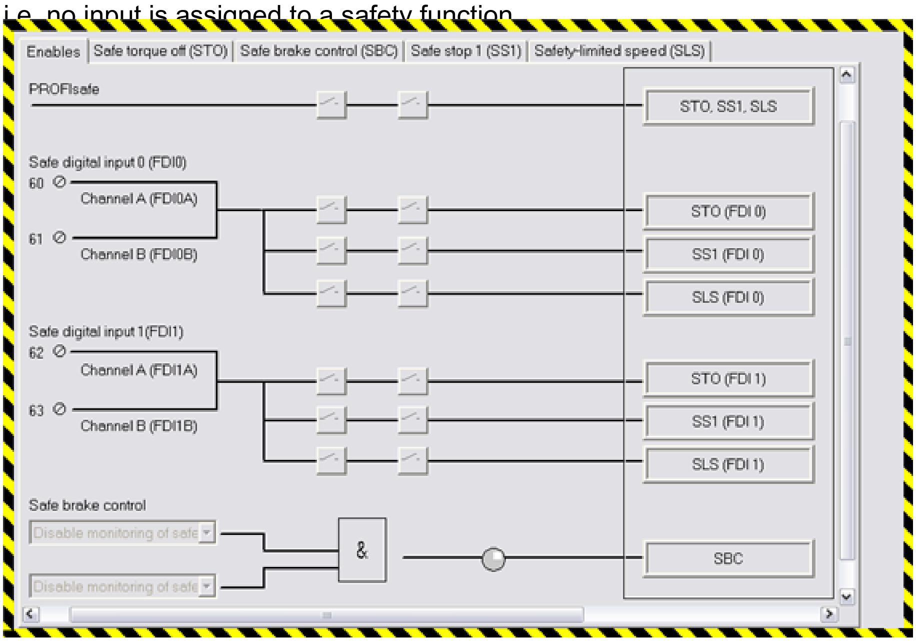
A fail-safe input of the frequency inverter is activated by assigning it a safety function. This is described in the following using an example. The example shows the assignment of the fail-safe digital input FDI0 to the STO safety function using STARTER.

Procedure

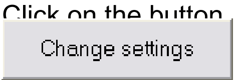
1. Connect your PC to the frequency inverter e.g. using the PC Connection Kit.
2. Launch the STARTER parameterization tool and go online.
3. In STARTER, call the screens with the fail-safe functions.



4. Select the "Enables" tab. None of the fail-safe inputs are activated in the factory setting, i.e. no input is assigned to a safety function.



5. Click on the button



on the lower edge of the STARTER screen and enter the safety password. The default password is "12345".
The frequency converter outputs alarm A1698 to signal that safety settings are currently being changed. Further, the following LEDs flash on the Control Unit: RDY, ES, STO, SS1, and SLS.

6. Assign the fail-safe digital input 0 (FDI0) to the STO function by clicking on the appropriate two switches.

The required function is always selected on two channels, i.e. both switches should always be closed to activate. An activated fail-safe input is represented by a green line.

Then make the settings for the STO function under the "Safe Torque Off (STO)" tab.

Testing the shutdown paths

Shutdown paths are circuits used to shut down a motor in a safety-relevant fashion. The shutdown paths must be checked regularly to ensure that the fail-safe frequency inverter complies with certification requirements.

In the factory setting, the frequency inverter always checks its shutdown path if the STO function is deselected.

The shutdown path test takes approximately three seconds. The frequency converter cannot be switched on during the test. The frequency converter signals this status as "switching on inhibited" in the status word (r0052, bit 6). A higher-level controller must evaluate this bit to ensure that the frequency converter accepts its ON command.

To minimize the waiting time whenever an STO request is issued, this function can be deactivated by making the relevant settings on the STO screen (P9601, bit 1 and P9801, bit 1).

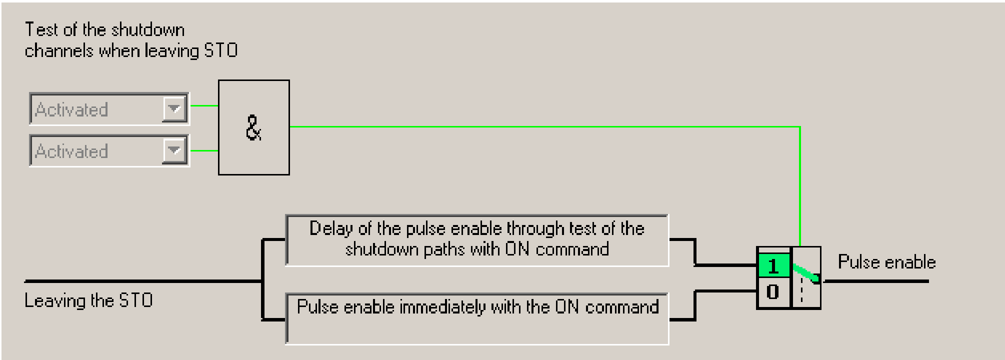


Figure 5-45 Testing the shutdown paths

A timer monitors the regular shutdown path test. The monitoring time (P9659) can be extended up to a maximum of one year. When the timer has expired, this is signaled via status word r9772, bit 15. A higher-level controller must monitor this bit to ensure that the STO safety function is tested on a regular basis.

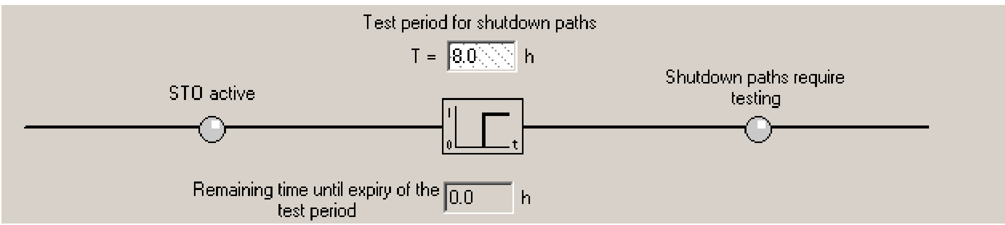


Figure 5-46 Test period for shutdown paths

Debouncing and filtering the signals from the fail-safe input

As soon as a fail-safe input has been assigned to a safety function, the frequency converter checks the consistency of the input signal. Consistent signals at both terminals always assume the same signal state (high or low).

Reasons for inconsistent input signals

With electromechanical sensors (e.g. EMERGENCY STOP buttons or door switches), the contacts may bounce briefly at the moment switching takes place. The two sensor contacts never switch at exactly the same time either. As a result, the frequency converter responds with a fault and indicates signal inconsistencies.

To prevent this, the input signals in the frequency converter must be filtered.

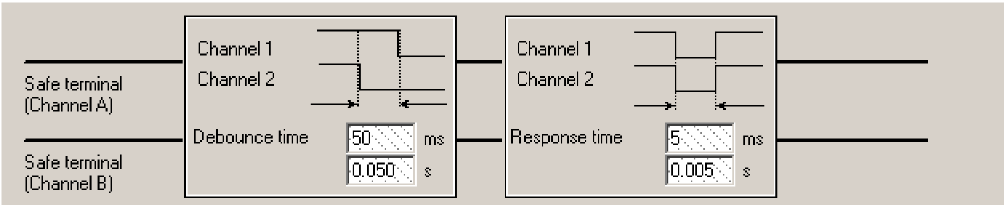


Figure 5-47 Debouncing and filtering the signals at the fail-safe inputs

Setting the signal filters in the frequency converter

Set the debounce time (P9650 and P9850) to such a level that faults caused by contact bounce or signal faults cannot occur.

Note

Short response times are essential for ensuring the functional safety of machines. The filter times increase the time required by the frequency converter to respond to fail-safe signals. For this reason, do not set the filter times any longer than required.

Completing the commissioning of the safety functions

1. Click on the button 

to complete all of the settings that you have made.
2. If the default password has not been changed, you are prompted to change it.
3. In the following dialog box, confirm the checksums of the safety-related parameters. This concludes the process of changing the safety settings.

5.12.5 Acceptance test and report

Acceptance test report for safety functions

To verify safety-related parameters, an acceptance test must be performed after initial commissioning has been carried out and after the safety-related parameters have been changed. The acceptance test must be documented in the form of a report. The acceptance test reports are part of the machine documentation and must be archived accordingly.

The checksums (r9798 and r9898) ensure that subsequent changes to safety-related parameters can be identified.

What must be carried out when an acceptance test is performed for safety functions?

1. **Machine documentation**
   Document the machine, including its fail-safe functions.
   – Description of the machine and overview/block diagram
   – Fail-safe functions for each drive
   – Description of the fail-safe equipment

   An empty document is provided as an example following this section.
2. **Function test**
   Check each individual fail-safe function. An empty document is provided as an example following this section.
3. **Complete the report**
   Document the commissioning period and sign the report.
   – Check the parameters for fail-safe functions.
   – Document the checksums.
   – Provide evidence showing that the data has been backed up and archived.
   – Sign the report.

   An empty document is provided as an example following this section.
4. **Enclosures with the report**

   Include records and printouts of measurements associated with the function test.
   – Alarm reports
   – Printouts of curve characteristics
   – When required, you can create a list with all of the changed parameters of the frequency inverter. Instructions on how to do this are available here: http://support.automation.siemens.com/WW/view/de/29319456

5.12.5.1 Documentation of the acceptance test

Overview

Acceptance test No.	
Date	
Person carrying out the test	

Table 5- 70 Description of the system and overview/block diagram

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Block diagram/overview diagram of the machine	

Table 5- 71 Fail-safe functions for each drive

Drive No.	Firmware version	SI version	Fail-safe functions
	r0018 =	r9770 =	Example: STO

Table 5- 72 Description of the fail-safe equipment/devices

Drive No.	Description
	Examples: Wiring of STO terminals (protective door, EMERGENCY OFF) grouping of STO terminals

5.12.5.2 Function check of the acceptance test

Description

The function check must be carried out for each individual drive (under the assumption that the machine permits this).

Conducting the test

First commissioning	Please enter a check mark	
Standard commissioning		

Function check, "Safe Torque Off" (STO)

This check involves the following steps:

Table 5- 73 Function, "Safe Torque Off" (STO)

No.	Description	Status
1.	Initial state • The frequency inverter signals "ready for switching on" (P0010 = 0) • No safety faults and alarms • r9772.0 = r9772.1 = 0 (STO deselected and inactive) • P9659 = time intervals for the forced checking procedure correctly set	
2.	Switch on the motor	
3.	Check whether the motor involved rotates	
4.	Select STO while the ON command is being issued	
5.	Check the following points: • The motor coasts down to a standstill • The motor is braked and held by the mechanical brake if a brake is being used • No safety fault • r9772.0 = r9772.1 = 1 (STO selected and active), r9772.14 = 1, if safe brake control is active	
6.	Deselect STO	

No.	Description	Status
7.	Check the following points: • No safety fault • r9772.0 = r9772.1 = 0 (STO deselected and inactive), r9772.14 = 0	
8.	Check whether the motor involved is running. If yes, check the following points: • That the cabling between the Control Unit and Power Module is correct • Correct assignment, drive No. - frequency inverter - Power Module - motor • That the hardware is operating correctly • That the shutdown paths are correctly wired • Correct STO terminal assignment at the Control Unit • Correct parameterization of the STO function • Routine for the forced checking procedure of the shutdown paths	

Function check, "Safe Stop 1" (SS1)

This check involves the following steps:

Table 5- 74 Function, "Safe Stop 1" (SS1)

No.	Description	Status
1.	Initial state • The frequency inverter signals "ready for switching on" (P0010 = 0) • No safety faults and alarms • r9772.0 = r9772.1 = 0 (STO deselected and inactive) • r9772.2 = r9772.3 = 0 (SS1 deselected and inactive)	
2.	Switch on the motor	
3.	Check whether the motor involved rotates	
4.	Select SS1 while the ON command is being issued	
5.	Check the following points: • The motor speed decelerates corresponding to the selected ramp time (if required, use a stopwatch) • The motor coasts down to a standstill after the parameterized minimum speed has been fallen below • The motor is braked and held by the mechanical brake if a brake is being used • No safety fault • r9772.1 = 1 (STO active) • r9772.2 = 1 (SS1 selected) • r9772.14 = 1, if the monitoring function of the safety-relevant brake is activated	
6.	Cancel SS1	

No.	Description	Status
7.	Check the following points: • No safety fault • r9772.1 = 0 (STO inactive) • r9772.2 = 0 (SS1 deselected) • r9772.14 = 0	
8.	Check whether the motor involved rotates. If yes, check the following points: • The cabling between the Control Unit and Power Module is correct • Correct assignment, drive No. - frequency inverter - Power Module - motor • The hardware can function correctly • Correct wiring of the shutdown paths • Correct STO terminal assignment at the Control Unit • Correct parameterization of the SS1 function	

Function check, "Safely Limited Speed" (SLS)

This check involves the following steps:

Table 5- 75 Function, "Safely Limited Speed" (SLS)

No.	Description	Status
1.	Initial state • The frequency inverter signals "ready for switching on" (P0010 = 0) • No safety faults and alarms • r9772.4 = r9772.5 = 0 (SLS deselected and inactive)	
2.	Switch on the motor. The motor speed must be higher than the parameterized safely limited speed, if the machine permits this	
3.	Check whether the motor involved rotates	
4.	Select SLS while the ON command is being issued	
5.	Check the following points: • r9772.4 = 1 (SLS selected) • The motor response depends on the selected mode of the SLS function – SLS mode 0 The drive speed decreases corresponding to the selected ramp time and then the frequency inverter is subsequently passivated – SLS mode 1 The motor speed decelerates corresponding to the selected ramp time. The motor then rotates with the parameterized safely limited speed – SLS mode 2 The frequency inverter is immediately passivated, the motor coasts down – SLS mode 3 The frequency inverter is immediately passivated, the motor coasts down • r9772.5 = 1 (SLS active)	
6.	Deselect SLS	

No.	Description	Status
7.	Check the following points: • No safety fault • r9772.4 = r9772.5 = 0 (SLS deselected and inactive)	
8.	Check whether the drive involved is running. If yes, check the following points: • The cabling between the Control Unit and Power Module is correct • Correct assignment, drive No. - frequency inverter - Power Module - motor • The hardware can function correctly • Correct wiring of the shutdown paths • Correct parameterization of the SLS function	

5.12.5.3 Filling in the acceptance report

Parameters of the fail-safe functions

	Comparison value of the checksums checked?	
	Yes	No
Control Unit		

Checksums

Drive		Checksums of the Control Unit	
Name	Drive No.	r9798	r9898

Data backup/archiving

	Storage medium			Where is it kept
	Type	Designation	Date	
Parameter				
PLC program				
Circuit diagrams				

Signatures

Commissioning engineer

Confirms that the checks and test listed above have been correctly conducted.

Date	Designation	Company/Dept.	Signature

Machinery construction OEM

Confirms the correctness of the parameterization documented above.

Date	Designation	Company/Dept.	Signature

Servicing and maintenance 6

6.1 Behavior of the frequency inverter when replacing components

Components should be replaced by the same type and the same version

To ensure maximum plant availability, the Control Unit and the Power Module can, when required, be replaced by a unit of the same type and the version without having to recommission the drive.

Note

Message F0395 indicates that components were replaced. In this case, before switching on, you should check the system functions.

Replace the control unit with the same time and the same version

- With automatic parameter download (without recommissioning the system)

The prerequisite in this case is that the frequency inverter is operated with a memory card and the setting p8458 = 1 or 2 (parameters are automatically downloaded from the memory card). The frequency inverter is parameterized using the automatic parameter download and message F0395 can be acknowledged.

- With manual parameter download (standard commissioning)

Parameters are not automatically downloaded if there is no memory card or with the setting P8458 = 0. If a valid parameter set is available, then the frequency inverter is parameterized by manually downloading this parameter set (from the memory card, Operator Panel or PC) and message F0395 can be acknowledged.

Note

A valid parameter set is a parameter set that matches the type and software release of the Control Unit and that has been adapted to fit the particular application.

Replace a Power Module by the same type

- Same power rating

If you replace a Power Module by the same type and the same power, then re-parameterization is not required and you can acknowledge message F0395.

- Same format, higher power rating

If you replace a Power Module by one of the same type and the same format, however with a higher power rating, then re-parameterization is not absolutely necessary and you can acknowledge message F0395. However, it is possible that the open-loop/closed-loop control accuracy is therefore reduced.

- Lower power rating

If you replace a Power Module by one with the same type and with a lower power rating, then then drive must be re-commissioned.

Replacing different components or version

If you replace different components (e.g. Profibus CU for Profinet CU) or components with different software releases, then the drive must always be re-commissioned.

Questions that can arise in conjunction with replacing components:

- How do I create a valid parameter set?
  When commissioning, you can create a valid parameter set either using the commissioning softwareSTARTER (Page 58) or using the Operator Panel (Page 71).
- Which options are available for saving a valid parameter set? You can save a valid parameter set either on the memory card (Page 77) or on the computer (Page 58) that you use for commissioning with STARTER.
- How do I load a valid parameter set into my frequency inverter?
  From the memory card when the frequency inverter is powered-up or by manually downloading a parameters set either from the memory card (Page 78) or from the PC (Page 58).

6.2 Replacing the Control Unit or Power Module

Replacing the Control Unit

When replacing components, ensure that you use the correct ones.

Procedure when replacing a Control Unit

1. Disconnect the converter power supply.
2. Wait 5 minutes until the device has discharged itself.
3. Disconnect the control cables from the Control Unit.
4. If a memory card is being used, remove it from the Control Unit.
5. Remove the defective Control Unit from the Power Module.
6. Mount a new Control Unit on the Power Module.
7. Reconnect the control cables.
8. If a memory card is being used, insert it into the new Control Unit.
9. Switch-on the frequency inverter power supply again.
10. If required, manually download a valid parameters set

Replacing the Power Module

⚠ CAUTION
Before you replace the Power Module, ensure that all of the parameter settings are saved in the EEPROM of the Control Unit (refer to P0014 or P0971).

Replacing a Power Module

1. Switch-off the Power Module power supply.
2. After you have switched it off, wait 5 minutes until the device has discharged itself.
3. Disconnect the Power Module connecting cable
4. Remove the Control Unit from the Power Module
5. Replace the Power Module
6. Mount the Control Unit onto the new Power Module
7. Connect the Power Module connecting cable
8. Switch-on the Power Module power supply again

Before switching-on the power supply again, ensure that the new Power Module is correctly installed and connected.

7 Messages and fault codes

7.1 Indicators (LEDs)

Indicators, alarms, and fault codes

The G120 converter features the following diagnostic indicators:

- LEDs on the Control Unit

  For a detailed overview of LED statuses, see "LED status indicators" (below).
- Fault and alarm numbers
  - Alarms provide warning information. They do not trigger any response from the system and do not need to be acknowledged.
  - If a fault occurs, the converter shuts down and the "SF" LED on the Control Unit lights up. The converter cannot be switched on again until the fault has been rectified. Once the fault has been rectified, it must be acknowledged.

  Alarm and fault numbers are displayed via the OP, STARTER, or a higher-level control system. The online help function in STARTER contains detailed troubleshooting information.

LED status indicators

SINAMICS G120 is equipped with a range of LEDs for indicating the operating statuses of standard and fail-safe converters.

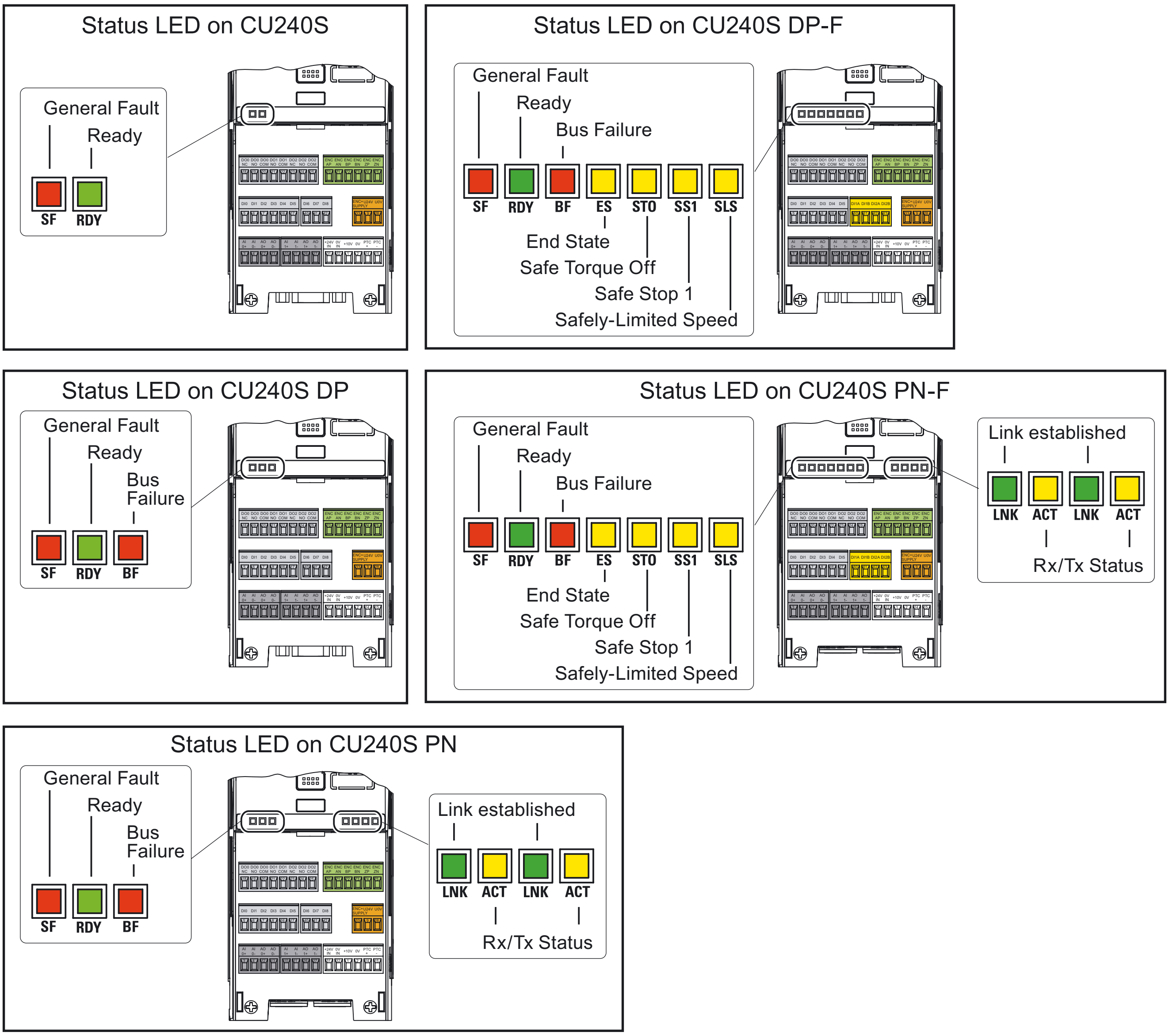


Figure 7-1 Status LED on the CU240S, CU240S DP, CU240S DP-F, CU240S PN

Diagnostics via LEDs

Note

"---" signals that the LED state (on, off or flashing) is not relevant for the corresponding state.

Statuses of standard CUs	Prio	SF (red)	RDY (green)
Commissioning	1	On or off	Flashing
Firmware upgrade of MMC / parameter download	1	On or off	Flashing
General faults	1	On	Off
Ready	3	Off	On

Statuses of PROFIBUS DP CUs	Prio	SF (red)	RDY (green)	BF (red)
Commissioning	1	On or off	Flashing	---
Firmware upgrade of MMC / parameter download	1	On or off	Flashing	---
General faults	3	On	Off	---
Bus failure (no data)	3	On or off	On or off	Flashing
Bus failure (searching for baud rate)	3	On or off	On or off	On
Ready	4	Off	On	---

Note

Control Unit with PROFIBUS DP interface – operation via terminals

If a Control Unit with a PROFIBUS DP interface is operated via the terminals, the fieldbus LED indicates a fault code. To avoid this, the fieldbus shutdown time in parameter P2040 must be set to "0".

Statuses of PROFINET CUs	Prio	SF (red)	RDY (green)	BF (red)	LNK (green)	ACT (yellow)
Commissioning	1	On or off	Flashing	---	Flashing	Flashing
Firmware upgrade of MMC / parameter download	1	On or off	Flashing	---	Flashing	Flashing
General faults	3	On	OFF	---	Flashing	Flashing
Bus failure (no data)	3	On or off	On or off	Flashing	On	OFF
Bus failure (searching for baud rate)	3	On or off	On or off	On	OFF	OFF
PROFIsafe failure	3	On	Off	---	Flashing	Flashing
Connection established	3	On or off	On or off	OFF	On	Flashing
No connection established	3	On or off	On or off	On	OFF	OFF
Data receipt/transfer	3	On or off	On or off	OFF	On	On
Ready	4	Off	On	---	Flashing	Flashing

Statuses of fail-safe CUs	Prio	SF (red)	RDY (green)	BF (red)	ES (yellow)	STO (yellow)	SS1 (yellow)	SLS (yellow)
Commissioning	1	On or off	Flashing	---	On or off	---	---	---
Safety commissioning	1	On or off	Flashing	---	Flashing	Flashing	Flashing	Flashing
Firmware upgrade of MMC / parameter download	1	On or off	Flashing	---	Flashing	Flashing	Flashing	Flashing
Passivized STO initiated	2	On	OFF	---	On	OFF	OFF	OFF
General faults	3	On	OFF	---	On or off	---	---	---
Bus failure (no data)	3	On or off	On or off	Flashing	On or off	---	---	---
Bus failure (searching for baud rate)	3	On or off	On or off	On	On or off	---	---	---
Ready	4	OFF	On	---	OFF	---	---	---
STO reached	5	On or off	On	---	On	Flashing	---	---
SS1 reached	5	On or off	On	---	On	---	Flashing	---
SLS reached	5	On or off	On	---	On	---	---	Flashing
STO initiated	6	On or off	On	---	OFF	Flashing	---	---
SS1 initiated	6	On or off	On	---	OFF	---	Flashing	---
SLS initiated	6	On or off	On	---	OFF	---	---	Flashing
STO parameterized	7	On or off	On	---	OFF	On	On or off	On or off
SS1 parameterized	7	On or off	On	---	OFF	On or off	On	On or off
SLS parameterized	7	On or off	On	---	OFF	On or off	On or off	On

Diagnostics via alarm and fault numbers

If an alarm or fault condition occurs, the OP displays the corresponding alarm or fault number.

- If an alarm is present, the converter continues to operate.
- If a fault occurs, the converter shuts down.

Table 7- 1 Alarm and fault numbers – cause and remedy

Alarm number	Significance	
A0700	Cause	The parameter or configuration settings made by the PROFIBUS master are invalid.
	Remedy	Correct the PROFIBUS configuration.
A0702	Cause	The connection to PROFIBUS is interrupted.
	Remedy	Check the connector, cable, and PROFIBUS master.
A0703	Cause	The PROFIBUS master is either not receiving any setpoints or is only receiving invalid setpoints (control word = 0).
	Remedy	Check the setpoints of the PROFIBUS master. Switch the SIMATIC CPU to "RUN".
A0704	Cause	At least one transmitter between two nodes is not yet active or has failed.
	Remedy	Activate the transmitter between the two nodes.
A0705	Cause	The converter is not receiving any actual values.
	Remedy	None (the converter is faulty).
A0706	Cause	PROFIBUS DP software error.
	Remedy	No diagnostics parameter r2041.
A0710	Cause	The converter has detected an error with the PROFIBUS data connection.
	Remedy	The Control Unit data interface may be interrupted.
A0711	Cause	Invalid PROFIBUS parameter.
	Remedy	Check addresses P0918 and P2041.
F0070	Cause	No communication via PROFIBUS. Initiated by A0702, A0703, and A0704. The message frame downtime set in P2040 has elapsed. For details, see "Faults and Alarms" in the List Manual.
	Remedy	Check the connection between the data transfer devices and make sure that a valid control word is used.

Reading fault codes

The following parameters must be taken into account during troubleshooting:

- Stored in parameter r0947 under its code number (e.g. F0003 = 3)
- Associated fault value; stored in parameter r0949 (0 = no fault value)
- The time stamp of the fault is stored in r0948 and can be read
- The number of fault codes (P0952) is stored in r0947 and can be read

Reading messages

The following parameters must be taken into account when alarms are processed:

- Stored in parameter r2110 under the code number; can be read (e.g. A0503 = 503). The value 0 indicates that no alarm is generated. The index allows you to access the two current alarms and the two previous alarms.

General fault acknowledgement

You can use one of the following methods to reset the fault number:

- Press FN on the BOP.
- Factory setting: acknowledge via DI 2.
- Set bit 7 in control word 1 (r0054).
- Switch the converter off and then on again.

  (Switch off/on the main power supply and the external 24 V supply for the Control Unit.)

Faults that can only be acknowledged by switching the device off and then on again

- F00051 Parameter EEPROM fault
- F00052 Power Stack fault
- F00061 Automatic download (no MMC)
- F00062 Automatic download (MMC content invalid)
- F00063 Automatic download (MMC content incompatible)
- F00064 The drive has attempted to download data automatically while ramping up.
- F01601 System startup fault

Note

The drive cannot be operated until all active faults have been acknowledged. The procedure for deleting F00395 is described under "Message F00395" in this manual.

Motor failure without fault code or alarm

If the motor does not start once the ON command has been issued:

- Check whether P0010 = 0.
- Check the converter status via r0052.
- Check the command and setpoint source (P0700 and P1000).
- Check whether the motor data refers to the converter data "load range" and "voltage".

Technical data 8

8.1 Technical data of the CU240S

Technical data of the CU240S, CU240S DP, CU240S DP-F, CU240S PN and CU240S PN-F

Feature	Data
Operating voltage	Supply from the Power Module or an external 24 V DC supply (20.4 V to 28.8 V, 0.5 A) via control terminals 31 and 32
Heat loss	< 40W
Setpoint resolution	0.01 Hz
Digital inputs (dependent on the CU type)	6 or 9, floating; PNP Low < 5 V, High > 10 V, maximum input voltage 30 V, 5.5 mA
Analog inputs	2, with 10-bit resolution AI0: 0 V to 10 V, 0 mA to 20 mA and -10 V to+10 V AI1: 0 V to 10 V and 0 mA to 20 mA Both analog inputs can also be configured as digital inputs
Digital outputs	3 relay outputs, 30 V DC / max. 0.5 A for a resistive load
Analog outputs	2 AO0: 0 V to 10 V or 0 mA to 20 mA AO1: 0 mA to 20 mA
Fail-safe inputs (dependent on the CU type)	2, two-channel, maximum input voltage 30 V, 5.5 mA
PFH	5 × 10E-8 Valid for all safety functions STO, SS1, SLS and SBC
Dimensions (WxHxD)	73 mm x 178 mm x 55 mm
Weight	0.52 kg

8.2 Technical data of the CU240E

CU240E

Feature	Data
Operating voltage	Supply from the Power Module
Heat loss	< 40W
Setpoint resolution	0.01 Hz
Digital inputs (dependent on the CU type)	6, floating; PNP/NPN switchable Low < 5 V, High > 10 V, maximum input voltage 30 V, 5.5 mA
Analog inputs	2, with 10-bit resolution AI0: 0 V to 10 V, 0 mA to 20 mA and -10 V to+10 V AI1: 0 V to 10 V and 0 mA to 20 mA Both analog inputs can also be configured as digital inputs
Digital outputs	3 relay outputs, 30 V DC / max. 0.5 A for a resistive load
Analog outputs	2 AO0: 0 V to 10 V or 0 mA to 20 mA AO1: 0 mA to 20 mA
Weight	0.21 kg

8.3 Common technical data, PM240 Power Modules

PM240

Feature	Version	
Line operating voltage	3 AC 380 V … 480 V ± 10%	The permissible line operating voltage depends on the installation altitude
Input frequency	47 Hz … 63 Hz	
Power factor λ	0.7 ... 0.85	
Overload capability	The Power Module PM240 can either be operated with high overload (HO) or low overload (LO). In order to avoid overtemperature of the Power Module, after the overload, as a minimum its load must decrease back to the base load (HO base load or LO base load).	
	HO base load 0.37 kW ... 75 kW	150% overload for 57 s 200% overload for 3 s 100% HO base load for 240 s
	HO base load 90 kW ... 200 kW	136% overload for 57 s 160% overload for 3 s 100% HO base load for 240 s
	LO base load 7.5 kW ... 90 kW	110% overload for 57 s 150% overload for 3 s 100% LO base load for 240 s
	LO base load 110 kW ... 250 kW	110% overload for 59 s 150% overload for 1 s 100% LO base load for 240 s
Pulse frequency	4 kHz for 0.37 kW ... 75 kW (HO) 2 kHz for 90 kW ... 200 kW (HO) The pulse frequency can be increased in 2 kHz steps. A higher pulse frequency reduces the permissible output current.	
Possible braking methods	DC braking, compound braking, dynamic braking with integrated braking chopper	
Degree of protection	IP20	
Operating temperature	0.37 kW ... 110 kW (HO) -10 °C … +50 °C (14 °F … 122 °F)	Higher operating temperatures are possible when the rated power is reduced (derating)
	132 kW ... 200 kW (HO) -10 °C … +40 °C (14 °F … 104 °F)	
	(LO) -10 °C … +40 °C (14 °F … 104 °F)	
Bearing temperature	-40 °C … +70 °C (-40 °F … 158 °F)	
Relative humidity	< 95% RH - condensation not permissible	
Installation altitude	0.37 kW ... 110 kW (HO) Up to 1000 m (3300 ft) above sea level	Higher altitudes are possible when the rated power is reduced (derating)
	132 kW ... 200 kW (HO) Up to 2000 m (6500 ft) above sea level	
Standards	UL, cUL, CE, C-tick, SEMI F47 In order that the system is UL-compliant, UL-certified fuses, overload circuit-breakers or intrinsically safe motor protection devices must be used	

8.4 Technical data, PM240 Power Modules

General conditions

The input currents specified for the PM240 Power Modules is the technical data apply for a 400V line supply with U_k = 1% referred to the frequency inverter power rating. When using a line reactor, the currents are reduced by a few percent.

Table 8- 1 PM240 Frame Size A

Order No.	6SL3224-0BE13-7UA0	6SL3224-0BE15-5UA0	6SL3224-0BE17-5UA0	6SL3224-0BE21-1UA0	6SL3224-0BE21-5UA0
Power rating for HO base load	0.37 kW / 0.5 PS	0.55 kW / 0.75 PS	0.75 kW / 1 PS	1.1 kW / 1.5 PS	1.5 kW / 2 PS
Input current for HO base load	1.6 A	2.0 A	2.5 A	3.8	4.8
Output current for HO base load	1.3 A	1.7 A	2.2 A	3.1	4.1
Fuse	10 A	10 A	10 A	10 A	10 A
Heat loss	0.097 kW	0.099 kW	0.102 kW	0.108	0.114
Cooling air requirement	4.8 l/s / 10 CFM	4.8 l/s / 10 CFM	4.8 l/s / 10 CFM	4.8 l/s / 10 CFM	4.8 l/s / 10 CFM
Cable cross-section for line and motor connections	1 … 2.5 mm^2 / 18 … 14 AWG	1 … 2.5 mm^2 / 18 … 14 AWG	1 … 2.5 mm^2 / 18 … 14 AWG	1 … 2.5 mm^2 / 18 … 14 AWG	1 … 2.5 mm^2 / 18 … 14 AWG
Weight	1.2 kg / 2.6 lb	1.2 kg / 2.6 lb	1.2 kg / 2.6 lb	1.2 kg / 2.6 lb	1.2 kg / 2.6 lb

Table 8- 2 PM240 Frame Size B and C

Order No., unfiltered	6SL3224-0BE22-2AA0	6SL3224-0BE23-0AA0	6SL3224-0BE24-0AA0	6SL3224-0BE25-5AA0	6SL3224-0BE27-5AA0	6SL3224-0BE31-1AA0
Order No., filtered	6SL3224-0BE22-2UA0	6SL3224-0BE23-0UA0	6SL3224-0BE24-0UA0	6SL3224-0BE25-5UA0	6SL3224-0BE27-5UA0	6SL3224-0BE31-1UA0
Power rating for HO base load	2.2 kW / 3 PS	3 kW / 4 PS	4 kW / 5 PS	5.5 kW / 7.5 PS	7.5 kW / 10 PS	11 kW / 15 PS
Input current for HO base load	7.6 A	10.2 A	13.4 A	16.7 A	23.7 A	32.7 A
Output current for HO base load	5.9 A	7.7 A	10.2 A	13.2 A	19 A	26 A
Input current for LO base load	7.6 A	10.2 A	13.4 A	21.9 A	31.5 A	39.4 A
Output current for LO base load	5.9 A	7.7 A	10.2 A	18 A	25 A	32 A
Fuse	16 A	16 A	16 A	20 A	32 A	35 A
Heat loss	0.139 KW	0.158 KW	0.183 KW	0.240 KW	0.297 KW	0.396 KW
Cooling air requirement	24 l/s 50 CFM	24 l/s 50 CFM	24 l/s 50 CFM	55 l/s 120 CFM	55 l/s 120 CFM	55 l/s 120 CFM
Cable cross-section for line and motor connections	1.5 … 6 mm^2 16 … 10 AWG	1.5 … 6 mm^2 16 … 10 AWG	1.5 … 6 mm^2 16 … 10 AWG	4 … 10 mm^2 12 … 8 AWG	4 … 10 mm^2 12 … 8 AWG	4 … 10 mm^2 12 … 8 AWG
Weight	4.3 kg / 9.5 lb	4.3 kg / 9.5 lb	4.3 kg / 9.5 lb	6.5 kg / 14 lb	6.5 kg / 14 lb	6.5 kg / 14 lb

Table 8- 3 PM240 Frame Size D and E

Order No., unfiltered	6SL3224-0BE31-5AA0	6SL3224-0BE31-8AA0	6SL3224-0BE32-2AA0	6SL3224-0BE33-0AA0	6SL3224-0BE33-7AA0
Order No., filtered	6SL3224-0BE31-5UA0	6SL3224-0BE31-8UA0	6SL3224-0BE32-2UA0	6SL3224-0BE33-0UA0	6SL3224-0BE33-7UA0
Power rating for HO base load	15 kW / 20 PS	18.5 kW / 25 PS	22 kW / 30 PS	30 kW / 40 PS	37 kW / 50 PS
Input current for HO base load	40 A	46 A	56 A	73 A	90 A
Output current for HO base load	32 A	38 A	45 A	60 A	75 A
Input current for LO base load	46 A	53 A	72 A	88 A	105 A
Output current for LO base load	38 A	45 A	60 A	75 A	90 A
Fuse	50 A	63 A	80 A	100 A	125 A
Heat loss	0.44 KW	0.55 KW	0.72 KW	1.04 KW	1.2 KW
Cooling air requirement	55 l/s / 120 CFM	55 l/s / 120 CFM	55 l/s / 120 CFM	110 l/s / 240 CFM	110 l/s / 240 CFM
Cable cross-section for line and motor connections	10 … 35 mm^2 7 … 2 AWG	10 … 35 mm^2 7 … 2 AWG	10 … 35 mm^2 7 … 2 AWG	25 … 35 mm^2 3 … 2 AWG	25 … 35 mm^2 3 … 2 AWG
Weight	Filtered: 16 kg / 35 lb; unfiltered: 13 kg / 29 lb	Filtered: 16 kg / 35 lb; unfiltered: 13 kg / 29 lb	Filtered: 16 kg / 35 lb; unfiltered: 13 kg / 29 lb	Filtered: 23 kg / 51 lb; unfiltered: 16 kg / 35 lb	Filtered: 23 kg / 51 lb; unfiltered: 16 kg / 35 lb

Table 8- 4 PM240 Frame Size F

Order No., unfiltered	6SL3224-0BE34-5AA0	6SL3224-0BE35-5AA0	6SL3224-0BE37-5AA0	6SL3224-0BE38-8UA0	6SL3224-0BE41-1UA0
Order No., filtered	6SL3224-0BE34-5UA0	6SL3224-0BE35-5UA0	6SL3224-0BE37-5UA0	-	-
Power rating for HO base load	45 kW / 60 PS	55 kW / 75 PS	75 kW / 100 PS	90 kW / 125 PS	110 kW / 150 PS
Input current for HO base load	108 A	132 A	169 A	205 A	235 A
Output current for HO base load	90 A	110 A	145 A	178 A	205 A
Input current for LO base load	129 A	168 A	204 A	234 A	284 A
Output current for LO base load	110 A	145 A	178 A	205 A	250 A
Fuse	160 A	200 A	250 A	250 A	315 A
Heat loss	1.5 KW	2.0 KW	2.4 KW	2.4 kW	2.5 kW
Cooling air requirement	150 l/s / 320 CFM	150 l/s / 320 CFM	150 l/s / 320 CFM	150 l/s / 320 CFM	150 l/s / 320 CFM
Cable cross-section for line and motor connections	35 … 120 mm^2 2 … 4/0 AWG	35 … 120 mm^2 2 … 4/0 AWG	35 … 120 mm^2 2 … 4/0 AWG	35 … 120 mm^2 2 … 4/0 AWG	35 … 120 mm^2 2 … 4/0 AWG
Weight	Filtered: 52 kg / 115 lb; unfiltered: 36 kg / 80 lb	Filtered: 52 kg / 115 lb; unfiltered: 36 kg / 80 lb	Filtered: 52 kg / 115 lb; unfiltered: 36 kg / 80 lb	39 kg / 90 lb	39 kg / 90 lb

Table 8- 5 PM240 Frame Size G

Order No.	6SL3224-0BE41-3UA0	6SL3224-0BE41-6UA0	6SL3224-0BE42-0UA0
Power rating for HO base load	132 kW / 177 PS	160 kW / 215 PS	200 kW / 268 PS
Input current for HO base load	245 A	297 A	354 A
Output current for HO base load	250 A	302 A	370 A
Input current for LO base load	297 A	354 A	442 A
Output current for LO base load	302 A	370 A	477 A
Fuse	355 A	400 A	630 A
Heat loss	3.9 KW	4.4 KW	5.5 KW
Cooling air requirement	360 l/s / 760 CFM	360 l/s / 760 CFM	360 l/s / 760 CFM
Cable cross-section for line and motor connections	95 ... 240 mm^2 3/0 ... 600 AWG	120 ... 240 mm^2 4/0 ... 600 AWG	185 ... 240 mm^2 6/0 ... 600 AWG
Weight	176 kg / 388 lb	176 kg / 388 lb	176 kg / 388 lb

8.5 Common technical data, PM250 Power Modules

PM250

Feature	Version	
Line operating voltage	3 AC 380 V … 480 V ± 10%	The permissible line operating voltage depends on the installation altitude
Input frequency	47 Hz … 63 Hz	
Power factor λ	0.9	
Overload capability	The Power Module PM250 can either be operated with high overload (HO) or low overload (LO). In order to avoid overtemperature of the Power Module, after the overload, as a minimum its load must decrease back to the base load (HO base load or LO base load).	
	HO base load 5.5 kW ... 75 kW	150% overload for 57 s 200% overload for 3 s 100% HO base load for 240 s
	LO base load 7.5 kW ... 90 kW	110% overload for 57 s 150% overload for 3 s 100% LO base load for 240 s
Pulse frequency	4 kHz The pulse frequency can be increased in 2 kHz steps. A higher pulse frequency reduces the permissible output current.	
Braking methods	Regenerative energy	
Degree of protection	IP20	
Operating temperature	HO base load -10 °C … +50 °C (14 °F … 122 °F)	Higher operating temperatures are possible when the rated power is reduced (derating)
	LO base load -10 °C … +40 °C (14 °F … 104 °F)	
Bearing temperature	-40 °C … +70 °C (-40 °F … 158 °F)	
Relative humidity	< 95% RH - condensation not permissible	
Installation altitude	Up to 1000 m (3300 ft) above sea level	Higher altitudes are possible when the rated power is reduced (derating)
Standards	UL, cUL, CE, C-tick, SEMI F47 In order that the system is UL-compliant, UL-certified fuses, overload circuit-breakers or intrinsically safe motor protection devices must be used	

8.6 Technical data, PM250 Power Modules

PM250 Power Module

Table 8- 6 PM250 Frame Size C and D

Order No.	6SL3225-0BE25-5AA0	6SL3225-0BE27-5AA0	6SL3225-0BE31-1AA0	6SL3225-0BE31-5AA0	6SL3225-0BE31-8AA0	6SL3225-0BE32-2AA0
Power rating for HO base load	5.5 kW 7.5 PS	7.5 kW 10.0 PS	11.0 kW 15 PS	15.0 kW 20 PS	18.5 kW 25 PS	22.0 kW 30 PS
Input current for HO base load	13.2 A	19.0 A	26.0 A	30.0 A	36.0 A	42.0 A
Output current for HO base load	13.2 A	19.0 A	26.0 A	32.0 A	38.0 A	45.0 A
Input current for LO base load	18.0 A	25.0 A	32.0 A	36.0 A	42.0 A	56.0 A
Output current for LO base load	18.0 A	25.0 A	32.0 A	38.0 A	45.0 A	60.0 A
Fuse	20 A	32 A	35 A	50 A	63 A	80 A
Heat loss	Available soon	Available soon	Available soon	0.44 kW	0.55 kW	0.72 kW
Cooling air requirement	38 l/s 0 CFM	38 l/s 80 CFM	38 l/s 80 CFM	22 l/s 46 CFM	22 l/s 46 CFM	39 l/s 82 CFM
Cable cross-section for line and motor connections	2.5 … 10 mm² 14 … 8 AWG	4 … 10 mm² 12 … 8 AWG	6 … 10 mm² 10 … 8 AWG	10 … 35 mm² 7 … 2 AWG	10 … 35 mm² 7 … 2 AWG	16 … 35 mm² 5 … 2 AWG
Weight	7.5 kg / 17 lb	7.5 kg / 17 lb	7.5 kg / 17 lb	15 kg / 33 lb	15 kg / 33 lb	16 kg / 35 lb

Table 8- 7 PM240 Frame Size E and F

Order No.	6SL3225-0BE33-0AA0	6SL3225-0BE33-7AA0	6SL3225-0BE34-5AA0	6SL3225-0BE35-5AA0	6SL3225-0BE37-5AA0
Power rating for HO base load	30.0 kW / 40 PS	37.0 kW / 50.0 PS	45.0 kW / 60 PS	55.0 kW / 75 PS	75 kW / 100 PS
Input current for HO base load	56 A	70 A	84 A	103 A	135 A
Output current for HO base load	60 A	75 A	90 A	110 A	145 A
Input current for LO base load	70 A	84 A	102 A	190 A	223 A
Output current for LO base load	75 A	90 A	110 A	145 A	178 A
Fuse	100 A	125 A	160 A	200 A	250 A
Heat loss	1 kW	1.3 kW	1.5 kW	2 kW	2.4 kW
Cooling air requirement	22 l/s / 46 CFM	39 l/s / 82 CFM	94 l/s / 200 CFM	94 l/s / 200 CFM	117 l/s / 250 CFM
Cable cross-section for line and motor connections	25 … 35 mm² 3 … 2 AWG	25 … 35 mm² 3 … 2 AWG	35 … 150 mm² 2 … - 5 AWG	70 … 150 mm² - 2 … - 5 AWG	95 … 150 mm² - 3 … - 5 AWG
Weight	21 kg / 46 lb	21 kg / 46 lb	51.0 kg / 112 lb	51.0 kg / 112 lb	51.0 kg / 112 lb

8.7 Common technical data, PM260 Power Modules

PM260

Feature	Version	
Line operating voltage	3 AC 660 V … 690 V ± 10%	The permissible operating voltage depends on the installation altitude
	The power units can also be operated with a minimum voltage of 500 V – 10 %. In this case, the power is linearly reduced as required.	
Input frequency	47 Hz … 63 Hz	
Power factor λ	0.95	
Overload capability	The Power Module PM260 can either be operated with high overload (HO) or low overload (LO). In order to avoid overtemperature of the Power Module, after the overload, as a minimum its load must decrease back to the base load (HO base load or LO base load).	
	HO base load 7.5 kW ... 37 kW	150% overload for 57 s 200% overload for 3 s 100% HO base load for 240 s
	LO base load 11 kW ... 55 kW	110% overload for 57 s 140% overload for 3 s 100% LO base load for 240 s
Pulse frequency	16 kHz	
Braking methods	Regenerative energy	
Degree of protection	IP20	
Operating temperature	HO base load -10 °C … +50 °C (14 °F … 122 °F)	Higher operating temperatures are possible when the rated power is reduced
	LO base load -10 °C … +40 °C (14 °F … 104 °F)	
Bearing temperature	-40 °C … +70 °C (-40 °F … 158 °F)	
Relative humidity	< 95% RH - condensation not permissible	
Installation altitude	Up to 1000 m (3300 ft) above sea level	Higher altitudes are possible when the rated power is reduced
Standards	CE	

8.8 Technical data, PM260 Power Modules

PM260 Power Module

Table 8- 8 PM260 Frame Size D and F

Order No., unfiltered	6SL3225-0BH27-5UA0	6SL3225-0BH31-1UA0	6SL3225-0BH31-5UA0	6SL3225-0BH32-2UA0	6SL3225-0BH33-0UA0	6SL3225-0BH33-7UA0
Order No., filtered	6SL3225-0BH27-5AA0	6SL3225-0BH31-1AA0	6SL3225-0BH31-5AA0	6SL3225-0BH32-2AA0	6SL3225-0BH33-0AA0	6SL3225-0BH33-7AA0
Power rating for HO base load	7.5 kW 10 PS	11 kW 15 PS	15 kW 20 PS	22 kW 30 PS	30 kW 41 PS	37 kW 50 PS
Input current for HO base load	10 A	13 A	18 A	26 A	34 A	41 A
Output current for HO base load	10 A	14 A	19 A	26 A	35 A	42 A
Input current for LO base load	13 A	18 A	22 A	34 A	41 A	60 A
Output current for LO base load	14 A	19 A	23 A	35 A	42 A	62 A
Fuse	20 A	20 A	32 A	50 A	50 A	80 A
Heat loss	Available soon	Available soon	Available soon	Available soon	Available soon	Available soon
Cooling air requirement	22 l/s 47 CFM	22 l/s 47 CFM	39 l/s 83 CFM	94 l/s 199 CFM	94 l/s 199 CFM	117 l/s 248 CFM
Cable cross-section for line and motor connections	2,5 … 16 mm² 14 … 6 AWG	4 … 16 mm² 12 … 6 AWG	6 … 16 mm² 10 … 6 AWG	10 ... 35 mm² 8 … 2 AWG	16 ... 35 mm² 6 … 2 AWG	25 ... 35 mm² 4 … 2 AWG
Weight	Unfiltered: 20 kg / 44 lb; filtered: 21 kg / 46 lb	Unfiltered: 20 kg / lb; filtered: 21 kg / 46 lb	Unfiltered: 20 kg / lb; filtered: 21 kg / 46 lb	Unfiltered: 46 kg / lb; filtered: 48 kg / lb	Unfiltered: 46 kg / 100 lb; filtered: 48 kg / 105 lb	Unfiltered: 46 kg / 100 lb; filtered: 48 kg / 105 lb

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