Operating Instructions · Edition 04/2006

# Control Unit

CU240S
CU240S DP
CU240S DP-F

Software version 2.0

# SINAMICS
## G120

SIEMENS

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# SINAMICS

# SINAMICS G120
# Control Units CU240S

Operating Instructions




Edition 04/2006 Software version V2.0

04/2006
A5E00766042B AA

## Safety Guidelines

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.

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**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.

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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.

## Prescribed Usage

Note the following:

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**Warning**

This device may only be used for the applications described in the catalog or the technical description and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens. Correct, reliable operation of the product requires proper transport, storage, positioning and assembly as well as careful operation and maintenance.

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## Trademarks

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## Disclaimer of Liability

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

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Order No.: A5E00766042B AA
Edition 04/2006

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# Introduction 1

## 1.1 Documents for the SINAMICS G120

### Available documentation

The following documents are available for the SINAMICS G120 inverters:

- Brochure
- Catalog
- Getting started Guide
- Operating Instructions
- Hardware Installation Manual
- Compact Operating Instructions (for the Control Units)
- Parameter List.

The documents can be downloaded from the Internet via the following link:
http://www.siemens.de/sinamics-g120

### Description of the documents

### Brochure

The brochure is advertising literature designed to introduce the product to the marketplace. It contains a basic outline of the product with a brief overview of the technical capabilities of the product.

### Catalog

The catalog presents information that allows the customer to select an appropriate inverter including all available options. It contains detailed technical specifications, ordering and pricing information to allow the customer to order the appropriate items for their application or plant.

### Getting started Guide

The Getting started Guide presents warnings, dimension drawings and a brief set up information for the customer.

## Operating Instructions

The Operating Instructions gives information for the Control Unit regarding the features of the product. It gives detailed information on commissioning, control modes, system parameters, troubleshooting, technical specifications and the available options from the product.

## Hardware Installation Manual

The Hardware Installation Manual gives information for the Power Modules regarding the features of the product. It gives detailed information on installation, technical specifications, dimension drawings and the available options from the product.

## Compact Operating Instructions

The Compact Operating Instructions gives a brief description of the installation, commissioning and control modes as well as an overview of troubleshooting, technical specifications and the available options from the product.

## Parameter List

The Parameter List contains a detailed description of all the parameters that can be modified and adapted for specific applications. The Parameter List also contains a series of function diagrams to diagramatically portray the nature and interoperability of the system parameters.

# 2 Safety notes

## Safety Instructions

The following Warnings, Cautions and Notes are provided for your safety and as a means of preventing damage to the product or components in the connected machines. This section lists Warnings, Cautions and Notes, which apply generally when handling the SINAMICS G120 product, classified as General, Transport and Storage, Commissioning, Operation, Repair and Dismantling and Disposal.

Specific Warnings, Cautions and Notes that apply to particular activities are listed at the beginning of the relevant sections in this manual and are repeated or supplemented at critical points throughout these sections.

Please read the information carefully, since it is provided for your personal safety and will also help prolong the service life of your SINAMICS G120 product and the equipment to which it is connected.

## General

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**Caution**

Children and the general public must be prevented from accessing or approaching the equipment!

This equipment may only be used for the purpose specified by the manufacturer. Unauthorized modifications and the use of spare parts and accessories that are not sold or recommended by the manufacturer of the equipment can cause fires, electric shocks and injuries.

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**Notice**

Keep these operating instructions within easy reach of the equipment and make them available to all users.

Whenever measuring or testing has to be performed on live equipment, the regulations of Safety Code BGV A2 must be observed, in particular § 8 "Permissible Deviations when Working on Live Parts". Suitable electronic tools should be used.

Before installing and commissioning, please read these safety instructions and warnings carefully and all the warning labels attached to the equipment. Make sure that the warning labels are kept in a legible condition and replace missing or damaged labels.

---

## Transport and storage

**Warning**

Correct transport, storage as well as careful operation and maintenance are essential for the proper and safe operation of the equipment.

**Caution**

Protect the equipment against physical shocks and vibration during transport and storage. It is important that the equipment is protected from water (rainfall) and excessive temperatures.

## Commissioning

**Warning**

Working on the equipment by unqualified personnel or failure to comply with warnings can result in severe personal injury or serious damage to material. Only suitably qualified personnel trained in the setup, installation, commissioning and operation of the product should carry out work on the equipment.

**Caution**

The control cables must be laid separately from the power cables. Carry out the connections as shown in the installation section in this manual, to prevent inductive and capacitive interference from affecting the correct function of the system.

## Operation

Warning

The SINAMICS G120 inverters operate at high voltages.

When operating electrical devices, it is impossible to avoid applying hazardous voltages to certain parts of the equipment.

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

Certain parameter settings may cause the SINAMICS G120 inverter to restart automatically after an input power failure, for example, the automatic restart function.

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

Motor parameters must be accurately configured for motor overload protection to operate correctly.

This equipment is capable of providing internal motor overload protection according to UL508C. Refer to P0610 and P0335, $i^2t$ is ON by default.

Only Control Units with fail-safe functions can be used as an "Emergency Stop Mechanism" (see EN 60204, section 9.2.5.4).

## Repair

Warning

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

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

Disconnect the power supply before opening the equipment for access.

## Dismantling and disposal

**Caution**

The SINAMICS G120s packaging is re-usable. Retain the packaging for future use.

Easy-to-release screw and snap connectors allow you to break the unit down into its component parts. You can recycle these component parts, dispose of them in accordance with local requirements or return them to the manufacturer.

# 3 Description

## Overview

The SINAMICS G120 inverter has been designed for the accurate and efficient control of the speed and torque for three-phase motors. The SINAMICS G120 system comprises two basic modules, the Control Unit (CU) and the Power Module (PM).

## Control Units

- CU240S

  Control Unit for operation via terminals
- CU240S DP

  Control Unit for operation via terminals or PROFIBUS DP Communication
- CU240S DP-F

  Control Unit with fail-safe functions for operation via terminals or PROFIBUS DP Communication (PROFIsafe).

## Power Modules

- PM240 400 V, IP20
  - Frame sizes A unfiltered
  - Frame sizes B … F unfiltered or with filter Class A.

PM240 power modules can be used for control units with and without fail-safe funtions.

# 3.1 Accessories for the SINAMICS G120

## Overview

The following options are available for the SINAMICS G120 Inverters:

## Control Unit accessories

- OP (Operator Panel)
- PC connection kit
- MMC (Multi Media Card)
- CU screening Kit

## Power Module accessories

- DIN rail mounting kit
- NEMA 1 kit
- Screen termination kit
- Brake and Safe brake modules
- Chokes
- Filters
- Braking resistor.

## Power Module spare parts

- Fan.

A description of the individual options, there purposes and ordering information is given in the SINAMICS G120 catalog.

## 3.2 Features and functions of the CU240S

### Common features

- Modular inverter
- Simple to install
- Signals are interconnected using BICO technology
- Data sets can be toggled
- Fast current limiting (FCL) for trip-free operation
- The power module or control unit can be simply exchanged in operation (hot swapping)
- Rugged EMC design
- Can be configured for a wide range of applications
- Parameter settings can be saved in a non-volatile fashion - either in an EEPROM or on the MMC
- Diagnostics using LEDs on the control unit
- High pulse frequencies for low noise motor operation
- 4 kHz factory setting, can be set from 2 kHz to 16 kHz
- Built-in braking chopper for resistor braking
- DC-link voltage controller
- Kinetic buffering
- Encoder Interface
- Closed-loop vector control (speed and torque) with or without encoder
- EM brake relay.

### Commissioning functions

- Quick commissioning
- Motor/control data are calculated
- Motor data identification routine
- Application commissioning
- Series commissioning
- Parameter reset to the factory setting.

### Operating functions

- Selectable setpoint channel
- Selectable ramp-function generator (RFG)
- JOG mode
- Freely-assignable function blocks (FFB)

- Positioning down ramp
- Automatic restart (WEA)
- Flying restart
- Current limiting
- Slip compensation
- Motor holding brake (MHB).

## Control functions

- V/f control with different characteristics
- SLVC (Sensorless vector control mode).
- VC (Vector control mode with encoder).

## Protective functions

- Motor protective functions
- Inverter protective functions
- Plant/system protective functions.

## Interfaces

- MMC-parameter memory (MMC-PS)
- Option port (USS on RS232)
- Motor temperature sensor PTC/KTY84
- Diagnostics interface.

## Fail-Safe Functions (only for CU240S DP-F)

- Safe Torque Off (STO)
- Safe Stop 1 (SS1)
- Safely-Limited Speed (SLS)
- Safe Brake Control (SBC).

The fail-safe functions can be triggered via Digital inputs (FDI0A … FDI1B) or PROFIsafe.

## 3.3 Variants of CU240S

### Layout characteristics of the CU240S variants

The figure below shows the various interfaces and control that are available on the Control Unit.

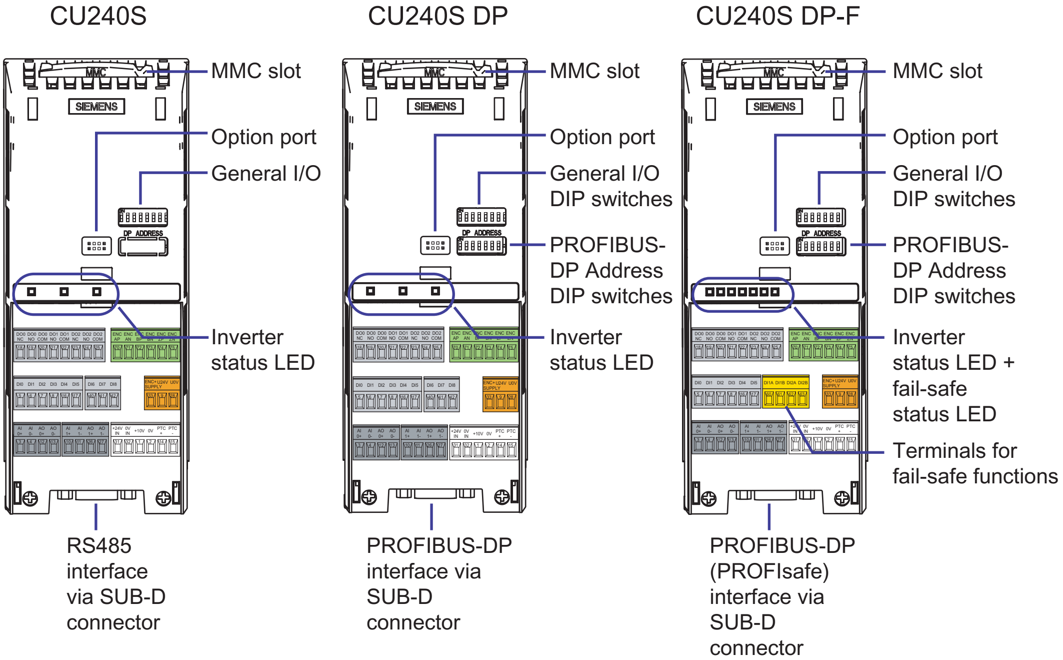



Figure 3-1 Variants of Control Units CU240S

### Variants

Table 3-1 Interfaces of the Control Units CU240S

| Control Unit | CU240S | CU240S DP | CU240S DP-F |
|---|---|---|---|
| Digital Inputs | 9 | 9 | 6 |
| Fail-safe digital Inputs | -- | -- | 2 |
| Digital Outputs | 3 | 3 | 3 |
| Analog Inputs | 2 | 2 | 2 |
| Analog Outputs | 2 | 2 | 2 |
| PTC/KTY84 interface | 1 | 1 | 1 |
| MMC interface | 1 | 1 | 1 |
| Encoder interface | 1, TTL or HTL | 1, TTL or HTL | 1, TTL or HTL |
| Option port | Starter or OP interface | Starter or OP interface | Starter or OP interface |
| Bus interface | USS on RS485 | PROFIBUS | PROFIBUS, PROFIsafe |
| Ext. 24 V | Yes | Yes | Yes |

## Functions

The Control Units CU240S incorporate numerous control technologies that allow the SINAMICS G120 to control the power module and monitor the connected motor.

Table 3-2 Functions of the Control Units CU240S

| Control Unit | CU240S | CU240S DP | CU240S DP-F |
|---|---|---|---|
| Upload and download of parameter sets via | • MMC Card<br>• OP<br>• STARTER | • MMC Card<br>• OP<br>• STARTER | • MMC Card<br>• OP<br>• STARTER |
| BICO Technology | x | x | x |
| Sensorless vector control (SLVC) | x | x | x |
| Vector control with encoder (VC) | x | x | x |
| Automatic and flying restart | x | x | x |
| Positioning ramp down | x | x | x |
| Overvoltage/undervoltage protection | x | x | x |
| Ground fault protection | x | x | x |
| Short-circuit protection | x | x | x |
| $I^2t$ thermal motor protection | x | x | x |
| PTC/KTY84 for motor protection | x | x | x |
| Slip compensation | x | x | x |
| Fast current limitation (FCL) for trip-free operation | x | x | x |
| V/f Control with FCC | x | x | x |
| V/f Control with Multi-point V/f characteristic | x | x | x |
| Safe Torque Off | -- | -- | x |
| Safe Stop 1 | -- | -- | x |
| Safely-Limited Speed | -- | -- | x |
| Ramp-function generator | x | x | x |
| Technology controller (PID) | x | x | x |
| Three Drive Data sets (DDS) | x | x | x |
| Three Command Data sets (CDS) | x | x | x |
| Free Function Blocks | x | x | x |
| Setpoint input via: | | | |
| • Analog inputs | x | x | x |
| • JOG function | x | x | x |
| • Motorized potentiometer | x | x | x |
| • Fixed frequencies | x | x | x |
| • RS485 | x | -- | -- |
| • PROFIBUS | -- | x | x |

## 3.4 Block diagrams

### CU240S Block Diagram

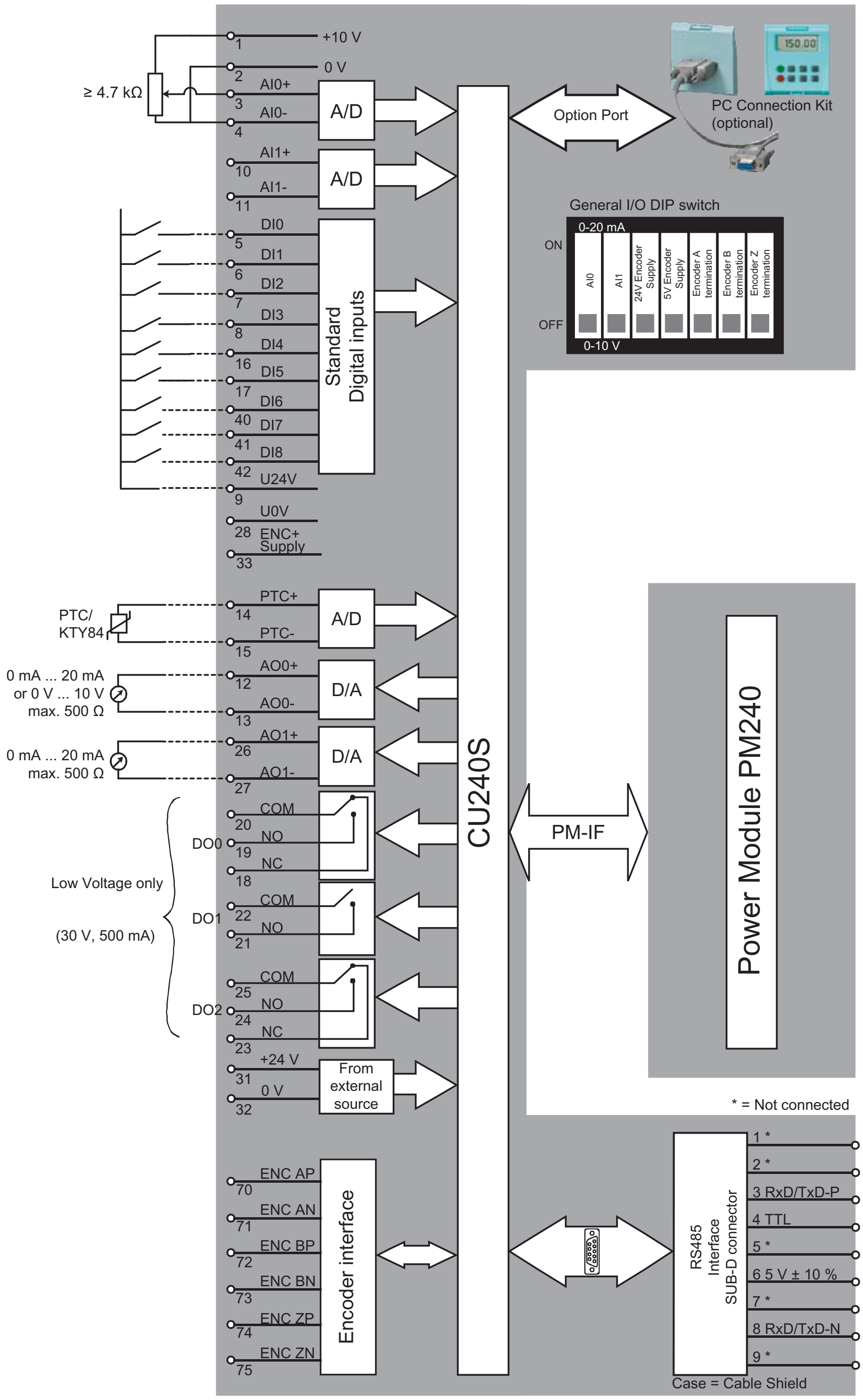



Figure 3-2 CU240S Block Diagram

## CU240S DP Block Diagram

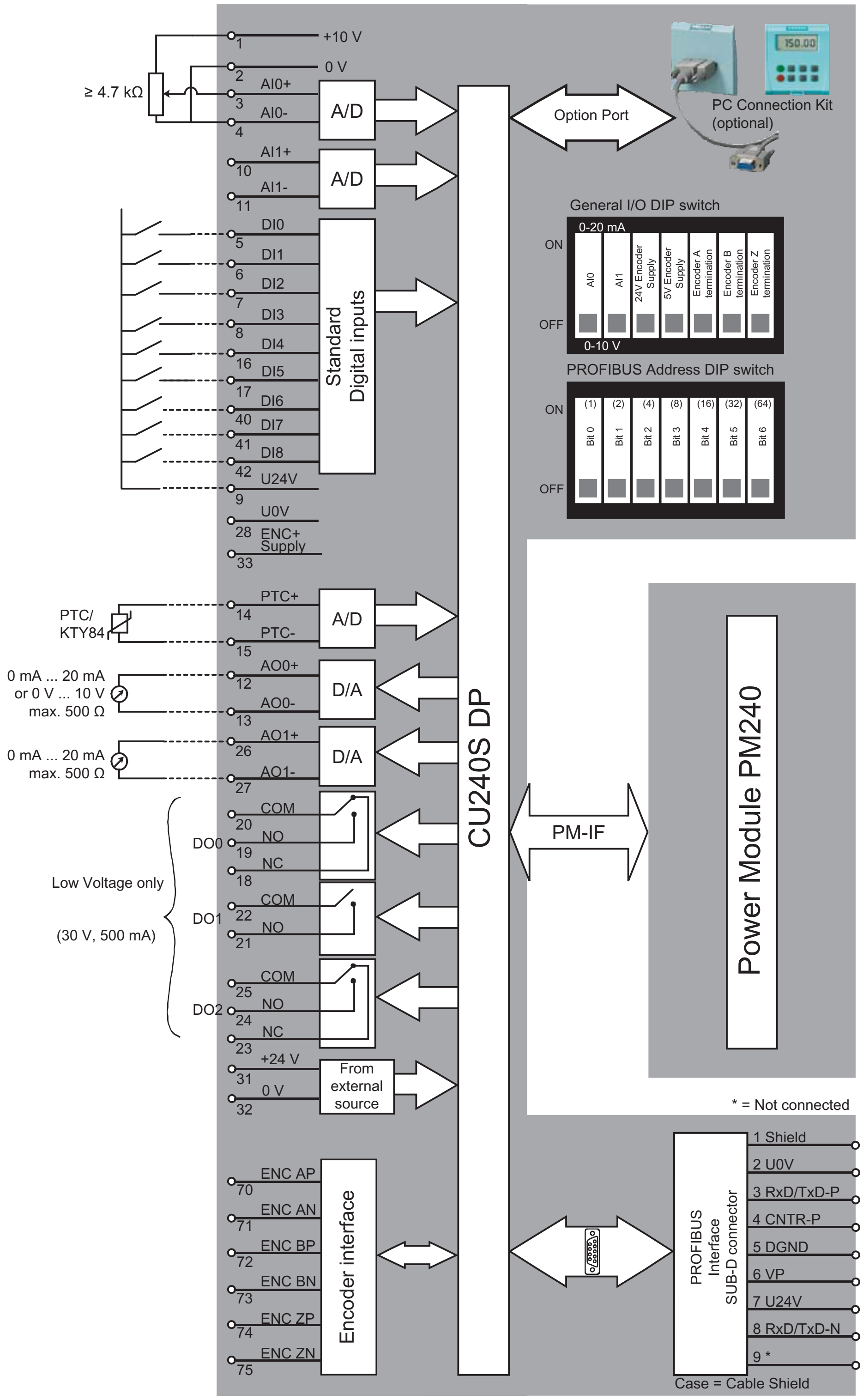



Figure 3-3 CU240S DP Block diagram

## CU240S DP-F Block Diagram

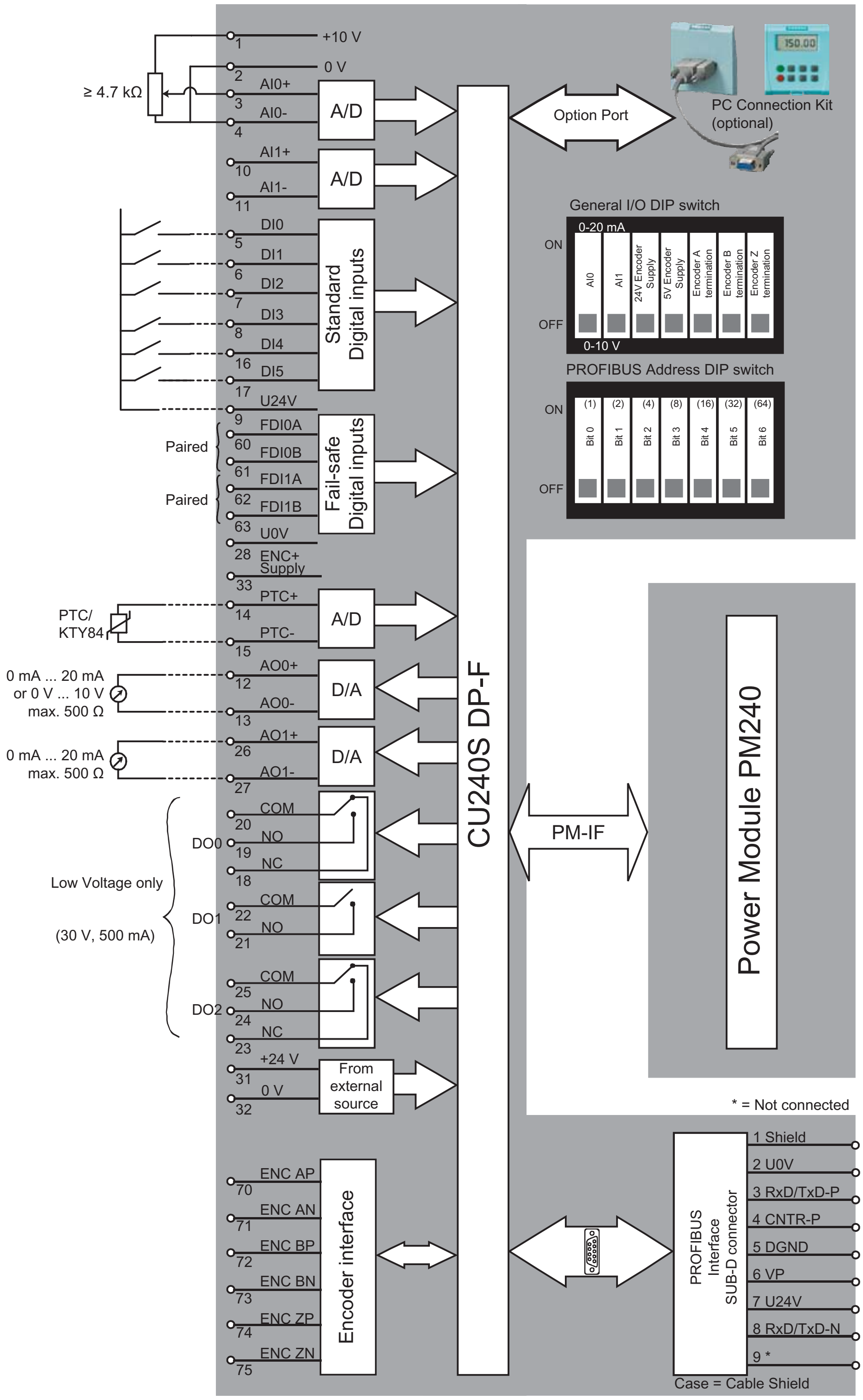



Figure 3-4 CU240S DP-F Block diagram

## 3.5 Interfaces of the CU240S variants

### Overview

Table 3-3 Following interfaces are available, see also figure "Variants of Control Units CU240S"

| | CU240S | CU240S DP | CU240S DP-F |
|---|---|---|---|
| MMC slot | x | x | x |
| Option port | x | x | x |
| Terminals | x | x | x |
| General I/O DIP switches | x | x | x |
| PROFIBUS DP DIP switches | -- | x | x |
| Status LED | x | x | x |
| Power module interface (PM-IF) | x | x | x |
| SUB-D connector (RS485 or PROFIBUS) | x | x | x |

### MMC

The Multi Media Card (MMC) is a small, removable flash storage device, with a low power consumption which provides the ability to store data sets for the inverter.

The MMC provides non-volatile data storage which requires no power to maintain the data stored on the card.

It is recommended that the SINAMICS-MMC (order number: 6SL3254-0AM00-0AA0) is used for the storage and transfer of data sets.

### Option port

Via the Option port the OP is connected to the inverter, it can also be used to connect a PC via the PC Connection Kit to the inverter for parameterizing using STARTER.

## Terminals

Table 3-4 Control terminals

| Terminal | Designation | Function | CU240S/ CU240S DP | CU240S DP-F |
|---|---|---|---|---|
| 1 | +10V | Non-isolated output +10 V, max. 10 mA | x | x |
| 2 | 0V | Supply reference (terminal 1) | x | x |
| 3 | AI0+ | Analog input 0 positive | x | x |
| 4 | AI0- | Analog input 0 negative | x | x |
| 5 | DI0 | Digital input 0, isolated | x | x |
| 6 | DI1 | Digital input 1, isolated | x | x |
| 7 | DI2 | Digital input 2, isolated | x | x |
| 8 | DI3 | Digital input 3, isolated | x | x |
| 9 | U24V | Isolated output +24 V – max. 100 mA | x | x |
| 10 | AI1+ | Analog input 1 positive | x | x |
| 11 | AI1- | Analog input 1 negative | x | x |
| 12 | AO0+ | Analog output 0 positive (0/4 mA … 20 mA, 0/2 V … 10 V with 500 Ω load) | x | x |
| 13 | AO0- | Analog output 0 negative | x | x |
| 14 | PTC+ | Motor temperature sensor (PTC or KTY84-130) | x | x |
| 15 | PTC- | Motor temperature sensor (PTC or KTY84-130) | x | x |
| 16 | DI4 | Digital input 4, isolated | x | x |
| 17 | DI5 | Digital input 5, isolated | x | x |
| 18 | DO0, NC | Digital output relay 0. normally closed, 0.5 A, 30 V DC | x | x |
| 19 | DO0, NO | Digital output relay 0. normally open, 0.5 A, 30 V DC | x | x |
| 20 | DO0, COM | Digital output relay 0. common, 0.5 A, 30 V DC | x | x |
| 21 | DO1, NO | Digital output relay 1. normally open, 0.5 A, 30 V DC | x | x |
| 22 | DO1, COM | Digital output relay 1. common, 0.5 A, 30 V DC | x | x |
| 23 | DO2, NC | Digital output relay 2. normally closed, 0.5 A, 30 V DC | x | x |
| 24 | DO2, NO | Digital output relay 2. normally open, 0.5 A, 30 V DC | x | x |
| 25 | DO2, COM | Digital output relay 2. common, 0.5 A, 30 V DC | x | x |
| 26 | AO1+ | Analog output 1 positive (0/4 mA … 20 mA, 0/2 V … 10 V with 500 Ω load) | x | x |
| 27 | AO1- | Analog output 1 negative | x | x |
| 28 | U0V | Supply reference (terminal 9) | x | x |
| 31 | +24V IN | 24 V input supply | x | x |

| Terminal | Designation | Function | CU240S/ CU240S DP | CU240S DP-F |
|---|---|---|---|---|
| 32 | 0V IN | Supply reference (terminal 31) | x | x |
| 33 | ENC+ SUPPLY | 5 V or 24 V power supply for Encoder configured by DIP switch, max. 300 mA | x | x |
| 40 | DI6 | Digital input 7, isolated | x | -- |
| 41 | DI7 | Digital input 8, isolated | x | -- |
| 42 | DI8 | Digital input 9, isolated | x | -- |
| 60 | FDI0A | Fail-safe Digital Input 0A | -- | x |
| 61 | FDI0B | Fail-safe Digital Input 0B | -- | x |
| 63 | FDI1A | Fail-safe Digital Input 1A | -- | x |
| 64 | FDI1B | Fail-safe Digital Input 1B | -- | x |
| 70 | ENC AP | Channel A non-inverting input | x | x |
| 71 | ENC AN | Channel A inverting input | x | x |
| 72 | ENC BP | Channel B non-inverting input | x | x |
| 73 | ENC BN | Channel B inverting input | x | x |
| 74 | ENC ZP | Channel 0 (zero) non-inverting input | x | x |
| 75 | ENC ZN | Channel 0 (zero) inverting input | x | x |

The control terminals have a maximum tighten torque of 0.25 Nm (2.2 lbf.in) and a nominal cross section of 1.5 mm$^2$ (AWG 14) for cable.

### Terminal layout of the CU240S variants

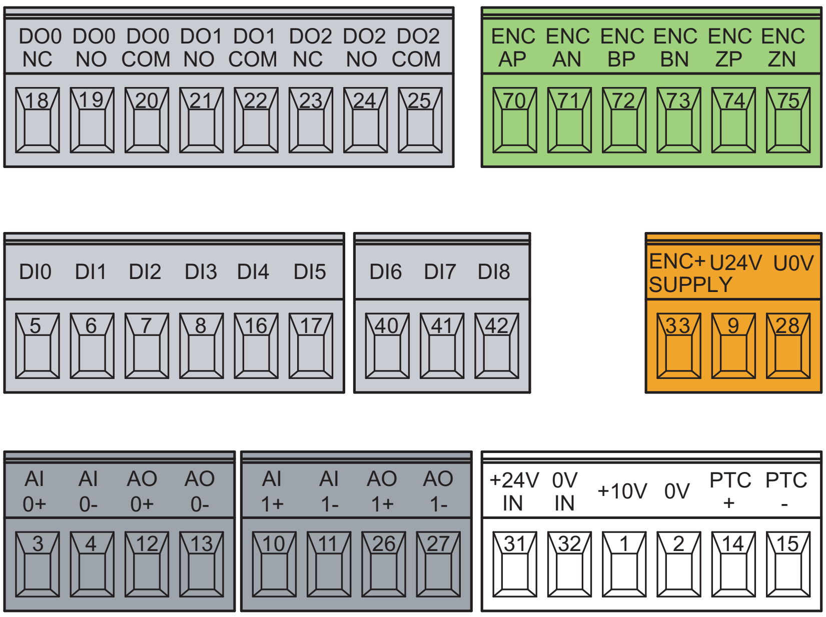



Figure 3-5 CU240S, CU240SDP Control Terminals

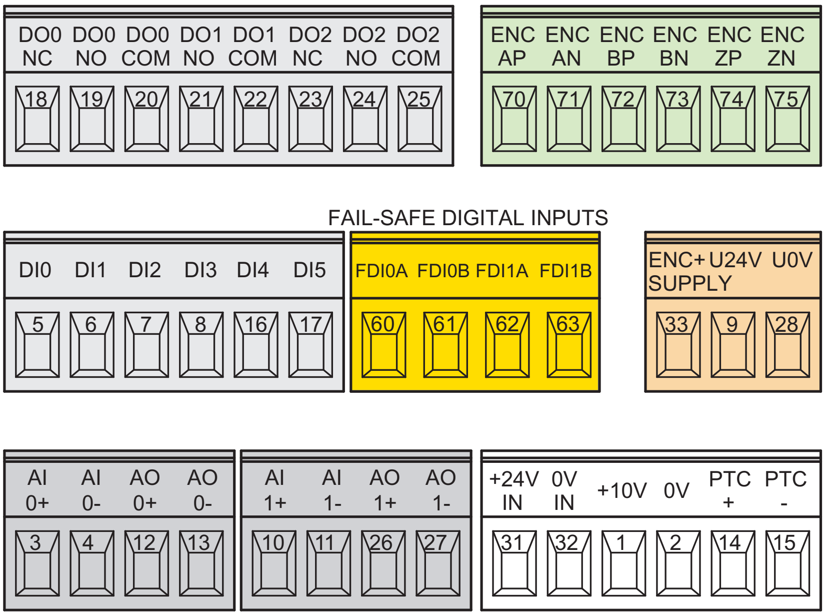



Figure 3-6 CU240S DP-F Control Terminals

## General I/O Dip switches (CU240S, CU240S DP and CU240S DP-F)

There are seven general I/O Dip switches that allow the settings described below.

In the factory setting the I/O Dip switches are in the OFF position.

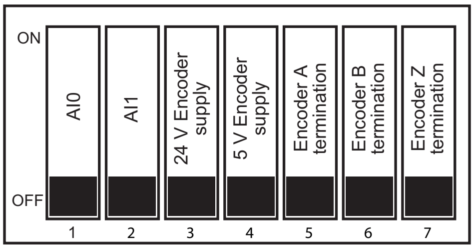



Figure 3-7 General I/O DIP switches

Table 3-5 Settings of the General I/O DIP switches

| DIP switch | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Meaning | AI0 | AI1 | 24 V Encoder supply | 5 V Encoder supply | Encoder A termi-nation | Encoder B termi-nation | Encoder Z termi-nation |
| ON ■ | 0 mA ... 20 mA | 0 mA ... 20 mA | 24 V | 5 V | Encoder A ON | Encoder B ON | Encoder Z ON |
| OFF ■ | -10 V ... +10 V | 0 V ... 10 V | 0 V | 0 V | Encoder A OFF | Encoder B OFF | Encoder Z OFF |

## PROFIBUS DP Dip switches (CU240S DP and CU240S DP-F)

The PROFIBUS-DP address can be set via seven DIP switches or via parameter "P0918". If an address is set via DIP switches, the value of p0918 will be ignored. The PROFIBUS-DP address can be set between 1 and 125.

In the factory setting the PROFIBUS-DP address DIP switches are in the OFF position.

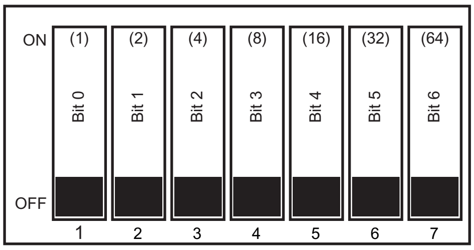



Figure 3-8 Profibus DIP switches

Table 3-6 Example address for the PROFIBUS-DP interface

| DIP switch | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Add to address | 1 | 2 | 4 | 8 | 16 | 32 | 64 |
| Example 1: Address = 3 = 1 + 2 | ▀ | ▀ | ▄ | ▄ | ▄ | ▄ | ▄ |
| Example 2: Address = 88 = 8 + 16 + 64 | ▄ | ▄ | ▄ | ▀ | ▀ | ▄ | ▀ |

## Status display via LED

The SINAMICS G120 inverters provide multiple functions and operating states which are indicated via LED.

### LED for standard CUs

The status for standard inverters is displayed via the following LED:

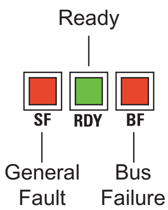



Figure 3-9 Status LED for standard inverters

## LED for CUs with fail-safe functions

For inverters with fail-safe functions the following additional LED are available:

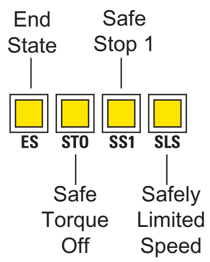



Figure 3-10 LED for CUs with fail-safe functions

For detailed description refer to "LED overview" in section "Service and maintenance".

## Power module interface

All necessary control signals for the correct operation of the inverter-system are transferred between the CU and PM utilizing the Power module interface (PM-IF).

## SUB-D connector

Via the SUB-D connector - depending on the type of Control Unit - the following interfaces are available:

| | | |
|---|---|---|
| • USS on RS485 | CU240S | For connecting e.g. USS master or STARTER |
| • PROFIBUS DP | CU240S DP | For connecting e.g. SIMATIC S7 and STARTER as class 2 master |
| • PROFIBUS DP | CU240S DP-F | For connecting e.g. SIMATIC S7 and STARTER as class 2 master |

## 3.6 Factory settings of the CU240S control units

### Factory Settings

P0700 = 0 is the same as P0700 = 2 or 6 dependend on type of Control Unit.

Table 3-7 Function Selection of Digital Input and Digital Output

| Parameter | P0700 = 2 | P0700 = 6 |
|---|---|---|
| P0701 | 1 | 0 |
| P0702 | 12 | 0 |
| P0703 | 9 | 9 |
| P0704 | 15 | 15 |
| P0705 | 16 | 16 |
| P0706 | 17 | 17 |
| P0707 | 18 | 18 |
| P0708 | 0 | 0 |
| P0709 | 0 | 0 |
| P0731 | 52.3 | 52.3 |
| P0732 | 52.7 | 52.7 |
| P0733 | 0.0 | 0.0 |

Table 3-8 BICO Command Parameter

| Parameter | P0700 = 2 | P0700 = 6 |
|---|---|---|
| P0840 | 722.0 | 2090.0 |
| P0842 | 0.0 | 0.0 |
| P0844 | 1.0 | 2090.1 |
| P0845 | 19.1 | 19.1 |
| P0848 | 1.0 | 2090.2 |
| P0849 | 1.0 | 1.0 |
| P0852 | 1.0 | 2090.3 |

Table 3-9 Command Sources for Fixed Frequencies

| Parameter | P0700 = 2 | P0700 = 6 |
|---|---|---|
| P1020 | 722.3 | 722.3 |
| P1021 | 722.4 | 722.4 |
| P1022 | 722.5 | 722.5 |
| P1023 | 722.6 | 722.6 (0.0 for CU240S DP-F) |

Table 3-10 Faults, Alarms, Monitoring

| Parameter | P0700 = 2 | P0700 = 6 |
|---|---|---|
| P2103 | 722.2 | 722.2 |
| P2104 | 0.0 | 2090.7 |
| P2106 | 1.0 | 1.0 |

## Factory Settings for Setpoint Source

| Source | CU240S | CU240S DP, CU240S DP-F |
|---|---|---|
| | P1000 = 2 | P1000 = 6 |
| Frequency setpoint | Analog setpoint (P0754 [%]) | Fieldbus (P2050.1 [Hex]) |

# Installing/Mounting

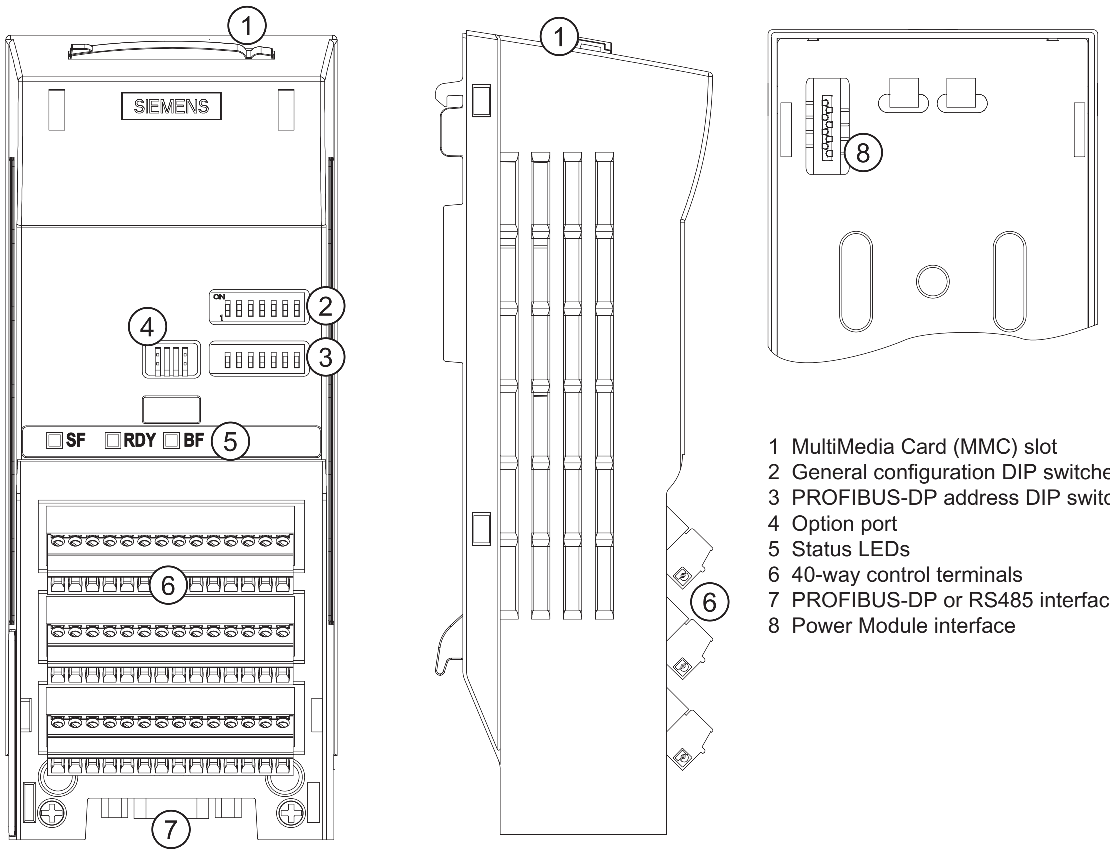
# 4

## Installing the Control Unit

The Control Unit allows the user to access the full functionality of the inverter.

**Warning**

An inverter can be switched on unintentionally if the installation is not performed correctly. The inverter must be started-up by personnel who are qualified and trained in installing systems of this type.




1 MultiMedia Card (MMC) slot
2 General configuration DIP switches
3 PROFIBUS-DP address DIP switches
4 Option port
5 Status LEDs
6 40-way control terminals
7 PROFIBUS-DP or RS485 interface
8 Power Module interface

Figure 4-1 General layout of a CU240 Control Unit

# 4.1 Fitting the CU to the PM

## Fitting the Control Unit to the Power Module

The Control Unit is fitted to the Power Module as shown in the figure below. To disconnect the CU push the release button on top of the PM.

The process of fitting the Control Unit to the Power Module is the same technique no matter which Control Unit or Power Module combination is required.

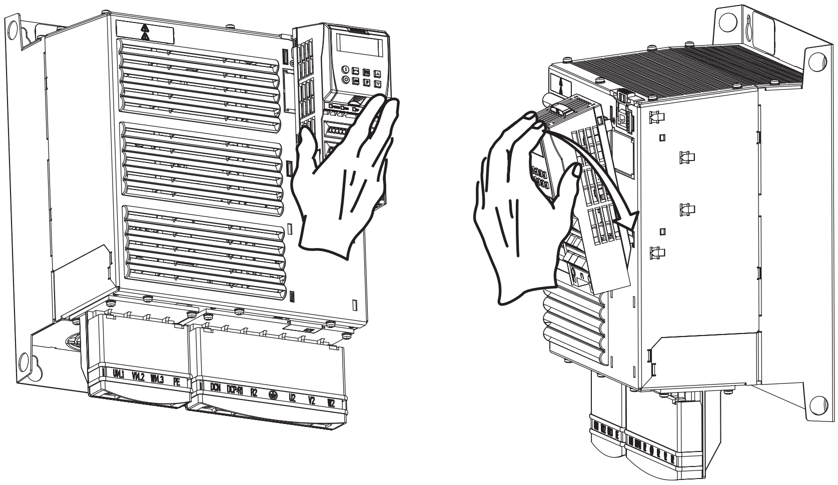


Figure 4-2 Fitting the Control Unit to the Power Module

**Caution**

Before snap-on the Control Unit to the Power Module while hot swap connect 24 V supply to the terminals.

# 4.2 Connecting the Control Unit via terminals

## Common information to the control terminals

To have access to the control terminals, the terminal cover must be removed, as shown in the figure below. The control terminals have a maximum tighting torque of 0.25 Nm (2.2 lbf.in) and a nominal cable cross section of 1.5 mm².

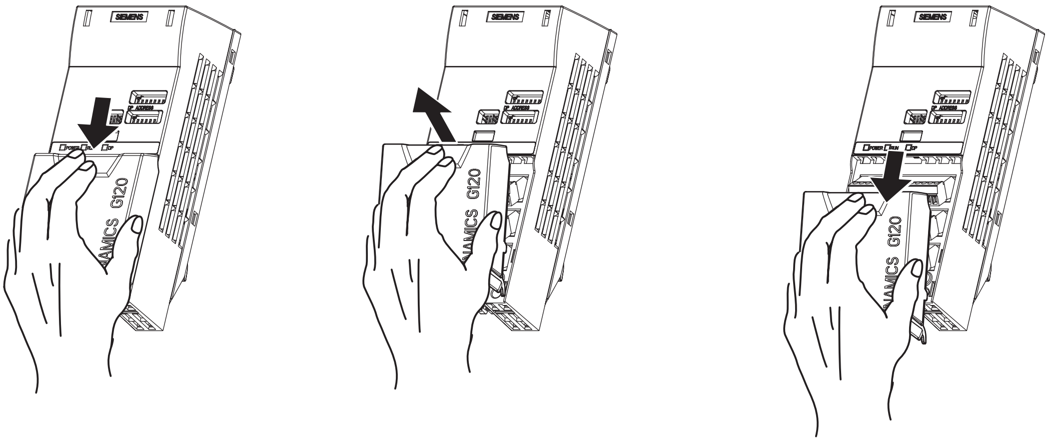


Figure 4-3 Removing the Control Unit terminal cover

The terminals of all variants of CU240 control units, once they have been wired, can be individually detached from the control terminal board housing, as shown in the figure below. This allows the control units to be swapped out for another of the same type without the need for rewiring.

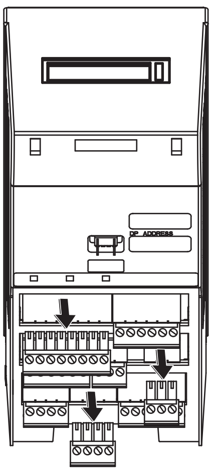


Figure 4-4 Removing the two-part connectors with a CU240S DP as example

After all the wiring of the control unit is completed - ensure that the terminal cover is replaced.

## 4.2.1 Setting-up the Control Unit via terminals

### Terminal wiring examples for the Control Unit CU240S, not for CU240S DP and CU240S DP-F

In this section examples of controlling a SINAMICS G120 inverter with a CU240S via terminals are shown.

- Basic control with the default settings
- Frequency setpoint and an additional setpoint via terminals (AI0 and AI1 used as voltage inputs)
- Frequency setpoint and an additional setpoint via terminals (AI0 and AI1 used as current inputs).

---

**Note**

To control the CU240S DP or CU240S DP-F via terminals is also possible, but in this case the parameter settings for command and setpoint source have to be changed.

---

### Basic control with the default settings

When shipped from the factory and fitted to the power module, a factory reset must be performed to read the power stack data into the control unit, before operating the inverter with the basic settings.

To operate the inverter with the basic settings, (without additional parameterization or DIP switch setting) the following conditions have to be fullfilled:

- The rated current of the inverter is at least as great as the rated current of the motor.
- The power range of the inverter matches the power range of the motor.
- The controlled motor is a 4-pole motor (best Siemens 1LA7).
- The default motor frequency for the inverter is 50 Hz and the units of measure is kW.

### Control settings

- Run and Stop Command
  The run and stop commands can be given using digital input 0 on terminal 5.
- Frequency Setpoint
  The required frequency can be achieved connecting a potentiometer to the analog inputs on terminals 3 and 4.
- Reverse
  A change of direction can be accomplished using digital input 1 on terminal 6.
- Fault Acknowledge (Ack)
  A fault on the inverter can be acknowledged using digital input 2 on terminal 7. This allows the fault signal to be reset.

- Output Frequency
  The actual output frequency can be displayed using the analog outputs on terminals 12 and 13.
- Fault
  Using relay 1 (RL1) on terminals 19 and 20 a fault condition can be indicated. For example using a lamp which will light-up to indicate a fault condition has occurred.
- Warning
  Using relay 2 (RL2) on terminals 21 and 22 a warning condition can be indicated. For example using a lamp which will light-up to indicate a warning condition has occurred.

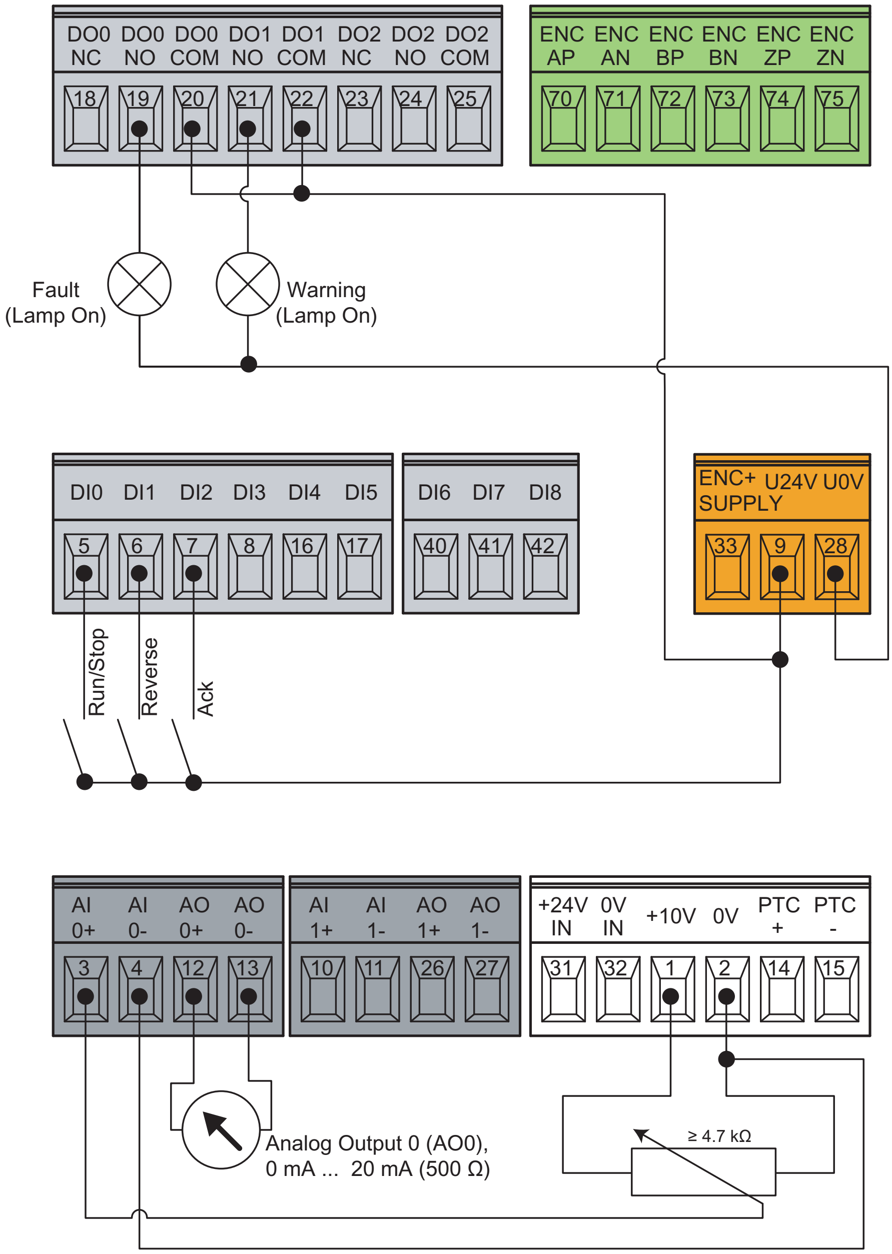



Figure 4-5 Default control wiring

## Frequency setpoint and an additional setpoint via terminals

### AI0 and AI1 used as voltage inputs

This type of control wiring allows a main frequency setpoint and an additional setpoint to be established, using potentiometers on analog inputs AI0 and AI1.

The figure below shows the wiring that is necessary to accomplish this functionality.

### DIP switch Settings

The general I/O DIP switch is used to configure the analog inputs (AI). Use DIP switches 1 and 2 to set the switches to the OFF position. For detailed information refer to "Analog input" in section "Function".

### Parameter Settings

No additional parameters require to be modified.

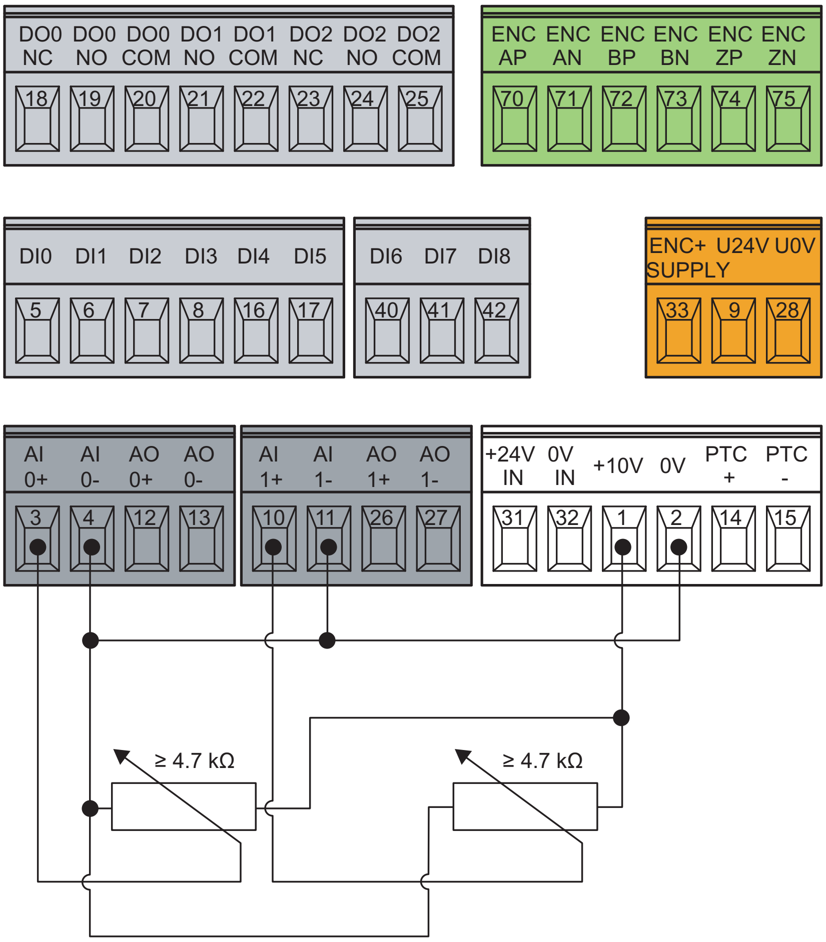



Figure 4-6 Terminal connection and DIP switch setting for using AI0 and AI1 as main and additional setpoint

## Frequency setpoint and an additional setpoint via terminals

### AI0 and AI1 used as current inputs

This type of control wiring allows a main frequency setpoint and an additional setpoint to be established, for example from a PLC.

The figure below shows the wiring that is necessary to accomplish this functionality.

### DIP switch Settings

The general I/O DIP switch is used to configure the analog inputs (AI). Use DIP switches 1 and 2 to set the switches to the ON position. For detailed information refer to "Analog input" in section "Function".

### Parameter Settings

The following parameter need to be changed to the values given below. These changes must only be made after the Quick Commissioning procedure has been completed.

### To use 0 mA … 20 mA

- P0003 = 3 Sets the access level to Expert.
- P1000[0] = 22 Setpoint now expected from the analog inputs.
- P0756[0] = 2 Sets analog input 0 (AI0) to current input.
- P0756[1] = 2 Sets analog input 1 (AI1) to current input.

### To use 4 mA … 20 mA

The following additional parameters need to be modified:

- P0757[0] = 4 Sets analog input 0 (AI0) to a minimum of 4 mA.
- P0761[0] = 4 Sets the deadband width of analog input 0 (AI0).
- P0757[1] = 4 Sets analog input 1 (AI1) to a minimum of 4 mA.
- P0761[1] = 4 Sets the deadband width of analog input 1 (AI1).

---

**Note**

Index [0] is analog input 0, Index [1] is analog input 1, if you are only using one analog input then you only need to change those indices for the specific analog input.

---

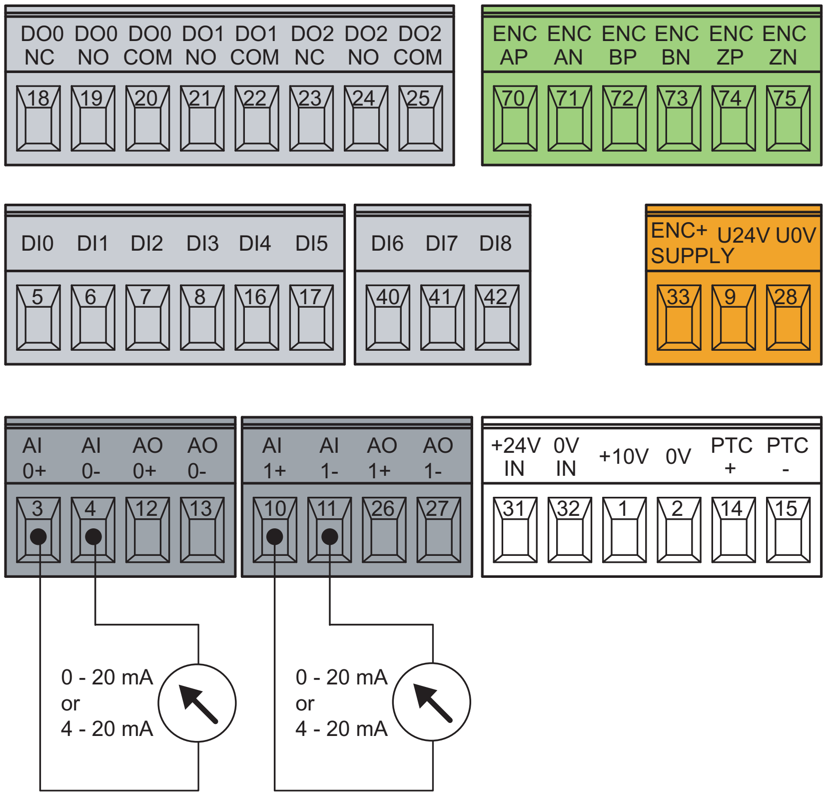



Figure 4-7 Current input control wiring

## 4.3 Connecting a CU240S DP or CU240S DP-F via PROFIBUS DP

#### PROFIBUS DP Interface

The function of the PROFIBUS DP interface is to provide a PROFIBUS DP-based link between inverters of the SINAMICS G120 product range and higher-level automation systems e.g. SIMATIC S7.

#### Configuration with SIMATIC S7

The layout of the PROFIBUS DP interface and the DIP switches for setting the PROFIBUS DP address are shown in the Commissioning section.

### 4.3.1 Setting the PROFIBUS DP address via DIP Switches

#### Setting the PROFIBUS DP address

Prior to using the PROFIBUS DP interface, the address of the node (inverter) must be set.

There are two methods for setting the PROFIBUS DP address:

- Using the seven PROFIBUS DP address DIP switches on the Control Unit
- Using parameter "P0918".

The PROFIBUS DP address can be set between 1 and 125.

---

Note

The address is taken from P0918 if all PROFIBUS DP address DIP switches are in the OFF position, otherwise the DIP switch setting is valid.

---

Caution

The power supply must be switched off before the DIP switch settings are changed. DIP switch setting changes do not take effect until the Control Unit has been powered-up again. The restart must be initiated by switching the power off and on again irrespective of whether the Control Unit is supplied with the inverter line supply or its own, separate 24 V connection.

---

### Setting the PROFIBUS DP address via DIP switches

The PROFIBUS DP address can be set via DIP switch, as shown in the table below.

Table 4-1 Example address for the PROFIBUS DP interface

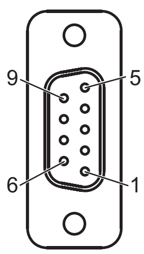
| DIP switch | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Add to address | 1 | 2 | 4 | 8 | 16 | 32 | 64 |
| Example 1: Address = 3 = 1 + 2 | | | | | | | |
| Example 2: Address = 88 = 8 + 16 + 64 | | | | | | | |

## 4.3.2 Connecting the PROFIBUS DP

### Connecting the Inverter to the PROFIBUS DP network

The inverter is connected to the PROFIBUS DP network via a sub-D socket on the CU240S DP or CU240S DP-F. The pins of the socket are short-circuit-proof and isolated.

Table 4-2 PIN assignment of the 9-pin sub-D socket

| | Pin | Designation | Meaning | Range |
|---|---|---|---|---|
|   | 1 | Shield | Ground connection | |
| | 2 | U0V | Isolated and user supply reference | |
| | 3 | RxD/TxD-P | Receive/send data P (B/B') | RS485 |
| | 4 | CNTR-P | Control Signal | TTL |
| | 5 | DGND | PROFIBUS data reference potential (C/C') | |
| | 6 | VP | Supply voltage positive | 5 V ± 10 % |
| | 7 | U24V | Isolated user supply +24 V @ 100 mA | |
| | 8 | RxD/TxD-N | Receive/send data N (A/A') | RS485 |
| | 9 | - | Not assigned | |
| | Case | Cable shield | Cable shield | |

### External 24 V supply

If the PROFIBUS DP interface is required to communicate with the Control Unit when the Power Module mains power is not present, a 24 V supply must be connected to the Control Unit terminals 31 (+ 24 V $I_n$) and 32 (0 V $I_n$).

## Maximum cable lengths

The PROFIBUS system can handle up to 126 stations. To run all these stations the PROFIBUS system is divided into segments. All segments have to be connected via repeater. The maximum number of stations on any segment must not exceed 32.

The maximum cable lengths are dependent on the baud rate (transmission speed). The maximum cable lengths specified in the table below can be guaranteed only with PROFIBUS bus cables (for example, Siemens PROFIBUS bus cable, order number 6XV1830-0EH10).

Table 4-3 Permissible cable length for one segment

| Baud rate | Max. cable lengths for one segment |
|---|---|
| 9.6 kbaud … 187.5 kbaud | 1000 m (3280 ft)* |
| 500 kbaud | 400 m (1312 ft)* |
| 1.5 Mbaud | 200 m (656 ft)* |
| 3 Mbaud … 12 Mbaud | 100 m (328 ft)* |
| * Repeaters can be installed to increase the length of a segment. | |

## Cable installation rules

During installation the bus cable must not be:

- twisted
- stretched or
- compressed.

Supplementary constraints as regards electromagnetic compatibility must also be observed.

## Bus connector

To connect the PROFIBUS cable to the PROFIBUS DP interface, a bus connector of one of the types described in the following table is recommended.

Table 4-4 Recommended PROFIBUS connectors

| Order Number | 6GK1 500-0FC00 | 6GK1 500-0EA02 |
|---|---|---|
| |  |  |
| PG socket | No | No |
| Max. baud rate | 12 Mbaud | 12 Mbaud |
| Terminating resistor | On/Off switch | On/Off switch |
| Outgoing cable unit | 180° | 180° |
| Interfaces<br>PROFIBUS nodes<br>PROFIBUS bus cable | <br>9-pin sub D socket<br>4 modular terminals for wires up to 1.5 mm² | <br>9-pin sub D socket<br>4 modular terminals for wires up to 1.5 mm² |
| Connectable PROFIBUS cable diameter | 8 ± 0.5 mm | 8 ± 0.5 mm |

---

**Note**

We recommend only these two connectors since they can be used without difficulty for all SINAMICS G120 models and are completely compatible in terms of outgoing cable unit angle.

---

## Bus terminator

Each bus segment must have a resistor network, i.e. a bus terminator, at both ends.

Where the recommended bus connectors have been used, the bus terminator can be switched in and out by means of switches as shown in the figure below.

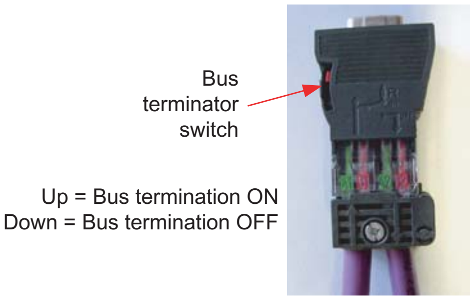



Figure 4-8 PROFIBUS DP bus termination switch

Using the recommended bus connectors the first and last node on the PROFIBUS network must be terminated (as shown in the figure below), this switching of the bus terminator provides both the 220 Ω termination and the 390 Ω biasing. The 390 Ω biasing maintains the potential difference between the signals in the PROFIBUS network cables.

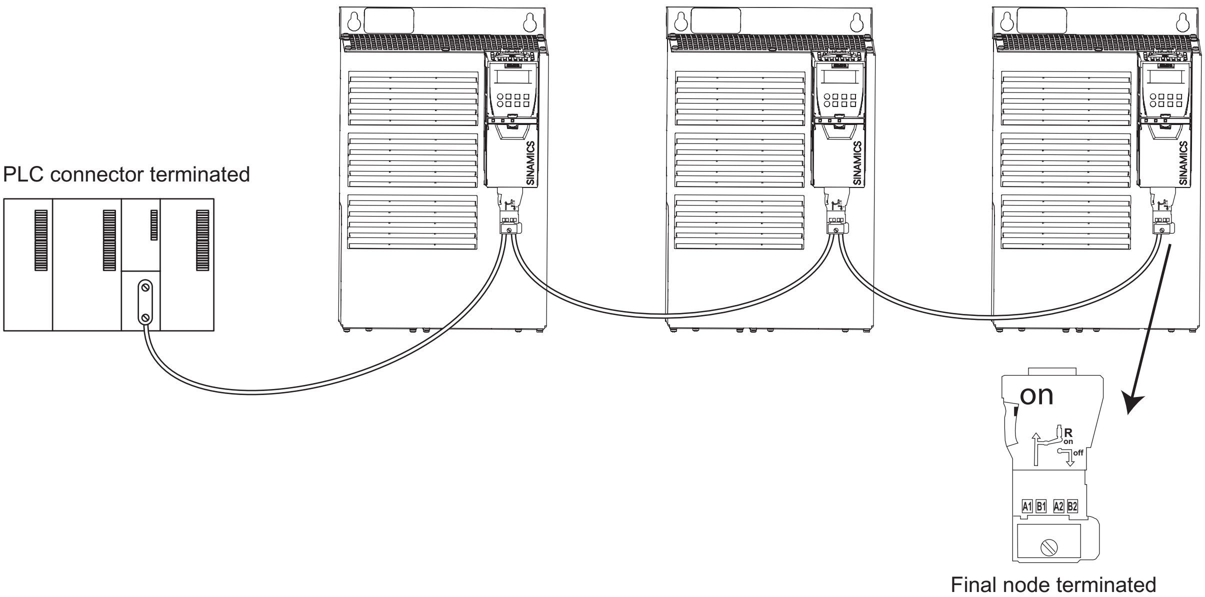



Figure 4-9 Bus termination and network biasing

### Warning

It must be ensured that any node where the biasing network for the bus is fitted is powered at all times that the bus is in operation.

### Removing a bus connector

You can remove the bus connector with looped-through bus cable from the PROFIBUS DP interface at any time without interrupting the data exchange on the bus. Only the final node must be terminated.

## 4.3.3 Screening the bus cable and EMC precautions

### Screening the bus cable and EMC precautions

The following EMC-related precautions must be taken to ensure interference-free PROFIBUS DP operation.

### Screening

The screen of the PROFIBUS DP cable must be connected in the bus connector. Additional screening is provided using a screen clamp on the bus cable screen which must make 360° contact with the protective earth. The solid copper core must not be scored when the insulation is removed from the core ends. You must also ensure that the screen of each bus cable is connected to protective earth at both the cabinet entry point and in the inverter housing.

---

**Note**

The bus cables must be internally twisted and screened, and installed separately from power cables with a minimum distance 20 cm (7.8 inches). The braided screen and underlying laminated foil screen (if applicable) must be connected in a 360°, positive connection at both ends, that is, the screen on the bus cable between two inverters must be connected to the inverter housing at both ends. The same applies to the screen of the bus cable between the PROFIBUS DP master and inverter.

Crossovers between bus and power cables must be laid at an angle of 90°.

---

### Equipotential bonding

Differences in potential (for example, due to different mains supplies) between the inverters and the PROFIBUS DP master must be avoided.

- Recommended equipotential bonding cables:
  - 16 mm² Cu for equipotential bonding cables up to 200 m long
  - 25 mm² Cu for equipotential bonding cables of over 200 m long.
- Equipotential bonding cables must be routed as close as possible to signal leads; this means that the area between the bonding conductor and signal lead is as small as possible.
- Equipotential bonding cables must be contacted in a 360° connection with the earth electrode/PE conductor.

## 4.4 Installing the Encoder Interface

### Preparation

- The Encoder unit has been fitted to the motor as described by the Installation Instructions supplied with the Encoder unit.
- The SINAMICS G120 inverter has been powered-down.

### Screening

To ensure the correct functioning of the encoder the guidelines listed below should be followed:

- Only twisted-pair screened cable should be used to connect the encoder to the Encoder Interface.
- If the encoder cable has a screen/earth/ground conductor, this should be terminated to the backplane of the inverter or the cabinet housing.
- Signals cables must not be installed close to power cables.

### Connections

The terminal descriptions and functions are shown in the table below.

Table 4-5 Encoder interface terminals

| Terminal | | Function |
|---|---|---|
| 70 | ENC AP | Channel A non-inverting input |
| 71 | ENC AN | Channel A inverting input |
| 72 | ENC BP | Channel B non-inverting input |
| 73 | ENC BN | Channel B inverting input |
| 74 | ENC ZP | Channel 0 (zero) non-inverting input |
| 75 | ENC ZN | Channel 0 (zero) inverting input |
| 33 | ENC+ Supply | 5 V or 24 V power supply for encoder, configured by DIP switch |
| 28 | U0V | Isolated encoder supply reference |

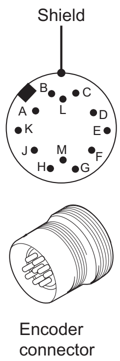
### Typical encoder wiring

The figure below shows a typical pulse encoder cable and how the encoder connections relate to the encoder terminals.

**Note**

Optimum signal clarity is achieved when differential wiring is used between the encoder and encoder module. This is especially useful when situated in a noisy environment or with long cables - however, the module will function correctly both with single ended or differential wiring and as such can tolerate a wire break when differential wiring is used. If the module loses the complete signal on either A or B lines, the inverter will trip with F0090.

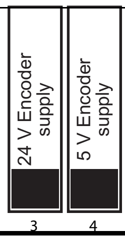
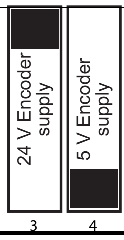
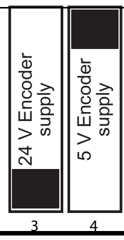
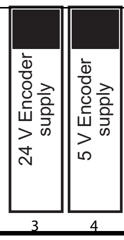
Table 4-6 Typical Encoder connections

| Encoder pin assignment | 1xP8001 Encoder designations | Enocder terminals | Rotary Pulse Encoder<br>1XP8001-1/Up = 10 V … 30 V (HTL)<br>1XP8001-2/Up = 5 V ± 5 % (TTL) |
|---|---|---|---|
| A | $U_{a2}$ | BN |   |
| B | $U_p$ | + 24 V or + 5 V | |
| C | $U_{a0}$ | Z | |
| D | $U_{a0}$ | ZN | |
| E | $U_{a1}$ | A | |
| F | $U_{a1}$ | AN | |
| G | $U_{as}$ | - | |
| H | $U_{a2}$ | B | |
| K | 0 V | 0 V | |
| L | 0 V | - | |
| M | $U_p$ | - | |

The encoder voltage is using the general I/O DIP switches 3 and 4.

The following table shows the possible settings:

Table 4-7 Encoder voltage settings

| On<br>OFF |   |   |   |   |
|---|---|---|---|---|
| Encoder supply voltage | 0 V | 24 V | 5 V | 24 V |
| Encoder type | No encoder | HTL encoder | TTL encoder | HTL encoder |

**Warning**

DIP switches 3 and 4 in ON position provide a supply voltage of 24 V to the encoder. Therefore it is not allowed to connect a TTL encoder to the inverter if both DIP switches, 3 and 4 are in ON position.

# Commissioning (software) 5

## 5.1 General commissioning information

### General commissioning information

The inverter can be adapted to various applications by changing the parameter values.

The parameter values can be changed, using one of the following optional components:

- The OP (Operator Panel), plugged into the Option port of the Control Unit
- The STARTER (Commissioning software via PC) can be connected to the Option port using a PC connection Kit
- The MMC for downloading complete parameter sets

This section shows how the commissioning of a G120 Inverter is performed using an OP. The commissioning process using STARTER is driven by dialog boxes and will not be described in this manual.

The inverter is delivered with identical factory settings for all CU240S control unit; except the settings of command and setpoint source and values depending on the power module.

---

**Note**

**Upload and download**

- Upload means to save the parameters from the EEPROM of an inverter to a PC (via STARTER), MMC or an OP.
- Download means to write a parameter set held on a PC, MMC or an OP to the RAM or EEPROM of an inverter.

---

# 5.2 Parameters

## Overview of parameters

The inverter is adapted to a particular application using the appropriate parameters. This means that each parameter is identified by a parameter number and specific attributes (e.g. readable, can be written into, BICO attribute, group attribute etc.). Within any one particular inverter system, the parameter number is unique. On the other hand, an attribute can be assigned a number of times so that several parameters can have the same attribute.

Parameters can be accessed using the following operator units:

- OP
- PC-based commissioning (start-up) tool "STARTER".

There are two main types of parameters; those that can be altered and those that are read-only.

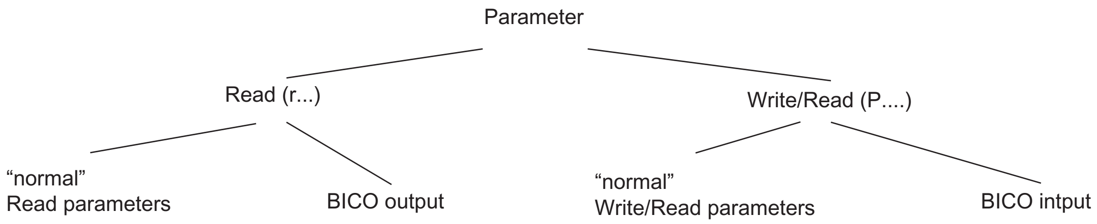



Figure 5-1 Parameter types

## 5.2.1 Write parameters

### Description

Parameters which can be written into and displayed are indicated by the prefix "P".

These parameters directly influence the behaviour of a function. The value of this parameter is saved in non-volatile memory (EEPROM) as long as the appropriate option was selected (non-volatile data save). Otherwise, these values are saved in the volatile memory (RAM) of the processor, which are lost after power failure or power-off/power-on operations.

Examples of the standard notation used throughout our manuals is given below.

**Notation examples:**

| | |
|---|---|
| P0970 | parameter 970 |
| P0748.1 | parameter 748, bit 01 |
| P0819[1] | parameter 819 index 1 |
| P0013[0 ... 19] | parameter 13 with 20 indices (indices 0 to 19) |

## 5.2.2 Monitoring parameters

### Description

Parameters which can only be monitored are indicated by the prefix "r".

These parameters are used to display internal quantities, for example states and actual values.

**Notation examples:**

| | |
|---|---|
| r0002 | monitoring parameter 2 |
| r0052.3 | monitoring parameter 52, bit 03 |
| r0947[2] | monitoring parameter 947 index 2 |
| r0964[0 ... 4] | monitoring parameter 964 with 5 indices (indices 0 to 4) |

## 5.2.3 Parameter Attributes

### Overview

In the Parameter List, the header line of each parameter shows all the attributes and groups for that specific parameter. The figure below shows the details for parameter P0700 and r1515.

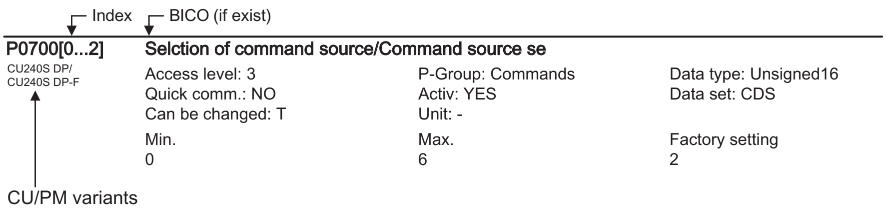



Figure 5-2 Description of attributes for parameter P0700

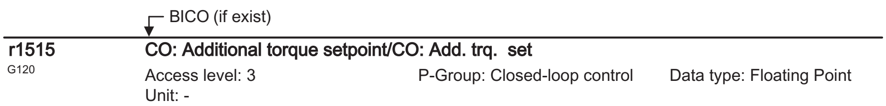



Figure 5-3 Description of attributes for parameter r1515

## Index

Using the index, a parameter (e.g. p0013[20]) is defined with several consecutive elements (in this case, 20). Each individual index is defined using a numerical value.

When transferred to a parameter this means that an indexed parameter can have several values. The values are addressed using the parameter number including the index value (e.g. p0013[0], p0013[1], p0013[2], p0013[3], p0013[4], ...).

Indexed parameters are used, for example:

- Drive Data Sets (DDS)
- Command Data Sets (CDS)
- Sub functions.

## BICO

The following types of connectable parameters are available. A description of BICO technology is given in the functions chapter.

Table 5-1 Parameter attributes - BICO

| BICO | Description |
|---|---|
| BI | Binector Input |
| BO | Binector Output |
| CI | Connector Input |
| CO | Connector Output |
| CO/BO | Connector Output/Binector Output |

## Access level

The access level is controlled using parameter P0003. In this case, only those parameters are visible at the OP, where the access level is less than or equal to the value assigned in parameter P0003. On the other hand, for STARTER, only access levels 0 and 3 are relevant. For example, parameters with access level 3 cannot be changed if the appropriate access level has not been set.

The following access levels are implemented in the SINAMICS G120 inverter units:

Table 5-2 Parameter attributes - access level

| Access level | Description |
|---|---|
| 0 | User-defined parameter list (refer to P0013) |
| 1 | Standard access to the most frequently used parameters |
| 2 | Extended access, e.g. to inverter I/O functions |
| 3 | Expert access only for experienced users |
| 4 | Service access only for authorized service personnel – with password protection. |

**Note**

In STARTER, all of the user parameters (access stage 3) are always displayed using the expert list – for the setting p0003 = 0, 1, 2 or 3.

When changing parameters using STARTER, or via a high-level control system, parameter value changes always become immediately effective.

## Change state

"P" parameters can only be changed depending on the inverter state. The parameter value is not accepted if the instantaneous state is not listed in the parameter attribute "Change state". For instance, the quick commissioning parameter P0010 with the attribute "CT" can only be changed in quick commissioning "C" or ready "T" but not in operation "U".

Table 5-3 Parameter attributes - Change state

| State | Description |
|---|---|
| C | Quick commissioning |
| U | Operation (Drive running) |
| T | Drive ready to run |

## Data types

The data type of a parameter defines the maximum possible value range. Five data types are used for SINAMICS G120. They either represent an unsigned integer value (U16, U32) or a floating-point value (float). The value range is frequently restricted by a minimum and maximum value (min, max) or using inverter/motor quantities.

Table 5-4 Parameter attributes - Data types

| Data type | Description |
|---|---|
| U16 | Unsigned, integer value with a size of 16 bits |
| U32 | Unsigned, integer value with a size of 32 bits |
| I16 | Signed integer 16-bit value |
| I32 | Signed integer 32-bit value |
| Float | A simple precise floating point value according to the IEEE standard format<br>max. value range: -3.39e+38 –+3.39e+38 |

## Unit

For SINAMICS G120, the units of a particular parameter involve the physical quantity (e.g. m, s, A). Quantities are measurable properties/characteristics of physical objects, operations, states and are represented using characters of a formula (e.g. V = 9 V).

Table 5-5 Parameter attributes - Unit

| Unit | Description |
|---|---|
| - | No dimension |
| % | Percentage |
| A | Ampere |
| V | Volt |
| Ohm | Ohm |
| us | Microseconds |
| ms | Milliseconds |
| s | Seconds |
| Hz | Hertz |
| kHz | Kilohertz |
| 1/min | Revolutions per minute [RPM] |
| m/s | Meters per second |
| Nm | Newton meter |
| W | Watt |
| kW | Kilowatt |
| Hp | Horse power |
| kWh | Kilowatt hours |
| °C | Degrees Celsius |
| m | Meter |
| kg | Kilograms |
| ° | Degrees (angular degrees) |

## Grouping

The parameters are sub-divided into groups according to their functionality. This increases the transparency and allows a quicker and more efficient search for specific parameters. Furthermore, parameter P0004 can be used to control the specific group of parameters that are displayed on the OP.

Table 5-6 Parameter attributes - Grouping

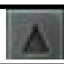
| Grouping | Description | | Main parameter area: |
|---|---|---|---|
| ALWAYS | 0 | all parameters | |
| INVERTER | 2 | inverter parameters | 0200 … 0299 |
| MOTOR | 3 | motor parameters | 0300 … 0399 and 0600 … 0699 |
| ENCODER | 4 | speed encoder | 0400 … 0499 |
| TECH_APL | 5 | technical applications/units | 0500 … 0599 |
| COMMANDS | 7 | control commands, digital I/O | 0700 … 0749 and 0800 … 0899 |
| TERMINAL | 8 | Analog inputs/outputs | 0750 … 0799 |
| SETPOINT | 10 | Setpoint channel and ramp-function gen. | 1000 … 1199 |
| Safety functions | | Fail-safe | 9000 … 9999 |
| FUNC | 12 | Inverter functions | 1200 … 1299 |
| CONTROL | 13 | Motor open-loop/closed-loop control | 1300 … 1799 |
| COMM | 20 | Communications | 2000 … 2099 |
| ALARMS | 21 | Faults, warnings, monitoring functions | 2100 … 2199 |
| TECH | 22 | Technology controller (PID controller) | 2200 … 2399 |

## Active

This attribute is only of importance in conjunction with an OP. The "Yes" attribute indicates that this value is already accepted when scrolling (when changing the value with  or ). Especially parameters which are used for optimization functions have this property (e.g. constant voltage boost P1310 or filter time constants). On the other hand, for parameters with the attribute "First confirm", the value is only accepted after first pressing the key

. These include, for example, parameters where the parameter value can have different settings/meanings (e.g. selecting the frequency setpoint source P1000).

Table 5-7 Parameter attributes - Active

| Active | Description |
|---|---|
| Yes | The value becomes valid by either scrolling with  or  |
| First confirm | The value is only accepted by pressing  |

---

**Note**

Parameter values that are changed using STARTER or a higher-level control do not have to be acknowledged.

---

## Quick commissioning

This parameter attribute identifies as to whether the parameter is included in the quick commissioning (QC) (P0010 = 1).

Table 5-8 Parameter attributes - Quick commissioning

| QC | Description |
|---|---|
| No | The parameter is not included in the quick commissioning |
| Yes | The parameter is included in the quick commissioning |

## Value range

The value range, which is specified as a result of the data type, is restricted by the minimum and maximum values (min, max) and using the inverter/motor quantities. Straightforward commissioning is guaranteed in so much that the parameters have a default value. These values (min, max, def) are permanently saved in the inverter and cannot be changed by the user.

Table 5-9 Parameter attributes - Value range

| Value range | Description |
|---|---|
| - | No value entered (e.g.: "r parameter") |
| Min | Minimum value |
| Max | Maximum value |
| Def | Default value |

## Data sets

A detailed description for the data sets is given in the respective section

Table 5-10 Data sets

| BICO | Description |
|---|---|
| CDS | Command data set |
| DDS | Drive data set |

## 5.3 Factory settings

### Factory default settings

The inverter system is shipped from the factory as a Control Unit and a Power Module. The Control Unit has three or seven LEDs (depending on the type of Control Unit) on the front panel which display the operating state of the inverter. For commissioning and operation the control unit has to be fitted to the power module as shown in section 4.

After a factory reset, the inverter can be operated without additional parameterization if the inverter default settings (which depend on the inverter type and size) match the following data of a 4-pole motor:

| | |
|---|---|
| Default line supply frequency | 50 Hz |
| Rated motor voltage | P0304 |
| Rated motor current | P0305 |
| Rated motor power | P0307 |
| Rated motor frequency | P0310 |
| Rated motor speed | P0311 |
| (A Siemens standard motor is recommended.) | |
| Further, the following conditions must be fulfilled: | |
| Control (ON/OFF command) using digital inputs (CU240S) | See pre-assigned inputs below. |
| Asyncronous motor | P0300 = 1 |
| Self-cooled motor | P0335 = 0 |
| Motor overload factor | P0640 = 150 % |
| Setpoint input using analog input 1 | P1000 = 2 |
| Min. frequency | P1080 = 0 Hz |
| Max. frequency | P1082 = 50 Hz |
| Ramp-up time | P1120 = 10 s |
| Ramp-down time | P1121 = 10 s |
| Linear V/f characteristic | P1300 = 0 |

Table 5-11 Pre-assignment of the digital inputs for a CU240S *)

| Digital Inputs | Terminals | Parameter | Function | Active |
|---|---|---|---|---|
| Command source* | - | P0700 = 2 | Terminals | Yes |
| Digital Input 0, DI0 | 5 | P0701 = 1 | ON/OFF1 | Yes |
| Digital Input 1, DI1 | 6 | P0702 = 12 | Reversing | Yes |
| Digital Input 2, DI2 | 7 | P0703 = 9 | Fault acknowledge | Yes |
| Digital Input 3, DI3 | 8 | P0704 = 15 | Fixed setpoint (direct) | No |
| Digital Input 4, DI4 | 16 | P0705 = 16 | Fixed setpoint (direct) | No |
| Digital Input 5, DI5 | 17 | P0706 = 17 | Fixed setpoint (direct) | No |
| Digital Input 6, DI6 | 40 | P0707 = 18 | Fixed setpoint (direct) | No |
| Digital Input 7, DI7 | 41 | P0708 = 0 | Digital input disabled | No |

| Digital Inputs | Terminals | Parameter | Function | Active |
|---|---|---|---|---|
| Digital Input 8, DI8 | 42 | P0709 = 0 | Digital input disabled | No |
| *) With CU240S DP and CU240S DP-F control units, P0700 and P1000 are set to 6 (command source and setpoint source via PROFIBUS-DP). | | | | |

If all the installation and commissioning requirements are met and the motor data matches the inverter data, the following is possible with the factory settings, when using a control unit CU240S:

| | |
|---|---|
| To start and stop the motor | Using DI0 with external switch |
| To reverse direction of rotation | Using DI1 with external switch |
| To reset faults | Using DI2 with external switch |
| To enter a frequency setpoint | Using AI0 with external potentiometer;<br>the default setting of the AI: Voltage input |
| To display the actual frequency value | Using AO0 as current output |

The potentiometer and the external switches can be connected through the inverter internal power supply, as shown in section "Connecting the Control Unit via terminals".

**Notice**

If settings have to be made which go beyond the factory settings, then depending on the complexity of the application, when commissioning the inverter, the particular function description as well as the parameter list including function charts must be carefully taken into consideration.

## 5.4 Parameterization with Operator Panel

### The Operator Panel (OP)

The OP is available as an option to enhance the effectiveness of parameterizing and control of the inverter. The control signals and speed reference can easily be set by pressing the appropriate buttons. The OP has the ability to upload and download parameter sets from an inverter to another inverter.


Figure 5-4 Operator Panel (OP, 6SL3255-0AA00-4BA1)

### Fitting the OP to the Control Unit

The OP is fitted to the Control Unit as shown in the figure below. No matter which class of Control Unit is being used, the process is the same.

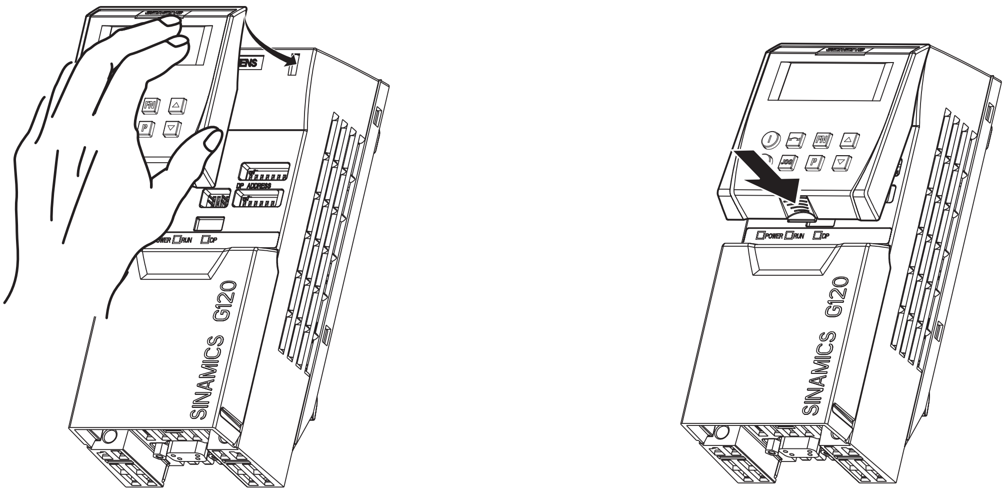
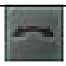
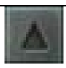



Figure 5-5 Fitting the OP to the CU

## 5.4.1 Function Keys of the OP

### Operator Panel - function keys

Table 5-12 OP keys and their functions

| Operator Panel Key | Function | Effects |
|---|---|---|
|  | Status display | The LCD indicates the settings which the drive inverter is presently using. |
|  | Start motor | The inverter is started by pressing the key. This key is deactivated in the default setting. Parameter P0700 or P0719 should be changed as follows to activate the key:<br>OP: P0700 = 1 or P0719 = 0 ... 16 |
|  | Stop motor | OFF1 — When this key is pressed, the motor comes to a standstill within the selected ramp-down time. It is deactivated in the default setting; to activate → refer to the "Start motor" key. |
| | | OFF2 — The motor coasts down to a standstill by pressing the key twice (or pressing once for a longer period of time). This function is always activated. |
|  | Direction reversal | To reverse the direction of rotation of the motor, press this key. The opposing direction is displayed using the minus character (-) or by the flashing decimal point. In the default setting this function is deactivated. To activate it → refer to the "Start motor" key. |
|  | Jog motor | In the "Ready to power-on" state, when this key is pressed, the motor starts and rotates with the pre-set jog frequency. The motor stops when the key is released. When the motor is rotating, this key has no effect. |
|  | Function | This key can be used to display additional information.<br>If you press the key during operation, independent of the particular parameter, for two seconds, the following data will be displayed:<br>1. Voltage of the DC current link (designated by d – units V).<br>2. Output current (A)<br>3. Output frequency (Hz)<br>4. Output voltage (designated by o – units V).<br>5. The value, selected in P0005 (if P0005 is configured so that one of the above pieces of data is displayed (1 to 4), then the associated value is not re-displayed).<br>The displays mentioned above are run-through one after the other by pressing again.<br>**Step function**<br>Starting from any parameter (rXXXX or PXXXX), if the key Fn is briefly pressed, then a jump is immediately made to r0000. You can then, when required, change an additional parameter. After returning to r0000, when key Fn is pressed, then the system returns to the starting point.<br>**Acknowledgement**<br>If alarm and fault messages are present, then these can be acknowledged by pressing key Fn. |
|  | Parameter access | Parameters can be accessed by pressing this key. |
|  | Increase value | When this key is pressed, the displayed value is increased. |
|  | Reduce value | When this key is pressed, the displayed value is decreased. |

## 5.4.2 Changing parameters via OP

### Changing parameter with the OP

The description below serves as an example that shows how to change any parameter using the OP.

Table 5-13 Changing P0003 - parameter access level

| | Step | Result on display |
|---|---|---|
| 1 | Press [P] to access 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 (set to 3) | 3 |
| 5 | Press [P] to confirm and store the value | P0003 |
| 6 | All level 1 to level 3 parameters are now visible to the user. | |

Table 5-14 Changing P0719 an index parameter - setting OP control

| | Step | Result on display |
|---|---|---|
| 1 | Press [P] to access parameters | r0000 |
| 2 | Press [▲] until P0719 is displayed | P0700 |
| 3 | Press [P] to access the parameter value | in000 |
| 4 | Press [▲] or [▼] to select index 1 | in001 |
| 5 | Press [P] to display actual set value | 0 |
| 6 | Press [▲] or [▼] to the required value | 11 |
| 7 | Press [P] to confirm and store the value | P0700 |
| 8 | Press [▼] until r0000 is displayed | r0000 |
| 9 | Press [P] to return the display to the standard drive display (as defined by the customer) | |

**Note**

The OP sometimes displays **"bUSY"** when changing parameter values. This means that the inverter is presently handling another higher-priority task.

# 5.5 Parameterization with MMC

## Overview

A G120 inverter can be parameterized by downloading a parameter set from the MMC to the inverter.

The download can be performed as

- manual download
- automatic download
- start-up download

A detailed download description can be found in the operation section.

# 5.6 Parameterization with STARTER

## Commissioning with STARTER

The following interfaces - which are Control Unit dependent are available:

Table 5-15 Connection possibilities for STARTER

| Type | USS on RS232 | USS on RS485 | PROFIBUS DP |
|---|---|---|---|
| PC connected to CU via | PC Connection Kit | Sub D cable & RS485 to RS232 converter | DP interface |
| Interface | Option port | Sub D connector | Sub D connector |
| Restrictions | Peer to peer | up to 31 slaves | up to 125 slaves |
| CU240S | X | X | -- |
| CU240S DP | X | -- | X |
| CU240S DP-F | X | -- | X |

## General information for connecting STARTER

USS address: see P2011, default setting P2011 = 0

USS baudrate: see P2010, default setting P2010 = 8 (≙ 38400 baud)

PROFIBUS-DP address: see P0918 or PROFIBUS-DP DIP switches.

## STARTER projects

Using STARTER either a new project can be created or an already existing project can be opened.

To create a new project in STARTER one of the following methods can be used:

- Search inverter
- Wizard

- Select inverter.

When opening an existing project or creating a new project STARTER is in the offline mode. To go online the button has to be pressed.

## Changing parameters with STARTER

Parameters can be changed online or offline (online preferred).

Online parameter changes are stored in the RAM of the inverter. A manual transfer from RAM to EEPROM can be triggered by pressing . When closing STARTER and the contents of the RAM and EEPROM are different, the user is asked whether or not they wish to transfer the RAM data to the EEPROM.

---

**Note**

Via P0014 the store mode can be changed,

- P0014 = 0: parameter changes stored in RAM (default)
- P0014 = 1: parameter changes stored in EEPROM

---

Parameter sets that have been changed offline can be transferred to the inverter using the download button.

---

**Caution**

Parameters for fail-safe functions can only be changed in the online mode.

When downloading parameters via STARTER, parameters belonging to fail-safe functions will not be downloaded.

---

## 5.7 Commissioning modes

### Commissioning overview

A differentiation is made between the following scenarios when commissioning the inverter via OP:

- Quick commissioning
- Motor data identification
- Calculating the motor/control data
- Commissioning the application
- Series commissioning.

When commissioning, initially, a quick or series commissioning should be carried-out. In case of commissioning the inverter with STARTER this means "reconfigure Drive". The actual "Commissioning the application" should actually only be commissioned if the inverter–motor combination provides a satisfactory result.

If the inverter is to be commissioned from a defined state, then the inverter can be reset to its initial state when it left the factory. This is accomplished by a reset of all the parameters back to the original factory settings; this is called a "Factory Reset".

The following check list should help you to commission the Inverter without any problems and to guarantee a high degree of availability:

- When handling the inverter, carefully observe all of the ESD measures.
- All of the screws must have been tightened up to their specified torque.
- All connectors and option modules must have been correctly inserted, locked or screwed into place.
- All of the components are grounded/earthed at the points provided and all of the shields have been connected.
- The Inverter has been designed for defined mechanical, climatic and electrical ambient conditions. It is not permissible that the specified limit values are exceeded in operation or when the Inverters are being transported. The following must be carefully observed:
  - Line supply conditions
  - Pollutant stressing
  - Gases which can have a negative impact on the function
  - Ambient climatic conditions
  - Storage/transport
  - Shock stressing
  - Vibration stressing
  - Ambient temperature
  - Installation altitude.

In addition, to carrying-out all of the installation work, an important prerequisite for successful commissioning is that the Inverter is not disconnected from the line supply while being parameterized. If a line supply failure interrupts commissioning, then inconsistencies can occur regarding the parameterization. In this case, it is important that the commissioning is re-started, possibly with a factory reset to establish the original factory settings.

---

Notice

**Behaviour of inverter on completion of commissioning**

The following behaviour should be taken into account when commissioning the inverter:

- standard commissioning with P0014 = 0:
  Parameters are only stored in RAM. RAM -> EEPROM can be started:
  - with OP: via setting P0971 = 1
  - with SATRTER in the online mode: via pressing
    RAM -> EEPROM will automatically be performed when starting data transfer from inverter to MMC (P0802 = 2).
- standard commissioning with P0014 = 1:
  All parameter changes will be saved in both RAM and EEPROM.
- While commissioning the fail-safe functions - only possible with a CU240S DP-F - the relating parameters are automatically stored in RAM and EEPROM
- Data from EEPROM can be transferred to MMC via P0802 = 2.
- Parameters can be changed independent whether an MMC is plugged in or not. Depending on the settings in P8458 after power cycle the parameters from EEPROM or MMC are used for start up. The customer has to take of the proper settings of P8458.
  - P8458 = 0, no automatic parameter download from the MMC.
  - P8458 = 1, automatic parameter download from the MMC only at the first start-up of the CU with plugged-in MMC
  - P8458 = 2, automatic parameter download from the MMC after each start-up of the CU with plugged-in MMC.

---

Warning

In case of automatic parameter download from the MMC at start up, F0395 will be generated.

In standard applications a confirmation test, in fail-safe applications an acceptance test has to be performed.

### 5.7.1 Quick commissioning

#### Description

If there is still no appropriate parameter set for the drive, then a quick commissioning must be carried-out for the closed-loop vector control and for the V/f control including a motor data identification routine. The following operator units can be used to carry-out quick commissioning:

- OP (option)
- PC Tools (with commissioning program STARTER).

When the quick commissioning is carried-out, the motor-drive inverter is basically commissioned; the following data must be obtained, modified or entered before quick commissioning is started:

- Enter the line supply frequency
- Enter the rating plate data
- Command/setpoint sources
- Min./max. frequency or ramp-up/ramp-down time
- Closed-loop control mode
- Motor data identification.

#### Parameterizing the inverter with OP

The frequency inverter is adapted to the motor using the quick commissioning function and important technological parameters are set. The quick commissioning shouldn't be carried-out if the rated motor data saved in the inverter (4-pole 1LA Siemens motor, star circuit configuration inverter (FU)-specific) match the rating plate data.

**Warning**

The motor data identification routine MUST not be used for loads which are potentially hazardous (for example, suspended loads for crane applications). Before the motor data identification routine is started, the potentially hazardous load must be carefully secured (for example, by lowering the load to the floor or by clamping the load using the motor holding brake).

The possible rating plate data is shown in the figure below. The precise definition and explanation of this data is defined in DIN EN 60034-1.

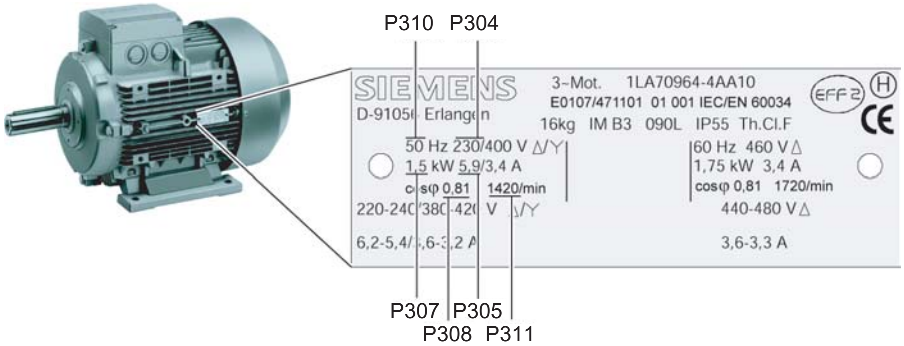



Figure 5-6 Example of typical motor rating plate

## Performing Quick Commissioning via OP

For applications using V/f (P1300 = 0 [default]) or Flux Current Control (FCC) (P1300 = 1 or 6), quick commissioning can be accomplished by setting the following paramters:

| | |
|---|---|
| Enter the motor frequency | P0100 |
| Enter the rating label data P0304, | P0304, P0305, P0307, P0310 and P0311 |
| Command and setpoint sources | P0700, P1000 |
| Minimum and maximum frequency | P1080, P1082 |
| Ramp-up and ramp-down times | P1120, P1121 |
| Closed-loop control mode | P1300 |
| Motor data identification | P1900 = 3 |

For applications using Vector Control (P1300 = 20 … 23), the parameters in the following flow chart should be set and used:

Parameters designated with an "*" offer more settings than are actually shown here. Refer to the Parameter list for additional settings.

Table 5-16 Quick commissioning - flow chart

| Parameter | Action/Description (Factory setting: **bold**)<br>Parameters with an "*" have more settings than listed below. Please refer to the parameter list | Your own setting |
|---|---|---|
| P0003 = 3 | User access level*<br>**1: Standard: Allows access into most frequently used parameters**<br>2: Extended: Allows extended access e.g. to inverter I/O functions<br>3: Expert: For expert use only | |
| P0004 = 0 | Parameter filter*<br>**0: All parameters**<br>2: Inverter<br>3: Motor<br>4: Speed sensor | |
| P0010 = 1 | Commissioning parameter filter*<br>**0: Ready**<br>1: Quick commissioning<br>30: Factory setting<br>Note: P0010 should be set to 1 in order to parameterize the data of the motor rating plate. | |
| P0100 = 0 | **Europe/North America** (enter the motor frequency) | |

| Parameter | **Action/Description** (Factory setting: **bold**)<br>Parameters with an "*" have more settings than listed below. Please refer to the parameter list | **Your own setting** |
|---|---|---|
| | **0: Europe [kW], frequency default, 50 Hz**<br>1: North America [hp]. frequency default, 60 Hz<br>2: North America [kW], frequency default, 60 Hz | |
| P0205 = 0 | **Inverter application** (enter the required overlaod)<br>**0: High overload** (for compressors, processing machines, etc.)<br>1: Light overload (for pumps and fans, etc.)<br>Note: This parameter is only effective for Inverters ≥ 5.5 kW/400 V. | |
| P0300 = 1 | **Select motor type**<br>**1: Asynchronous rotational motor**<br>2: Synchronous rotational motor (Note: only V/f control types (P1300 < 20) are permitted) | |
| P0304 = ? | **Rated motor voltage** (enter value from the motor rating plate in V)<br>The input of rating plate data must correspond with the wiring of the motor (star/delta). This means, if delta wiring is used for the motor, delta rating plate data has to be entered. | |
| P0305 = ? | **Rated motor current**<br>enter value from the motor rating plate in A | |
| P0307 = ? | **Rated motor power**<br>enter value from the motor rating plate in kW or hp<br>Note: if P0100 = 0 or 2, data is in kW and if P0100 = 1, data is in hp. | |
| P0308 = ? | **Rated motor cosPhi** (only visible if P0100 = 0 or 2)<br>enter cosφ from the motor rating plate.<br>Setting P0308 = 0 causes internal calculation of value. | |
| P0309 = ? | **Rated motor efficiency** (only visible if P0100 = 1)<br>enter value (%) from the motor rating plate.<br>Setting P0309 = 0 causes internal calculation of value | |
| P0310 = ? | **Rated motor frequency**<br>enter value from the motor rating plate in Hz<br>Pole pair number recalculated automatically if parameter is changed. | |
| P0311 = ? | **Rated motor speed**<br>enter value from the motor rating plate in RPM)<br>Setting P0311 = 0 causes internal calculation of value.<br>Note: Required for vector control and V/f control with speed controller.<br>Slip compensation in V/f control requires rated motor speed for correct operation. | |
| P0314 = ? | **Motor pole pair number**<br>1: 2-pole motor<br>2: 4-pole motor<br>Recalculated automatically when P0310 (rated motor frequency) or P0311 (rated motor speed) is changed. | |
| P0320 = ? | **Motor magnetizing current**<br>Setting P0320 = 0 causes calculation according the setting of P0340 = 1 (data entered from rating plate) or by P3900 = 1, 2 or 3.<br>The calculated value is displayed in parameter r0331. | |
| P0335 = 0 | **Motor cooling**<br>**0: Self-cooled using shaft mounted fan attached to the motor**<br>1: Force-cooled, using a separately powered cooling fan<br>2: Self-cooled and internal fan<br>3: Force-cooled and internal fan | |
| P0400 = 0 | **Select encoder type**<br>**0: Disabled**<br>2: Quadrature encoder no zero pulse<br>12: Quadrature encoder & zero pulse<br>**Note:** Encoders with zero pulse can also be connected, but the zero pulse is not used. | |

| Parameter | **Action/Description** (Factory setting: **bold**)<br>Parameters with an "*" have more settings than listed below. Please refer to the parameter list | Your own setting |
|---|---|---|
| P0408 = ? | **Encoder pulses per revolution**<br>Specifies the number of encoder pulses per revolution (encoder resolution)<br>Note: The encoder resolution is limited by the max. pulse frequency of the encoder circuits (f_max = 300 kHz). | |
| P0500 = 0 | **Technological application**<br>Selects technological application<br>**0: High overload**<br>1: Light overload (for pumps and fans, etc. sets internally P1300 = 2) | |
| P0610 = 2 | **Motor I2t temperature reaction**<br>Defines reaction when motor temperature reaches warning threshold.<br>0: No reaction, warning only<br>1: Warning and Imax reduction<br>**2: Warning and trip (F0011)** | |
| P0625 = ? | **Ambient motor temperature**<br>Ambient temperature of motor at time of motor data identification.<br>**Note:** It is only allowed to change the value when the motor is cold. A motor identification has to be made after changing the value. | |
| P0640=150 | **Motor overload factor**<br>Defines motor overload current limit [%] relative to P0305 (rated motor current).<br>This defines the limit of the maximum output current as a percentage of the rated motor current (P0305). This parameter is set, using P0205 for high overload, to 150 % and for light overload, up to 110 %. | |
| P0700 = 2 | **Selection of command source***<br>enter the command source<br>0: Factory default setting<br>1: OP (keypad)<br>**2: Terminal (Default for CUS240S)**<br>4: USS on RS232<br>5: USS on RS485<br>**6: Fieldbus (Default for CUS240S DP and CUS240S DP-F)** | |
| P0727 = 0 | **Selection of 2-/3-wire method**<br>Determines the control method using the terminals.<br>**0: Siemens (start/dir)**<br>1: 2-wire(fwd/rev)<br>2: 3-wire(fwd/rev)<br>3: 3-wire(start/dir) | |
| P1000 = 2 | **Selection of frequency setpoint***<br>enter the frequency setpoint source<br>0: No main setpoint<br>1: MOP setpoint<br>**2: Analog setpoint (Default for CUS240S)**<br>3: Fixed frequency<br>4: USS on RS232<br>5: USS on RS485<br>**6: Fieldbus (Default for CUS240S DP and CUS240S DP-F)**<br>7: Analog setpoint 2 | |
| P1080 = ? | **Minimum frequency**<br>Enter the lowest motor frequency (in Hz) to which the motor operates independently of the frequency setpoint. The value set here is valid for both clockwise and anticlockwise rotation. | |
| P1082 = ? | **Maximum frequency**<br>Enter the maximum frequency (in Hz) to which the motor is limited independently of the frequency setpoint. The value set here is valid for both clockwise and anticlockwise rotation. | |

| **Parameter** | **Action/Description** (Factory setting: **bold**)<br>Parameters with an "*" have more settings than listed below. Please refer to the parameter list | **Your own setting** |
|---|---|---|
| P1120 = ? | **Ramp-up time**<br>Enter the time (in seconds) in which the motor should accelerate from standstill up to maximum motor frequency P1082. If the ramp-up time is set too short, this can cause alarm A0501 (current limit value) or tripping the inverter with fault F0001(overcurrent). | |
| P1121 = ? | **Ramp-down time**<br>Enter the time (in seconds) in which the motor should decelerate (using braking) from the maximum frequency P1082 down to standstill. If the ramp-down time is set too short, this can cause alarm A0501 (current limit value) or A0502 (overvoltage limit value) or tripping the inverter with fault F0001 (overcurrent) or F0002 (overvoltage). | |
| P1135 = ? | **OFF3 ramp-down time**<br>Enter the time (in seconds) in which the motor should decelerate (using braking) from the maximum frequency P1082 down to standstill with an OFF3 command (fast stop). If the ramp-down time is set too short, this can cause alarm A0501 (current limit value) or A0502 (overvoltage limit value) or tripping the inverter with fault F0001 (overcurrent) or F0002 (overvoltage). | |
| P1300 = 0 | **Control mode***<br>enter the required control mode<br>**0: V/f with linear characteristic**<br>1: V/f with FCC<br>2: V/f with parabolic characteristic<br>3: V/f with programmable characteristic<br>20: Sensorless vector control<br>21: Vector control with sensor<br>22: Sensorless vector torque-control | |
| P1500 = 0 | **Selection of torque setpoint***<br>enter the source for the torque setpoint<br>**0: No main setpoint**<br>2: Analog setpoint<br>4: USS on RS232<br>5: USS on RS485<br>6: Fieldbus | |
| P3900 = ? | **End quick commissioning (QC)***<br>**0: No quick commissioning** (no motor calculations)<br>1: Motor calculation and reset of all parameters that haven't been changed to factory settings while QC process.<br>2: Motor calculation and reset of all I/O settings to factory settings.<br>3: Only motor calculation - other parameters are not reset.<br>Note: If P3900 = 1, 2, or 3 P0340 is set to 1 and the value from P1082 is written into P2000. The appropriate motor data will be calculated.<br>While end of quick commissioning is performed **"bUSY"** will be displayed on the OP. This means that the control data are being calculated and the respective parameter values are stored in the EEPROM. After quick commissioning has been completed, P3900 and P0010 will be set to 0. | |
| END | **End of the quick commissioning/Inverter setting**<br>If additional functions must be implemented for the Inverter, please use the instructions **Adaption to the application** and **Technological interconnections**. We recommend this procedure for motors with a high dynamic response. | |

Next to "Quick Commissioning" the "Motor Data Identification" and additionally in case of vector mode (P1300 = 20/21) the "Speed Control Optimisation" should be performed.

Both need an ON command to start.

### Motor data identification

| | | |
|---|---|---|
| P0010 = 0 | **Commissioning parameter filter***<br>Check if P0010 = 0 (Ready) | |
| P1900 = 3 | **Select motor data identification***<br>**0: Disabled**<br>2: Identification of all parameters in standstill.<br>3: Identification of all parameters in standstill including saturation curve | |
| ON command | **Start motor data identification**<br>Once P1900 ≠ 0, alarm A0541(motor data identification active) is generated that states, the next ON command will initiate the motor data identification. When the ON Command is given, current flows through the motor and the rotor aligns itself.<br>Note: When motor data identification is complete A0541 will be cleared and P1900 will be set to zero. | |

### Speed control optimisation

| | | |
|---|---|---|
| P0010 = 0 | **Commissioning parameter filter***<br>Check if P0010 = 0 (Ready) | |
| P1960 = 1 | **Speed control optimisation**<br>**0: Disable**<br>1: Enable | |
| ON command | **Start Speed control optimisation**<br>We recommend the Speed control optimisation if vector mode (P1300 = 20 or 21) is selected. Once P1960 = 1, alarm A0542 is generated, that states, the next ON command will initiate the optimisation. If there is a problem with speed control optimisatuon due to instability the drive may trip with fault F0042, because no stable value has been obtained on the ramp up within a reasonable time.<br>Note: When Speed control optimisation is complete A0542 will be cleared and P1960 will be cleared to zero. | |

## 5.7.2 Calculating the motor and control data

### Overview

Internal motor/control data is calculated using parameter P0340 or, indirectly using parameter P3900 or P1910. The functionality of parameter P0340 can, for example, be used if the equivalent circuit diagram data or the moment of inertia values are known. The following settings are possible for P0340:

| | |
|---|---|
| 0 | No calculation |
| 1 | Complete parameterization |
| 2 | Calculation of the equivalent circuit diagram data |
| 3 | Calculation of V/f and Vector control |
| 4 | Calculation of the controller settings |

For the complete parameterization (P0340 = 1), in addition to the motor and control parameters, parameters are also pre-assigned which refer to the motor rated data (for example, torque limits and reference quantities for interface signals). A complete list of all of the parameters depending on P0340 is included in the parameter manual.

When calculating the motor/control data using P0340, there are different scenarios, which can be called-up as a function of the known data.

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**Note**

When exiting quick commissioning with P3900 > 0, internally P0340 is set to 1 (complete parameterization).

For the motor data identification, after the measurement has been completed, internally P0340 is set to 3.

---

## Performing the calculation of motor and control data via OP

| Parameter | Description | Your setting |
|---|---|---|
| P0340 = 1 | **Calculation of motor parameters**<br>This parameter is required during commissioning in order to optimize the operating behavior of the inverter. For the complete parameterization (P0340 = 1), in addition to the motor/control parameters, parameters are pre-assigned which refer to the rated motor data (e.g. torque limits and reference quantities for interface signals). A list of the parameters, which are calculated, depending on the setting of P0340, are included in the parameter list.<br>0: No calculation<br>**1: Complete parameterization**<br>2: Calculation of equivalent circuit data<br>3: Calculation of V/f and Vector control data<br>4: Calculation of controller settings only | |
| If additional catalog data is known enter the data in P0341, P0342 and P0344. | | |
| P0341 = ? | **Motor inertia [kg*m$^2$]** | |
| P0342 = ? | **Total/motor inertia ratio** | |
| P0344 = ? | **Motor weight** (entered in kg) | |
| If the ECD data is known, enter the data in P0350, P0354, P0356, P0358, P0360.<br>**If the ECD data is not known, then: Set P0340 = 4. To calculate the controller settings and skip to END.** | | |
| P0350 = ? | **Stator resistance (line-to-line)** (entered in Ω)<br>Stator resistance in Ω of the motor which is connected (from line-to-line). This parameter value also includes the cable resistance. | |
| P0354 = ? | **Rotor resistance** (entered in Ω)<br>Defines the rotor resistance of the motor equivalent diagram (phase value). | |
| P0356 = ? | **Stator leakage inductance** (entered in mH)<br>Defines the stator leakage inductance of the motor equivalent diagram (phase value). | |
| P0358 = ? | **Rotor leakage inductance** (entered in mH)<br>Defines the rotor leakage inductance of the motor equivalent diagram (phase value). | |
| P0360 = ? | **Main inductance** (entered in mH)<br>Defines the main (magnetizing) inductance of the motor equivalent diagram (phase value). | |
| P0340 = 3 | **Calculation of motor parameters**<br>**3: Calculation of V/f and Vector control**<br>All of the parameters, dependent on the ECD data are calculated and, in addition, the controller settings (P0340 = 4). | |
| END | The motor parameters have been calculated and it is now possible to return to the additional parameterization in the Section "Adaptation to the application". | |

## 5.7.3 Motor data identification

### Motor identification data

The Inverter has a measuring technique which is used to determine the motor parameters:

| | | |
|---|---|---|
| Equivalent circuit diagram (ECD) | → | P1910 = 1 |
| Magnetizing characteristic (saturation curve) | → | P1910 = 3 |

For control-related reasons, it is essential that the motor data identification is performed. Without performing the motor data identification it is only possible to estimated ECD data using information from the motor rating plate. For example, the stator resistance is extremely important for the stability of the closed-loop Vector control and for the voltage boost of the V/f characteristic. The motor data identification routine should be executed, especially if long feeder cables or if third-party motors are being used.

If the motor data identification routine is being started for the first time, then the following data is determined, starting from the rating plate data (rated [nominal] data) with P1910 = 1:

- ECD data
- Motor cable resistance
- IGBT on-state voltage and compensation of IGBT gating dead times.

The rating plate data represents the initialization values for the identification. This is the reason that it is necessary to have the correct input from the rating plate data when determining the data specified above.

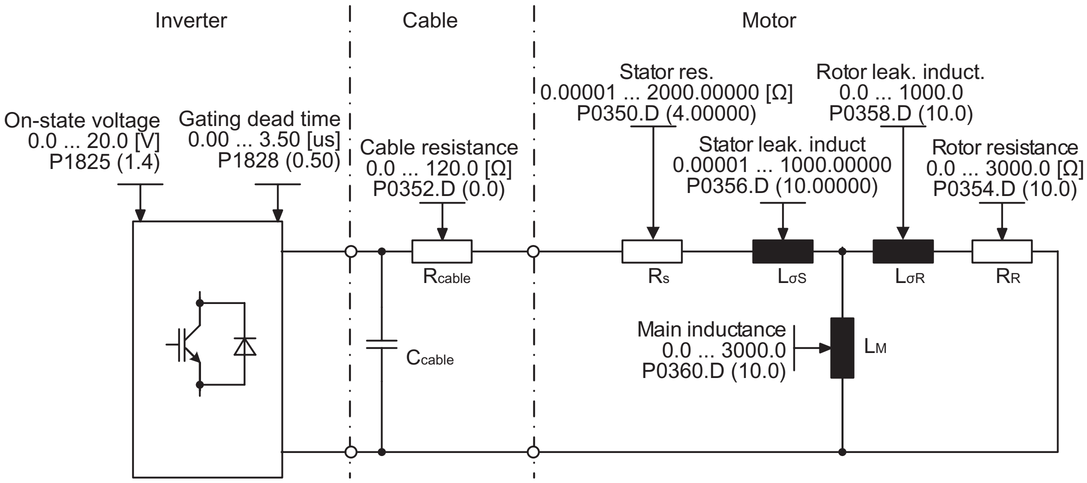



Figure 5-7 Equivalent circuit diagram (ECD)

In addition to the ECD data, the motor magnetizing characteristic (see the figure above) can be determined using the motor data identification (P1910 = 3). If the motor combination is operated in the field-weakening range (which is above the nominal frequency of the motor), then this characteristic should be determined, especially when Vector control is being used. As a result of this magnetizing characteristic, the Inverter can, in the field-weakening range, accurately calculate the current which is generated in the field and in-turn achieve a higher torque accuracy.

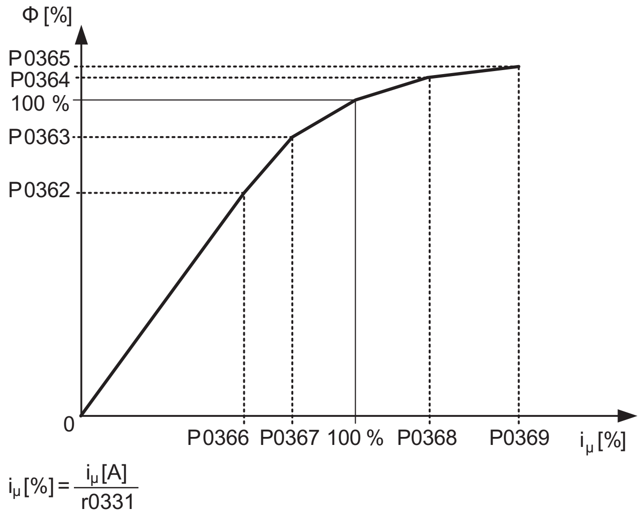



Figure 5-8 Magnetizing characteristic

After selecting the motor data identification using parameter P1910, alarm A0541 is immediately generated. The motor identification routine is started by the ON command and different excitation signals are impressed in the motor (DC and AC voltages). This measurement is carried-out with the motor at a standstill and it takes, including the data calculation per selection (P1910 = 1 or 3), between 20 seconds and 4 minutes to complete. The identification time depends on the motor and increases with its size (this takes approx. 4 min. for a 200 kW motor).

The motor data identification routine must be carried-out with the motor in the **cold** condition so that the motor resistance values saved can be assigned to the parameter of the ambient temperature P0625. Only then is the correct temperature adaptation of the resistances possible during operation.

The motor data identification routine operates with the results of the "Complete parameterization" P0340 = 1 or the motor equivalent diagram data which was last saved. The results become increasingly better the more times that the identification routine is executed (up to 3 times).

**Warning**

It is not permissible to carry-out the motor identification routine for loads which are potentially hazardous (e.g. suspended loads for crane applications). Before starting the motor data identification routine, the potentially hazardous load must be secured (e.g. by lowering the load to the floor or clamping the load using the motor holding brake).

When starting the motor data identification routine, the rotor can move into a preferred position. This is more significant for larger motors.

**Note**

The equivalent circuit data (P0350, P0354, P0356, P0358, P0360), with the exception of parameter P0350, should be entered as phase values. In this case, parameter P0350 (line-to-line value) corresponds to twice the phase value.

The motor cable resistance P0352 is defined as a phase value.

During the motor identification routine, the stator resistance and the motor cable resistance are determined and entered into parameter P0350. If a correction is made in parameter P0352, then the Inverter defines the motor cable resistance using the following relationship: P0352 = 0.2 * P0350.

If the motor cable resistance is known, then the value can be entered into parameter P0352 after the motor data identification. The stator resistance is appropriately reduced as a result of this entry and is therefore more precisely adapted to the actual application.

It is not necessary to lock the motor rotor for the motor data identification routine. However, if it is possible to lock the motor rotor during the identification routine (i.e. by closing the motor holding brake), then this should be used to determine the equivalent circuit diagram data.

The following formula can be applied to check the correctness of the motor rating plate data:

$P_N = \sqrt{3} * V_{NY} * I_{NY} * \cos\varphi * \eta \approx \sqrt{3} * V_{N\Delta} * I_{N\Delta} * \cos\varphi * \eta$

Where:

| | |
|---|---|
| $P_N$ | rated motor power |
| $V_{N\,Y}$, $V_{N\,\Delta}$ | rated motor voltage (star/delta) |
| $I_{N\,Y}$, $I_{N\,\Delta}$ | rated motor current (star/delta) |
| $\cos\varphi$ | power factor |
| $\eta$ | efficiency |

If Problems occur during the identification run, for example, the current controller oscillates, then the rating plate data should be re-checked and an approximately correct magnetizing current P0320 entered. The motor data identification routine should then be re-started by called P0340 = 1.

## Motor data identification - flow chart

| Parameter or Action | Description (Factory setting: **Bold**) |
|---|---|
| P0625 = ? | **Ambient motor temperature** (entered in °C)<br>The motor ambient temperature is entered at the instant that motor data is being determined (factory setting: **20 °C**).<br>The difference between the motor temperature and the motor ambient temperature P0625 must lie in the tolerance range of approx. ± 5 °C. If this is not the case, then the motor data identification routine can only be carried-out after the motor has cooled down. |
| Is the motor temperature (P0625) within the tolerance described above. If not the motor must be allowed to cool down. | |
| P1910 = 1 | **Select motor data identification**<br>**0: Disabled**<br>1: Identification of all parameters that have change. These changes are applied to the controller.<br>3: Identification of saturation curve with parameter change |
| Note: For P1910 = 1 → P0340 is internally set to 3 and the appropriate data calculated (refer to parameter list P0340) | |
| ON | **Power-up the motor**<br>The measuring operation must be started with a continuous ON command. If so doing the motor aligns itself and conducts current. Diagnostics via r0069 (CO: phase currents) is possible. Alarm message A0541 (motor data identification routine active) is output. |
| A0541 | After the motor data identification routine has been completed:<br>1. P1910 is reset (P1910 = 0)<br>2. A0541 is withdrawn |
| OFF1 | In order to set the inverter into a defined state, an OFF1 command must be issued before the next step. |
| P1910 = 3 | **Select motor data identification**<br>**0: Disabled**<br>1: Identification of all parameters that have change. These changes are applied to the controller.<br>3: Identification of saturation curve with parameter change |
| Note: For P1910 = 3 → P0340 is internally set to 2 and the appropriate data calculated (refer to parameter list P0340) | |
| ON | **Power-up the motor**<br>The measuring operation must be started with a continuous ON command. |
| A0541 | After the motor data identification routine has been completed:<br>1. P1910 is reset (P1910 = 0)<br>2. A0541 is withdrawn |
| OFF1 | In order to set the inverter into a defined state, an OFF1 command must be issued before the next step. |
| END | Motor identification is finished. |

## 5.7.4 Commissioning the application

### Commissioning the application

After the motor - Inverter combination has been commissioned using quick commissioning, the following parameters should be adapted and set according to the requirements of your specific application. As an example, the following points should be considered:

- Functional requirements of the inverter (for example, closed-loop process control with PID controller)
- Limit values
- Dynamic requirements
- Starting torques
- Load surge requirement
- Overload
- Diagnostics.

If the application includes a function, which is not covered by the quick commissioning, then the "Function" section in this manual or the parameter list should be consulted.

---

Note

In the factory setting, parameter changes are stored in the volatile memory of the inverter (RAM). To safe the changes in the EEPROM one of the following methods can be used:

- Set P0014 = 1 all changes stored immediately in the EEPROM
- start data transfer from RAM to EEPROM via P0971 = 1 (when using OP) via  (with STARTER).

The durartion of the data transfer depends on the number of changed parameters. In some cases it can last several minutes.

With the OP data transfer is displayed with "bUSY".

When using STARTER it is displayed via a progress bar. The sucessful transfer is displayed via a dialog box.

---

## Commissioning the application - flow charts

The parameters designated with an "*" offer more setting possibilities than are listed here. Refer to the parameter list for additional setting possibilities.

## General settings

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P0003 = 3 | User access level*<br>**1: Standard: Allows access into most frequently used parameters.**<br>2: Extended: Allows extended access e.g. to inverter I/O functions<br>3: Expert: For expert use only | |
| P0210 = ? | Supply voltage (enter the voltage in V)<br>This parameter enters the real line supply voltage to which the Inverter is connected. Only necessary if P1254 = 0 (default: P1254 = 1). | |
| P0290 = 2 | Inverter overload reaction<br>This defines the response of the Inverter to an internal overtemperature.<br>0: Reduce output frequency<br>1: Trip (F0004)<br>**2: Reduce pulse frequency and output frequency**<br>3: Reduce pusle frequency then trip (F0004) | |
| P0335 = 0 | Motor cooling (enter the motor cooling system)<br>**0: Self-cooled using the shaft mounted fan attached to the motor**<br>1: Force-cooled using the separately powered cooling fan<br>2: Self-cooled and internal fan<br>3: Force-cooled and internal fan | |

## Pulse Encoder

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P0400 = 0<br>or<br>P0400 = ? | Select encoder type *<br>**0: Disabled** (no encoder fitted)<br>2 or 12: Two quadrature encoder (two channels) | |
| P0408 = ? | Number of encoder pulses (Only if encoder is fitted)<br>Enter the number of encoder pulses per revolution. The number of encoder pulses per revolution P0408 is limited by the maximum pulse frequency of the pulse encoder module ($f_{max}$ = 300 kHz) | |

## Temperature Sensor

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P0601 = 0<br>or<br>P0601 = ? | **Motor temperature sensor**<br>**0: No sensor** (→ P0610)<br>1: PTC thermistor (→ P0604)<br>2: KTY84 (→ P0604) | |
| P0604 = ? | **Threshold motor temperature**<br>Enter the warning threshold for motor overtemperature protection. The trip temperature (threshold) is where either the inverter is tripped or Imax is reduced (P0610) which is always 10 % above the warning threshold. | |
| P0610 = 2 | **Motor I2t temperature reaction**<br>Defines the reaction when the mtor temperature reaches the warning threshold.<br>0: No reaction, only a warning<br>1: Warning and $I_{max}$ reduced (this results in a reduced output frequency)<br>**2: Warning and trip (F0011)** | |

## Temperature calculation without sensor

In the vector control mode (P1300 = 20/21/22/23) Temperature calculations is possible without sensor. The following parameters have to be set.

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P0621= 1 | **Motor temperature identification after restart**<br>**0: No identification**<br>1: Temperature identification only at first "motor on" after power cycle<br>2: Temperature identification at each motor on. | |
| P0622 = | **Motor magnetizing time for temperature identification after stator restistance identification**<br>This parameter will be initialised with a value for one calculating cycle of the motor temperature. It depends on the identified rotor time constant. Due to accuracy reasons this calculation may be performed several times. | |

## Selection of command source

The available command sources depend on the used CU.

Default setting on the control unit used the command source is set per default to different values.

| Parameter | **Description** (Factory setting: **bold**) | Setting |
|---|---|---|
| P0700 = 2/6 | **Selection of command source**<br>This selects the digital command source<br>0: Factory default setting<br>1: OP (keypad)<br>**2: Terminal** (P0701 … P0709), factory setting for CU240S<br>4: USS on RS232<br>5: USS on RS485 (not available with CU240S DP and CU240S DP-F)<br>**6: Fieldbus** (P2050 … P02091), factory setting for CU240S DP and CU240S DP-F, not available with CU240S) | |

## Assigning digital input functions

| Parameter | **Description** (Factory setting: **bold**) | | | Setting |
|---|---|---|---|---|
| P0701 = 1 | **Terminal 5:<br>Digital Input 0 (DI0)** | factory settings for CU240S | Possible values for P0701 to P0708:<br>0: Digital input disabled<br>1: ON/OFF1<br>2: ON reverse /OFF1<br>3: OFF2 - coast to standstill<br>4: OFF3 - quick ramp-down<br>9: Fault acknowledge<br>10: JOG right<br>11: JOG left<br>12: Reverse<br>13: MOP up (increase frequency)<br>14: MOP down (decrease frequency)<br>15: Fixed frequency selector bit0<br>16: Fixed frequency selector bit1<br>17: Fixed frequency selector bit2<br>18: Fixed frequency selector bit3<br>25: DC brake enable<br>27: Enable PID 2<br>29: External trip 2<br>33: Disable additional freq setpoint<br>99: Enable BICO parameterization | |
| P0702 = 12 | **Terminal 6:<br>Digital Input 1 (DI1)** | | | |
| P0703 = 9 | **Terminal 7:<br>Digital Input 2 (DI2)** | | | |
| P0704 = 15 | **Terminal 8:<br>Digital Input 3 (DI3)** | | | |
| P0705 = 16 | **Terminal 16:<br>Digital Input 4 (DI4)** | | | |
| P0706 = 17 | **Terminal 17:<br>Digital Input 5 (DI5)** | | | |
| P0707 = 0 | **Terminal 40:<br>Digital Input 6 (DI6)** | factory settings for CU240S<br>not availble with CU240S DP-F | | |
| P0708 = 0 | **Terminal 41:<br>Digital Input 7 (DI7)** | | | |
| P0709 = 0 | **Terminal 41:<br>Digital Input 8 (DI8)** | | | |
| P0724 = 3 | **Debounce time for digital inputs**<br>Defines the debounce time (filtering time) used for digital inputs.<br>0: No debounce time<br>1: 2.5 ms debounce time<br>2: 8.2 ms debounce time<br>**3: 12.3 ms debounce time** | | | |
| P9603 = 00 | Terminal 62, 63: SLS via FD1A and FD1B | | not availble with CU240S and CU240S DP | |
| P9603 = 01 | Terminal 60, 61: SLS via FD0A and FD0B | | | |
| P9603 = 02 | Terminal 62, 63: SS1 via FD1A and FD1B | | | |

| Parameter | Description (Factory setting: **bold**) | | Setting |
|---|---|---|---|
| P9603 = 03 | Terminal 60, 61: SS1 via FD0A and FD0B | | |
| P9603 = 04 | Terminal 62, 63: STO via FD1A and FD1B | | |
| P9603 = 05 | Terminal 60, 61: STO via FD0A and FD0B | | |

## Assigning digital output functions

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P0731 = 52:3 | **BI: function of digital output 0 (DO0),** defines the source for digital output 0<br>Terminal 18: DO0, NC/Terminal 19: DO0, NO/Terminal 20: DO0, COM<br>**52:3 Inverter fault active** | |
| P0732 = 52:7 | **BI: function of digital output 1**,defines the source for digital output 1<br>Terminal 21: DO1, NO/Terminal 22: DO1, COM<br>**52:7 Inverter warning active** | |
| P0733 = 0:0 | **BI: function of digital output 2,** defines the source for digital output 2<br>Terminal 23: DO0, NC/Terminal 24: DO0, NO/Terminal 25: DO0, COM<br>**0:0 Digital output disabled** | |
| P0748 | **Invert digital outputs**<br>Bits 0, 1 and 2 can be used to invert the signals of digital outputs 0, 1 and 2 | |

## Frequency setpoint set

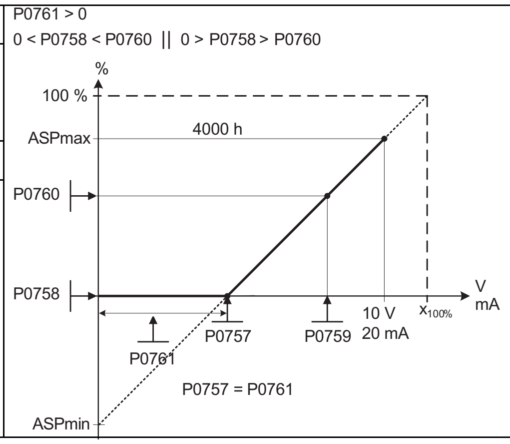
| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P1000 = ? | **Selection of frequency setpoint**<br>0: No main setpoint<br>1: MOP setpoint (P1031 … P1040)<br>**2: Analog setpoint** (P0756 … P0762), factory setting for CU240S<br>3: Fixed frequency (P1001 … P1023)<br>6: **Fieldbus** (P2050 … P02091), factory setting for CU240S DP and CU240S DP-F, not available with CU240S)<br>7: Analog setpoint 2<br>10: Additional setpoint (1 = MOP) + Main setpoint (0 = No main setpoint)<br>11: Additional setpoint (1 = MOP) + Main setpoint (1 = MOP)<br>12: Additional setpoint (1 = MOP) + Main setpoint (2 = Analog setpoint)<br>…<br>62: Additional setpoint (6 = Fieldbus) + Main setpoint (2 = Analog setpoint)<br>63: Additional setpoint (6 = Fieldbus) + Main setpoint (3 = Fixed frequency)<br>… | |

## Frequency setpoint via MOP (P1000 = 1)

| Parameter | **Description** (Factory setting: **bold**) | Setting |
|---|---|---|
| P1031 = 0 | **Setpoint memory of the MOP**<br>The last motorized potentiomenter setpoint, which was active before the OFF command or switching-off, can be saved.<br>**0: MOP setpoint will not be stored**<br>1: MOP setpoint will be stored in P1040 | |
| P1032 = 1 | **Inhibit reverse direction of MOP**<br>0: reverse direction is allowed<br>**1: Reverse direction inhibited** | |
| P1040 = 5 | **Setpoint of the MOP**<br>Defines the setpoint [Hz] of the motorized potentiometer (MOP). | |

## Frequency setpoint via analog input (AI) (P1000 = 2)

| Parameter | **Description** (Factory setting: **bold**) | Setting |
|---|---|---|
| P0756 = 0 | **AI type**<br>Defines the type of the analog input and also enables analog input monitoring.<br>**0: Unipolar voltage input (0 to +10 V)**<br>1: Unipolar voltage input with monitoring (0 V … +10 V)<br>2: Unipolar current input (0 mA … 20 mA)<br>3: Unipolar current input with monitoring (0 mA … 20 mA)<br>4: Bipolar voltage input (-10 V … +10 V)<br>**NOTE**: The following applies for P0756 … P0760:<br>Index 0: Analog input 0 (AI0), terminals 3 and 4<br>Index 1: Analog input 1 (AI1), terminals 10 and 11 | |
| P0757 = 0 | **Value x1 of AI scaling [V/mA]** | |
| P0758 = 0.0 | **Value y1 of AI scaling**<br>this parameter represents the value of x1 as a percentage of P2000 (reference frequency) | |
| P0759 = 10 | **Value x2 of AI scaling [V/mA]** | |
| P0760 = 100 | **Value y2 of AI scaling**<br>This parameter represents the value of x2 as a percentage of P2000 (reference frequency) | |



## Frequency setpoint via fixed frequency (P1000 = 3)

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P1016 = 1 | Fixed frequency mode, defines the selection method for fixed frequencies.<br>**1: direct selection**<br>2: binary coded | |
| P1001 = 0 | **Fixed frequency 1**, (FF1)<br>Value given in Hz. | |
| P1002 = 5 | **Fixed frequency 2** | |
| P1003 = 10 | **Fixed frequency 3** | |
| P1004 = 15 | **Fixed frequency 4** | |
| P1005 = 20 | **Fixed frequency 5** | |
| P1006 = 25 | **Fixed frequency 6** | |
| P1007 = 30 | **Fixed frequency 7** | |
| P1008 = 35 | **Fixed frequency 8** | |
| P1009 = 40 | **Fixed frequency 9** | |
| P1010 = 45 | **Fixed frequency 10** | |
| P1011 = 50 | **Fixed frequency 11** | |
| P1012 = 55 | **Fixed frequency 12** | |
| P1013 = 60 | **Fixed frequency 13** | |
| P1014 = 65 | **Fixed frequency 14** | |
| P1015 = 65 | **Fixed frequency 15** | |
| P1020 = 722.3 | **Fixed frequency selection - Bit 0**<br>Selects DI3 for FF selection | |
| P1021 = 722.4 | **Fixed frequency selection - Bit 1**<br>Selects DI4 for FF selection | |
| P1022 = 722.5 | **Fixed frequency selection - Bit 2**<br>Selects DI5 for FF selection | |
| P1023 = 722.6 | **Fixed frequency selection - Bit 3**<br>Selects DI6 for F selection | |

The fixed frequency can be selected via four digital inputs (default DI3 … DI6).

**Fixed frequences via direct selection (P1016 = 1):**

With the default settings additional combinations as follows are possible:

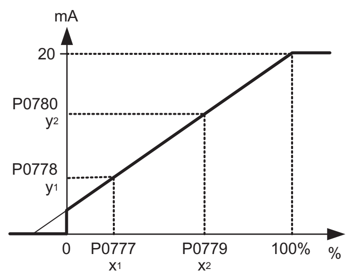
| Fixed Frequency selected via | FF- Par | FF [Hz] |
|---|---|---|
| DI3 (P1020 =722.3) | P1001 (default = 0 Hz) | 0 |
| DI4 (P1021 =722.4) | P1002 (default = 5 Hz) | 5 |
| DI5 (P1022 =722.5) | P1003 (default = 10 Hz) | 10 |
| DI6 (P1023 =722.6) | P1004 (default = 15 Hz) | 15 |
| DI3, DI4 | P1001+P1002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

**Fixed frequences via binary coded selection (P1016 = 2):**

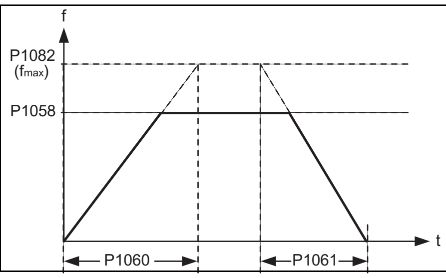
With binary coded selection each frequency, set in one of the parameters P1002 … P1015 can be directly selected.

| Fixed Frequency selected via | FF- Par | FF-default setting [Hz] |
|---|---|---|
| DI3 (P1020 =722.3) | P1001 | 0 |
| DI4 (P1021 =722.4) | P1002 | 5 |
| DI5 (P1022 =722.5) | P1003 | 10 |
| DI6 (P1023 =722.6) | P1004 | 15 |
| DI3, DI4 | P1005 | 20 |
| DI4, DI5 | P1006 | 25 |
| DI5, DI6 | P1007 | 30 |
| DI3, DI5 | P1008 | 35 |
| DI4, DI6 | P1009 | 40 |
| DI3, DI6 | P1010 | 45 |
| DI3, DI4, DI5 | P1011 | 50 |
| DI4, DI5, DI6 | P1012 | 55 |
| DI3, DI5, DI6 | P1013 | 60 |
| DI3, DI4, DI6 | P1014 | 65 |
| DI3, DI4, DI5, DI6 | P1015 | 65 |

## Analog outputs

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P0771 = 21 | **CI: Analog output**<br>Defines the function of the 0 mA … 20 mA analog output<br>**21: CO: actual frequency (scaled according to P2000)**<br>24: CO: actual output frequency (scaled according to P2000)<br>25: CO: actual output voltage (scaled according to P2001)<br>26: CO: actual DC-link voltage (scaled according to P2001)<br>27: CO: Output current (scaled according to P2002)<br>**NOTE:** The following applies for P0771 … P0785:<br>Index 0: analog output 0 (AO0), terminals 12 and 13<br>Index 1: analog output 1 (AO1), terminals 26 and 27 | |
| P0775 = 0 | **Permit absolute value**<br>Decides if the absolute value of the analog output is used.<br>If enabled, this parameter will take the absolute value of the value to be outputed.<br>If the value was originally negative then the corresponding bit in r0785 is set. | |
| P0776 = 0 | **Type of analog output**<br>Scaling of r0774.<br>**0: Current output**<br>1: Voltage output<br>**NOTE:** P0776 changes over the scaling of r0774 (0 mA … 20 mA ⇔ 0 V … 10 V).<br>Scaling parameters P0778, P0780 and the deadband are always entered in 0 mA … 20 mA.<br>Analog output 0 can be switched to a voltage output with a range 0 … 10 V.<br>Analog output 1 is only a current output. When it is used as voltage output, it must be terminated using a 500 Ω resistor. | |
| P0777 = 0.0 | **Value x1 of the analog output scaling**<br>Defines x1 output characteristic in percentage. This parameter represents the lowest analog value as a percentage of P200x (depending on the setting of P0771). | |
| P0778 = 0 | **Value y1 of the analog output scaling**<br>This parameter represents the value of x1 in mA.<br><br> | |
| P0779 = 100 | **Value x2 of the analog output scaling**<br>This defines x2 of the output characteristic in percentage. This parameter represents the highest analog value as a percentage of P200x (depending on the setting of P0771). | |
| P0780 = 20 | **Value y2 of the analog output scaling**<br>This parameter represents the value of x2 in mA. | |
| P0781 = 0 | **Width of analog output deadband**<br>This sets the width of the deadband in mA for the analog output. | |

## JOG frequency

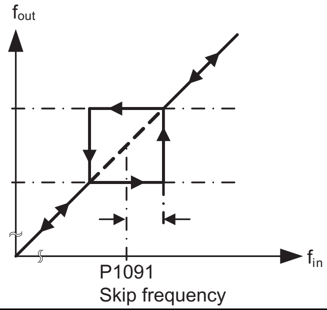
| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P1057 = 1 | **JOG Enable**<br>P1057 = 0 JOG-function diabled<br>**P1057 = 1 JOG-function enabled** | |
| P1058 = 5 | **JOG frequency right**<br>Frequency in Hz when the motor is being jogged in the clockwise direction of roatation. | |
| P1059 = 5 | **JOG frequency left**<br>Frequency in Hz when the motor is being jogged in the counter-clockwise direction of rotation. | |
| P1060 = 45 | **JOG ramp-up time**<br>Ramp-up time in seconds from 0 to the maximum frequency (P1082). The JOG ramp-up is limited by P1058 or P1059.   | |
| P1061 = 50 | **JOG ramp-down time**<br>Ramp-down time in seconds from the maximum frequency (P1082) to 0. | |

## Additional Setpoints

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P1074 = 1.0 | **BI: disable additional setpoint** | |
| P1075 = 775 | **CI: additional setpoint**<br>Defines the source of the additional setpoint which is added to the main setpoint.<br>**Common settings:**<br>755: Analog input setpoint<br>1024: Fixed frequency setpoint<br>1050: MOP setpoint | |
| P1076 = 1.0 | **CI: additional setpoint scaling**<br>Defines the source to scale the additional setpoint.<br>**Common settings:**<br>1: Scaling of 1.0 (100 %)<br>755: Analog input setpoint<br>1024: Fixed frequency setpoint<br>1050: MOP setpoint | |

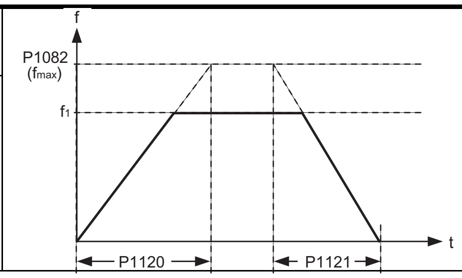
## Skip Frequency

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P1091 = 7.5 | **Skip frequency 1** (entered in Hz)<br>Avoids mechanical resonance effects and suppresses (skips) frequencies in the range around the skip frequency ± P1101 (skip frequency bandwidth). | |
| P1092 = 0.0 | **Skip frequency 2** | |
| P1093 = 0.0 | **Skip frequency 3** | |
| P1094 = 0.0 | **Skip frequency 4** | |
| P1101 = 1.0 | **Skip frequency bandwidth** (entered in Hz) | |




## Ramp times

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P1120 = 8 | **Ramp-up time**<br>Enter the acceleration time in seconds. | |
| P1121 = 5 | **Ramp-down time**<br>Enter the deceleration time in seconds. | |




## Rounding

| Parameter | Description (Factory setting: **bold**) | | Setting |
|---|---|---|---|
| P1130 = 5.0 | **Ramp-up initial rounding time** (in seconds) | The rounding times are recommended, as abrupt responses can be avoided therefore reducing stress and damage to the mechanical system.<br>The ramp-up and ramp-down times are extended by the component of the rounding ramps. | |
| P1131 = 5.0 | **Ramp-up final rounding time** (in seconds) | | |
| P1132 = 5.0 | **Ramp-down initial rounding time** (in seconds) | | |
| P1133 = 5.0 | **Ramp-down final rounding time** (in seconds) | | |
| P1134 = 0 | **Rounding type**<br>**0: continuous smoothing** (jerk-free)<br>1: Discontinuous smoothing<br>**NOTE**: for discontinuous rounding (P1134 = 1), after the setpoint is reduced or an OFF1 command, the final rounding at ramp-up (P1131) and the initial rounding at ramp-down (P1132) are not executed. | | |

## Parameters to set before finishing the application setting

The following parameters should be configured for each application

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P1800 = 4 | **Pulse frequency** (kHz)<br>The pulse frequency can be changed in 2 kHz steps. The range extends from 2 kHz up to 16 kHz. The complete inverter output current at 50 °C is reached with 4 kHz.<br>The maximum output frequency is limited by the pulse frequency. Operation up to 133 Hz is possible with a pulse frequency of 2 kHz. If a higher output frequency is required, then the pulse frequency should also be increased (10 kHz pulse frequency - maximum output frequency of 650 Hz)<br>If low-noise operation is not required, then the inverter losses and the high-frequency disturbances emitted by the inverter can be reduced by selecting lower pulse frequencies. | |
| P2000 = 50 | **Reference frequency** (Hz)<br>The reference frequency in Hertz corresponds to a value of 100 %.<br>This setting should be changed if a maximum frequency of higher than 50 Hz is required.<br>**NOTE**: This scaling acts on the maximum frequency of the analog setpoints, fixed frequencies and motorized potentiometer normalization operations are referred to 100 %. | |
| P2001 = 1000 | **Reference voltage** (V)<br>The reference voltage in Volts (output voltage) corresponds to a value of 100 %.<br>**NOTE**: This setting should only be changed if it is necessary to output the voltage with another scaling. | |
| P2002 = ? | **Reference current** (A)<br>The reference current in Apmeres (output current) corresponds to a value of 100 %. Factory setting is 200 % of the rated motor current (P0305).<br>**NOTE**: This setting should only changed if it is necessary to output the current with another scaling. | |
| P2003 = ? | **Reference torque** (Nm)<br>The reference torque in Newton-metres corresponds to a value of 100 %. Factory setting is 200 % of the rated motor torque, determined from the motor data, for a constant motor torque.<br>**NOTE:** This setting should only changed if it is necessary to output the torque with another scaling. | |
| P2004 = ? | **Reference power** (kW or hp)<br>The reference power in kW or hp corresponds to a value of 100 %. Factory setting is 200 % of ther rated motor power at constant motor torque.<br>This setting should only be changed if it is necessary to output the power with another scaling. | |
| bUSY | Once the save command is given, "bUSY" will be displayed | |
| END | When the save is completed, the display will return to normal and parameterization is complete. | |

## Finishing the application setting

| Parameter | Description (Factory setting: **bold**) | Setting |
|---|---|---|
| P0971 = 1 | **Transfer data from RAM to EEPROM**<br>**0: Disabled**<br>1: Start data transfer, RAM → EEPROM<br>All of the parameter changes are transferred from the RAM into the EEPROM which means that they are saved in a non-volatile state within the Inverter (data is not lost when the power fails).<br>While the transfer is active, "bUSY" will be displayed on the OP. Once the transfer is completed P0970 will be set internally to "0" and the "P0970" will be displayed. | |

### 5.7.5 Series Commissioning

#### Overview

Series commissioning means the possibility to transfer the parameter set from one inverter into a number of other inverters which allows fast commissioning for identical applications (for example series machines or group inverters).

The series commissioning is divided into the following steps:

- create a proper parameter set
- upload this parameter set
- download of the uploaded parameter set into the new inverter

To perform series commissioning an appropriate parameter set must be available. This parameter set can be created by parameterizing an Inverter via OP or STARTER.

**Caution**

Parameter download between different types of control units and of different firmware versions is not recommended.

Basically, it is possible to download parameter sets off different CU types, however, as the parameter sets might differ, the user is fully responsible for the consistency of the downloaded parameter set.

Therefore, the customer has to confirm his responsibility in case of an automatic download by acknowledging F0395.

Once an inverter with an appropriate parameter set is available, the parameter set can be uploaded and in the next step downloaded into the new inverter via OP, STARTER or MMC. The various interfaces are shown in the figure below.

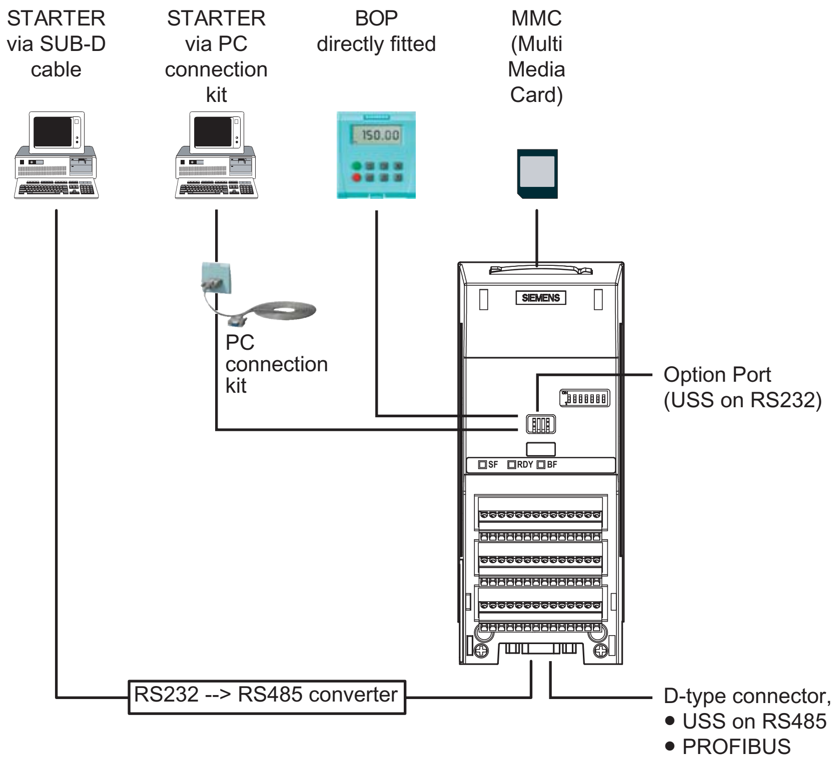



Figure 5-9 Series commissioning interfaces

**Warning**

For series commissioning, all of the communication interfaces as well as also the digital and analog interfaces are re-initialized. This results in a brief communications failure or causes the digital outputs to switch.

Potentially hazardous loads must be carefully secured before starting a series commissioning.

Potentially hazardous loads can be secured as follows before starting series commissioning:

- Lower the load to the floor, or
- Clamp the load using the motor holding brake.

**Note**

**Manual and automatic download**

With a manual download all necessary parameters excluding the safety parameters (only with fail-safe CUs) are downloaded into the inverter. A manual download can be triggered by the customer as described in the following.

With an automatic download even the safety parameters are downloaded into the inverter. An automatic download can only be performed with an MMC at Start-up or after a swapping an inverter component (CU or PM), details are described in the following sections and in the chapter "Operation" of this manual.

### 5.7.5.1 Series commissioning with the OP

#### Upload and download a parameter set with an OP

A single parameter set can be uploaded from an inverter and then downloaded into another inverter.

**Note**

The following important restrictions should be considered when performing upload and download:

- Only the parameter set stored in the EEPROM of the inverter is uploaded to the OP.
- Safety parameter cannot be uploaded to the OP.
- Once the upload or download procedure has started, it should not be interrupted.
- It is possible to uplaod data from inverters of different power and voltage ratings.
- During download, if data are not compatible with the inverter, the default values for the the affected parameter will be written to the inverter.
- During the up or download the "RDY" LED (green) is flashing. After finishing that process successfully the "RDY" LED is on.
- During the upload process any data already held by the OP is overwritten.
- If the download fails, the inverter will not function correctly and the "SF" LED (red) is on.
  - Possible fault messages in case of download failure with OP
    F0055, F0056, F0057 or F0058
  - Possible fault messages in case of download failure with MMC
    F061, F0062 or F0063

**Notice**

After upload and download of parameters between differing Control Units, parameter settings must be checked.

To copy a parameter set from one inverter to another, the following procedure should be performed.

## Upload a parameter set with an OP

### Prerequisites

- An inverter with an apropriate parameter set is available (upload inverter)
- Supply voltage is active for the upload inverter
- The upload inverter is in "Ready State".

| Parameter | Action / Description (Factory setting: **bold**) | Setting |
|---|---|---|
| | **Fit the OP to the Inverter - for the parameter set to be uploaded, perform the following steps:** | |
| P0003 = 3 | **User access level***<br>**1: Standard: Allows access into most frequently used parameters**<br>2: Extended: Allows extended access e.g. to inverter I/O functions<br>3: Expert: For expert use only | |
| P0010 = 30 | **Commissioning parameter***<br>**0: Ready**<br>1: Quick commissioning<br>2: Inverter<br>30: Factory setting, parameter transfer<br>95: Commissioning the fail-safe functions (CUs with Safety-Integrated functions only) | |
| P0802 = 1 | **Transfer data from EEPROM**<br>**0: Disabled**<br>1: Start OP transfer<br>2: Start MMC Transfer<br>While the upload is active "bUSY" will be displayed on the OP and the inverter will not react to any commands. | |
| | If the upload has been completed successfully, P0010 and P0802 will be set to 0 and the OP display will return to normal.<br>If the upload has failed, F00055 (failure while saving parameter on OP) or F00057 (OP fault) will be displayed.<br>In this case attempt another download or perform a factory reset. | |
| | **After a successful upload disconnect the OP from the upload inverter.** | |

## Download a parameter set with an OP

### Prerequisites

- Supply voltage is active for the download inverter
- The download inverter is in "Ready State".

| Parameter | Action / Description (Factory setting: **bold**) | Setting |
|---|---|---|
| | **Fit the OP to the inverter and perform the download according the flow chart.** | |
| P0003 = 3 | **User access level***<br>**1: Standard: Allows access to the most frequently used parameters**<br>2: Extended: Allows extended access e.g. to inverter I/O functions<br>3: Expert: For expert use only | |
| P0010 = 30 | **Commissioning parameter***<br>**0: Ready**<br>1: Quick commissioning<br>2: Inverter<br>30: Factory setting, parameter transfer<br>95: Safety commissioning (for Safety-Integrated CUs only) | |
| P0803 = 1 | **Transfer data to EEPROM**<br>**0: Disabled**<br>1: Start OP transfer<br>2: Start MMC Transfer<br>While the download is active "bUSY" will be displayed on the OP and the inverter will not react to any commands. | |
| | If the download has been completed successfully, P0010 and P0803 will be set to 0 and the OP display will return to normal.<br>If the download has failed, F00055 (failure while saving parameter to EEPROM), F00057 (OP fault) or F00058 (OP contents incompatible) will be displayed.<br>In this case attempt another download or perform a factory reset to allow the inverter to return to a known state. | |
| | **After a successful download the OP can be removed and inserted into another inverter for download. Then perform the download steps again until the series commissioning has been completed for all inverters.** | |

### 5.7.5.2 Series commissioning with STARTER

#### Upload a parameter set with STARTER

**Prerequisites**

- An inverter with an apropriate parameter set is available (upload inverter)
- STARTER is installed on the PC used for series commissioning
- Supply voltage is active for the upload inverter
- The upload inverter is in "Ready State".

**Connect the STARTER PC via the Option Port** (USS on RS232, peer to peer) **to the upload inverter** (PC connection Kit requiered), press the online button **and perform the upload by activating the button** .

---

**Note**

**Upload with STARTER to MMC**

If you want to upload a parameter set with STARTER to an MMC, P0010, P0802 must be set via the expert list.

---

#### Download a parameter set with STARTER

**Prerequisites**

- Supply voltage is active for the download inverter
- The download inverter is in "Ready State".

**Connect the STARTER PC via the Option Port** (USS on RS232, peer to peer) **to the download inverter** (PC connection Kit requiered), press the online button **and perform the download by activating the button** . The data set must be saved in the EEPROM.

---

**Note**

If you want to perform an manual download of a parameter set with STARTER from an MMC, P0010, P0803 and P0804 must be set via the expert list.

---

### 5.7.5.3 Inserting and removing the MMC

## Inserting the MMC

To insert an MMC into the Control Unit of the inverter, the process shown in the figure below should be performed.

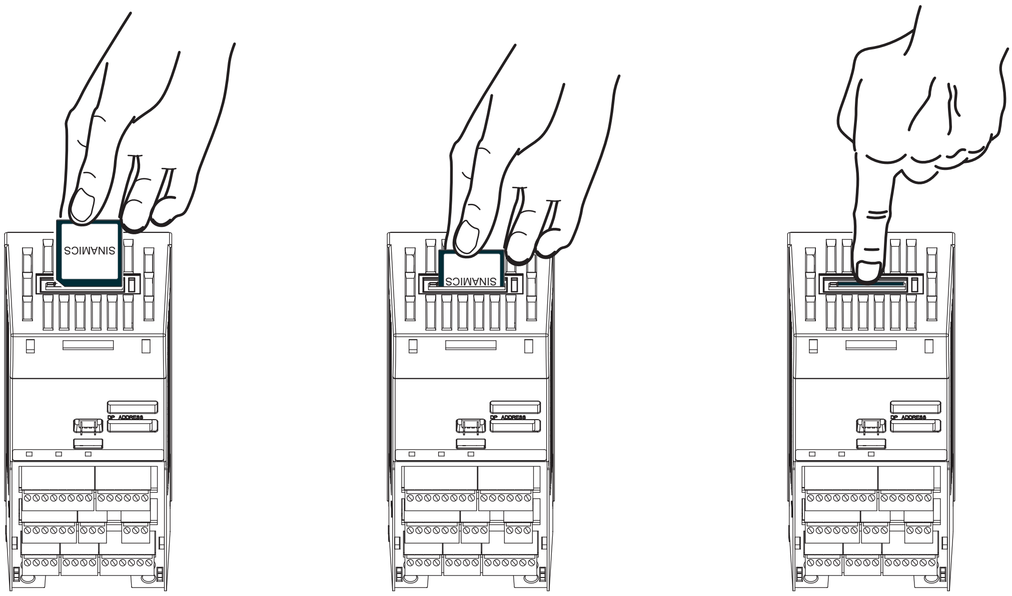


Figure 5-10 Installing the MultiMedia Card (MMC)

## Removing the MMC

To remove the MMC from the Control Unit, the following procedure should be performed:

1. Using a thin-bladed screwdriver, push down the release-catch on the MMC housing.
2. Grasp the MMC gently and pull upwards.

This procedure is shown in the figure below.

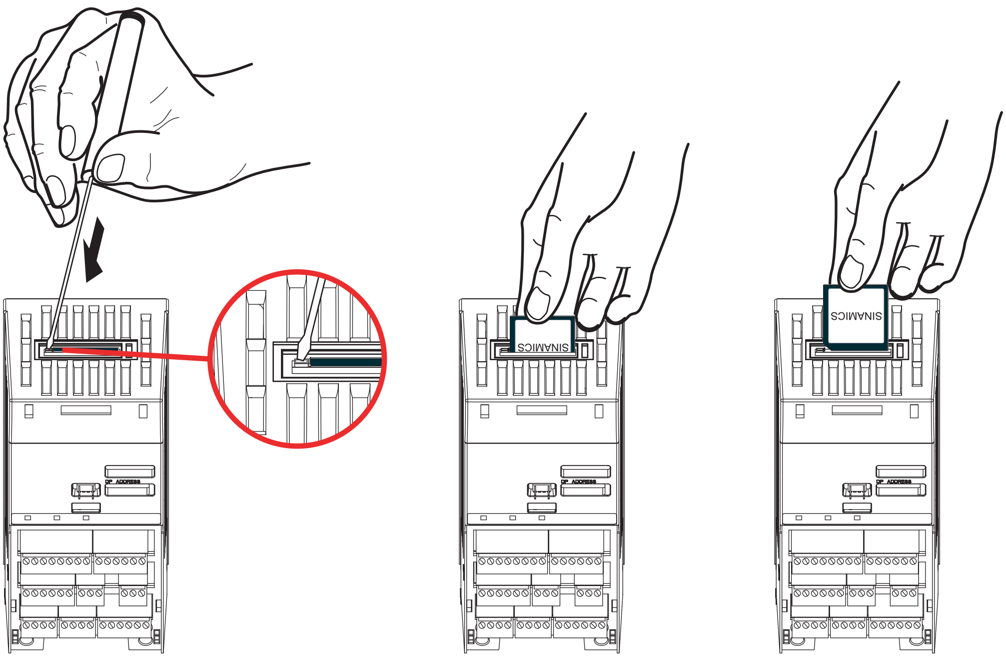



Figure 5-11 Removing the MMC from the Control Unit

### 5.7.5.4 Series commissioning with MMC

## Upload and download a parameter set with an MMC

A parameter set can be uploaded from an inverter and then downloaded into another inverter. The following important restrictions must be considered when using the copying procedure:

- An inverter with an apropriate parameter set is available (upload inverter)
- The upload inverter can be accessed via OP, STARTER or PROFIBUS
- An MMC Type 6SL3254-0AM00-0AA0 is available.

## Upload a parameter set with an MMC

### Prerequisites

To perform a series commissioning with the MMC the following conditions must be fullfiled:

- Supply voltage is active for the upload inverter
- The upload inverter is in "Ready State".

| Parameter | Action/Description (Factory setting: **bold**) | Setting |
|---|---|---|
| | **Insert the MMC to the inverter - for the parameter set to be uploaded, perform the following steps:** | |
| P0010 = 30 | **Commissioning parameter***<br>**0: Ready**<br>1: Quick commissioning<br>2: Inverter<br>30: Factory setting<br>95: Commissioning the fail-safe functions (CUs with Safety-Integrated functions only) | |
| P0804 = ? | **Select Clone file**<br>**0: clone00.bin**<br>…<br>99: clone99.bin | |
| P0802 = 2 | **Transfer data from EEPROM**<br>**0: Disabled**<br>1: Start OP Transfer<br>2: Start MMC Transfer | |
| | If the upload has been completed successfully, P0010 and P0802 will be set to 0 and the "RDY" LED is on.<br>If the upload has failed, F0061 (MMC-PS not fitted) will be displayed, LED "SF" (red) is on. In this case insert an MMC and attempt another upload. | |
| | **After a successful upload remove the MMC from the upload inverter.** | |

## Manual Download of a parameter set with an MMC

**Note**

The following important restrictions should be considered when using the download procedure:

- During the download the inverter will not react to any commands.
- Once the download procedure has started, it cannot be interrupted.
- During download, if the data is not compatible with the inverter, the default values for those parameters will be written into the inverter memory.
- If the download fails, the inverter will not function correctly.

### Prerequisites

- Supply voltage is active for the download inverter
- The download inverter is in "Ready State".

| Parameter | **Action/Description** (Factory setting: **bold**) | **Setting** |
|---|---|---|
| | **Insert the MMC to the download inverter and perform the manual download according the flow chart.** | |
| P0010 = 30 | **Commissioning parameter***<br>0: **Ready**<br>1: Quick commissioning<br>2: Inverter<br>30: Factory setting<br>95: Commissioning the fail-safe functions (CUs with Safety-Integrated functions only) | |
| P0804 = ? | **Select Clone file** (for download)<br>0: **clone00.bin**<br>…<br>99: clone99.bin | |
| P0803 = 2 | **Transfer data to EEPROM**<br>0: **Disabled**<br>1: Start OP Transfer<br>2: Start MMC Transfer | |
| | If the download has been completed successfully, P0010 and P0803 will be set to 0 and the "RDY" LED is on.<br>If the upload has failed, F0061 (MMC-PS not fitted) or F0062 (MMC-PS contents invalid) resp. F0063 (MMC-PS contents incompatible) will be displayed, LED "SF" (red) is on.<br>In this case insert a proper MMC and attempt another download or perform a factory reset. | |
| | **After a successful manually download remove the MMC from inverter and insert it to the next download inverter. Then perform the download steps again until the series commissioning has been completed for all inverters.** | |

## Automatic Download

The automatic download at start-up is controlled via P8458. With the automatic download all necessary parameters including the parameters regarding fail-safe functions are downloaded into the inverter.

---

**Note**

**MMC for "automatic download"**

For an automatic download always the file clone00.bin will be used.

The user has to take care, that clone00.bin (saved as "clone00.bin" with STARTER on PC or via setting P0804 = 00 with the OP) is available on the MMC, used for an automatic parameter download at start-up. Otherwise automatic download will not be porocessed.

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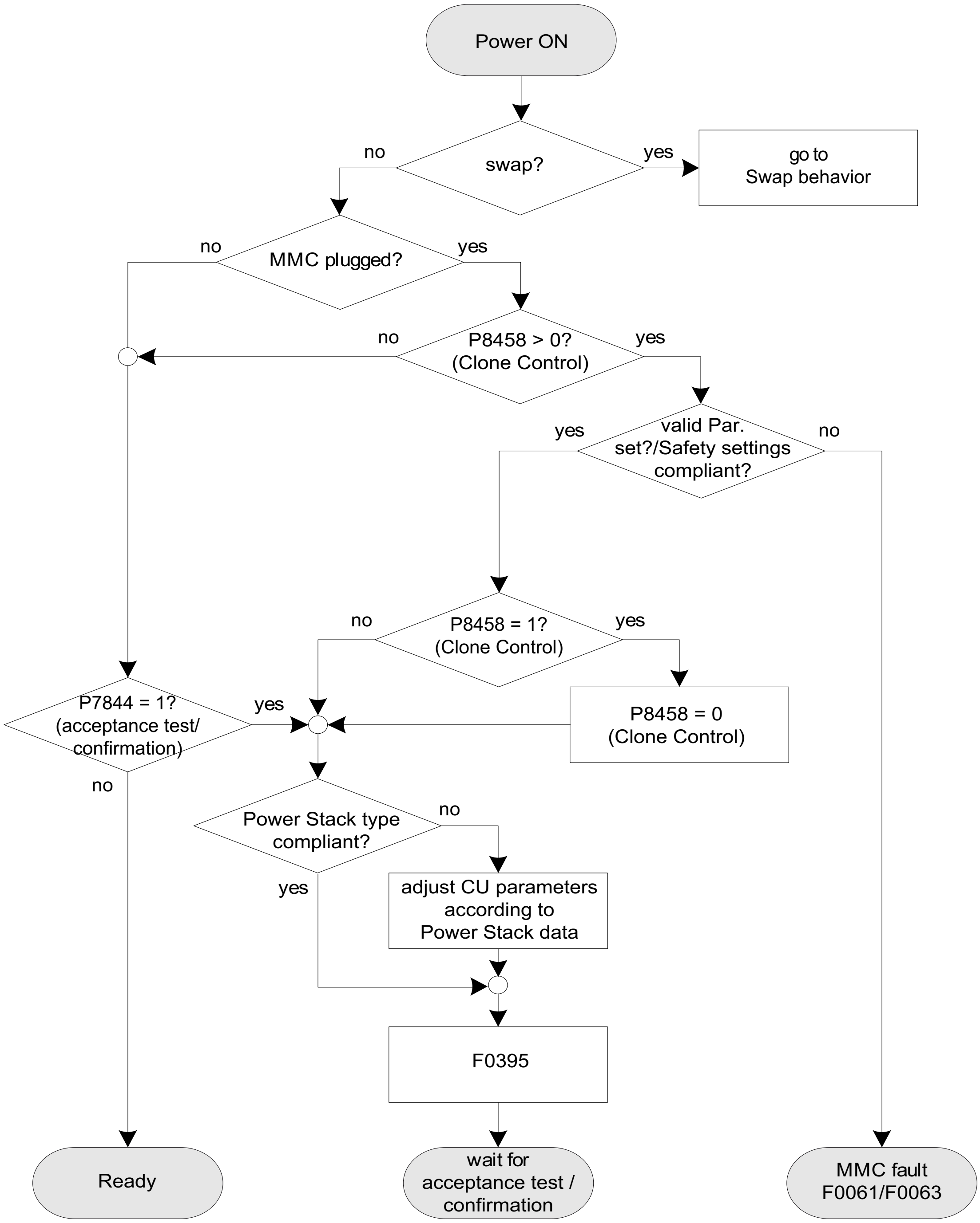


Figure 5-12 Automatic download - overview

The possible settings for P8458 and their functions are given below.

| | |
|---|---|
| P8458 = 0: | Automatic parameter download from the MMC is inhibited. |
| P8458 = 1: | Automatic parameter download from the MMC only at the first start-up of the CU (default setting). |
| P8458 = 2: | Automatic parameter download from the MMC after each start-up of the control unit. |

## Successful automatic download

After a successful automatic download, F0395 will be displayed.

- In case of a standard CU a confirmation is necessary.
- In the case of CUs with safety integrated functions, an acceptance test must be performed.

### Confirmation

On standard CUs the current parameter set needs to be checked and confirmed by clearing F0395. It can be cleared via:

- Digital input or PLC signal (depends on the settings of P0700)
- setting P7844 = 0.

**Warning**

The user is responsible for ensuring that the parameters held in the CU are the correct parameters for their application.

### Acceptance test

On CUs with integrated fail-safe functions it is necessary to do an acceptance test (refer to the "Safety-Integrated functions" section in this manual). To clear F0395 on CUs with integrated fail-safe functions the following procedure has to be followed:

- P0010 = 95
- P9761 = fail-safe password
- P7844 = 0

### Automatic download fault

If the automatic download process fails, the CU will return to the parameter set previously held in the EEPROM and the following fault codes are generated:

Table 5-17 Automatic download fault codes

| Fault code | Description |
|---|---|
| F0061 | Automatic download of parameters was not successful. |
| F0063 | Automatic download of parameters was not successful (e.g. wrong CU). |

In this case check, wether the MMC is defective or a parameter set clone00.bin is available or the parameter set is valid.

## 5.7.6 Reset parameters to factory settings

### Overview

With a factory setting a defined initial state of all of the inverter parameters can be realized.

You can re-establish the initial state by carrying-out a factory via p0970. The factory setting values are designated as "Def" in the parameter list.

After a factory reset, the inverters have the following basic settings:

**CUs with RS485 interface (no PROFIBUS interface)**

- Control using the digital inputs
  - ON/OFF using DI0
  - Direction of rotation reversal using DI1
  - Fault acknowledgement using DI2.
- Setpoint input using analog input 1
- Signal output using the digital outputs
  - Fault active using DO0
  - Warning active using DO1.
- Actual frequency using the analog output
- The basic V/f characteristic is the control mode (P1300 = 0)
- Asynchronous motor (P0300 = 1).

**CUs with PROFIBUS interface**

- For the PROFIBUS variants the command source and setpoint source will be set to PROFIBUS communication.
- The basic V/f characteristic is the control mode (P1300 = 0)
- Asynchronous motor (P0300 = 1).

**Note**

When resetting the parameters to the factory setting, the communications memory is re-initialized. This means that communications are interrupted for the time it takes to perform the reset.

**Warning**

**Safety-Integrated parameters**

When using CUs without safety-integrated functions, only the factory reset with P0970 = 1 must be taken into account.

When using CUs with safety integrated functions two reset methods are available:

- P0970 = 1 resets only non fail-safe function relating parameters (application parameters).
  If a factory reset with P0970 =1 is performed on a Safety-Integrated control unit all application parameters will be reset, previous parameters settings regarding fail-safe functions remain unchanged. This means, no acceptance test has to be performed.
- P0970 = 10 (password protected) resets only fail-safe function relating parameters
  If parameters regarding fail-safe functions must be changed, an acceptance test has to be performed.

## Reset to the factory setting

| Parameter or action | Description |
|---|---|
| P0003 = 1 | **User access level***<br>1: Standard: Allows access into most frequently used parameters. |
| P0004 = 0 | **Parameter filter**<br>0: All parameters |
| P0010 = 30 | **Commissioning parameter***<br>30: Factory setting |
| P0970 = 1 | **Factory reset***<br>1: Parameter reset to the default values |
| BUSY (on OP)<br>Progress bar (STARTER) | The inverter carries-out a parameter reset (duration, approx. 10 s) and then automatically exits the reset menu and sets<br>P0970 = 0: Disabled<br>P0010 = 0: Ready |

**Note**

The following parameters will not be changed with a factory reset:

P0014 Store mode

P0100 Europe / North America

P0201 power stack code number

Data depending on actual Power module

## 5.8 Commissioning the Fail-safe Functions

### Available fail-safe functions

- Safe Torque Off (STO)
- Safe Stop 1 (SS1)
- Safely Limited Speed (SLS)
- Safe Brake Control (SBC).

The signals for STO, SS1 and SLS are connected to the Control Unit, an EM-Brake is connected to the Power Module.

### Command source for fail-safe functions

As command source for the fail-safe signals either the fail-safe terminals (60 … 63) or PROFIsafe can be used (see p9603 and p9803).

---

**Note**

Via terminal you can use up to two of the three safety functions (STO, SS1 and SLS) while via PROFIsafe all three functions are available.

---

When using PROFIsafe as command source the PROFIsafe address per default is identical to the PROFIBUS DP address for the inverter (set in P0918 or via DIP switch).

---

**Note**

The PROFIsafe address can be changed with P9810. This can become necessary if more than one inverter have the same PROFIBUS DP address (e.g. two inverters in different PROIFBUS DP lines of a higher level control, e.g. SIMATIC S7). In this case it is mandatory to change the address not only in P9810, but also in HW-Configuration, otherwise F1640 will occur.

---

### Commissioning parameters regarding fail-safe functions

Parameters regarding fail-safe functions can only be accessed on a Safety Integrated Control Unit (CU), on a standard CU this parameters are not available. For safety reason parameters are handled by pairs and stored on two separate processors within the Safety Integrated CU.

When commissioning of fail-safe functions is completed, checksums for each processor data are created. These checksums are permanently compared. If they differ, the inverter initiates a latched safe torque off (LSTO) state and stops the system.

The access level of the fail-safe function parameters is 3, therefore set P0003 = 3, when using an OP.

To enter the commissioning mode for fail-safe functions set parameter P0010 = 95.

When the safety commissioning mode is initiated a password must be set in parameter P9761. The default password for the system is 12345, it is highly recommended that this password is changed to ensure complete security of the fail-safe function parameters. More detailed description of this process is given in the following flow charts.

The commissioning process of fail-safe functions would normally be accomplished with the use of either the STARTER software or the optional Operator Panel (OP).

When a parameter is modified, the relevant value is transmitted to the relevant processor in the CU. The value is transmitted back to the user interface and can be checked by the processor and the user for correctness.

To complete commissioning of fail-safe functions use parameter P3900 = 10, which accepts all the changes to the safety relevant parameters. All values stored on both processors are checked and if no discrepancies are found the inverter state will change from "safety commissioning" to "ready".

If, however, a discrepancy is found safety commissioning can not be finished. The fault number will be shown in r0947. In this case interrupt the safety commissioning with P3900 = 11 to reload to the former stored safety settings. To reset all safety related parameters to their default values set P0970 = 10.

If a fault is made during safety commissioning, and the system is in an undefined state, it is recommended to perform a safety reset with P0970 = 10.

When changing safety parameters, each parameter will be written to the P1 processor and its equivalent parameter to the P2 processor, for example:

- P9603 – enables the selection of the required safe digital input terminals or PROFIsafe communications for P1 processor.
- P9803 – enables the selection of the required safe digital input terminals or PROFIsafe communications for P2 processor.

To select the PROFIsafe communications, following actions would be performed:

1. P9603 would be set to the value 128.
2. The system would read the change, process the information to the drive processor memory and verify that the information has been received correctly.
3. P9803 would be set to the value 128.
4. The system would read the change, process the information to the communication processor memory and verify that the information has been received correctly.
5. Once both write actions have been verified by the system, a checksum is created.

When commissioning has been completed, a checksum for all the data held in both memories is created and continually checked to verify the integrity of the data.

**Notice**

**Behaviour of inverter on completion of commissioning**

The following behaviour should be noted when commissioning the inverter:

- After commissioning the fail-safe functions the safety parameters are automatically stored in the RAM and EEPROM.
- If an MMC is plugged into the CU, this is not affected by normal commissioning or commissioning the fail-safe functions.
- To save the EEPROM content on a MMC, a transfer EEPROM to MMC via P0802 = 2 must be performed.
- After commissioning the fail-safe functions, an acceptance test must be carried out.

## 5.8.1 Parameters for fail-safe functions

### Parameters for fail-safe functions

The following table gives an overview of all parameters for fail-safe functions. Safety related parameters have access level 3 (P0003 = 3). To modify values of safety related parameters a password is required (P9761). A detailed description is given in the parameter list.

Since there are two processors on CUs with integrated fail-safe functions, they will be distinguished as follows:

- The drive processor will be termed as P1
- The communications processor will be termed as P2.

Table 5-18 Parameters for fail-safe functions

| Parameter | Description | Unit | Default value | Min. value | Max. value |
|---|---|---|---|---|---|
| Drive processor | | | | | |
| P9601 | SI enable parameter | - | 2 | 0 | 2 |
| P9602 | SI enable safe brake monitoring | - | 0 | 0 | 1 |
| P9603 | SI Selection of Safety Source | - | 0 | 0 | 128 |
| P9650 | SI Safe Digital Input debounce delay time | ms | 50 | 0 | 2000 |
| P9651 | SI Safe Digital Input filter delay time | ms | 5 | 0 | 100 |
| P9659 | SI maximum time until test stop | h | 8.0 | 0.1 | 8760.0 |
| r9660 | SI remaining time until test stop | h | - | - | - |
| P9680 | SI braking ramp delay | ms | 250 | 10 | 99000 |
| P9681 | SI braking ramp down time | ms | 10000 | 100 | 99000 |
| P9682 | SI minimum speed for standstill detection | Hz | 5.0 | 2.0 | 20.0 |
| P9690 | SI setpoint for SLS | Hz | 10.0 | 1.0 | 300.0 |
| P9691 | SI tolerance for SLS | Hz | 13.0 | 5.0 | 302.0 |
| P9692 | SI response to selecting SLS | - | 1 | 0 | 2 |
| r9760 | SI internal password | - | 12345 | 1000 | 99999 |
| P9761 | SI input password | - | 0 | 1000 | 99999 |
| P9762 | SI change password | - | 0 | 1000 | 99999 |
| P9793 | SI change password confirmation | - | 0 | 1000 | 99999 |
| r9770 | SI Firmware version | - | - | - | - |
| r9771 | SI hardware functions | - | - | - | - |
| r9772 | SI status word | - | - | - | - |
| r9798 | SI display checksum | - | 0000h | 0000h | FFFFh |
| P9799 | SI parameter checksum | - | 0000h | 0000h | FFFFh |
| P9810 | PROFIsafe destination address | - | 0 | 0 | 65534 |
| Communication processor | | | | | |
| P9801 | SI enable parameter | - | 2 | 0 | 2 |
| P9802 | SI enable safe brake monitoring | - | 0 | 0 | 1 |
| P9803 | SI Selection of Safety Source | - | 0 | 0 | 128 |
| P9850 | SI Safe Digital Input debounce delay time | s | 0.050 | 0.000 | 2.000 |
| P9851 | SI Safe Digital Input filter delay time | s | 0.005 | 0.000 | 0.100 |
| P9880 | SI braking ramp delay | s | 0.250 | 0.010 | 99.000 |
| P9881 | SI braking ramp down time | s | 10.000 | 0.100 | 99.000 |
| P9882 | SI minimum speed for standstill detection | kHz | 0.005 | 0.002 | 0.020 |
| P9890 | SI setpoint for SLS | kHz | 0.010 | 0.001 | 0.300 |
| P9891 | SI tolerance for SLS | kHz | 0.013 | 0.005 | 0.302 |
| P9892 | SI response to selecting SLS | - | 1 | 0 | 2 |
| r9898 | SI display checksum | - | 0000h | 0000h | FFFFh |
| P9899 | SI parameter checksum | - | 0000h | 0000h | FFFFh |

## 5.8.2 Password for fail-safe functions

### Password for fail-safe functions

There are four parameters associated with the password protection system. All these parameters require level 3 access (only important when using OP) – the parameters are as follows:

- r9760 – shows the currently valid password for fail-safe function parameters.
- P9761 – used to enter the password.
- P9762 – used for entering a new password (5 digits with no leading zero (0)).
- P9763 – used to confirm a new password.

When a password is entered (5 digits with no leading zero), it is compared with the password held in r9760.

If correct, access is granted.

If incorrect, the parameters for fail-safe functions will be locked out and the user will have to manually exit the commissioning mode for fail-safe functions by using parameter P3900 = 11 which cancels all previous changes to the parameters for fail-safe functions.

To change the password see "General steps for commissioning of fail-safe functions"

## 5.8.3 Checksums

### Checksums

All parameters for fail-safe functions are verified by the use of checksums. These checksums ensure the integrity of the data held within the drive processors memory.

There are four checksum, two for each of the processors, these are:

- r9798 – actual checksum for P1.
- P9799 – reference checksum for P1.
- r9898 – actual checksum for P2.
- P9899 – reference checksum for P2.

### 5.8.4 General steps for commissioning fail-safe functions

#### General steps to change fail-safety funcitons

The parameters designated with an "*" offer more setting possibilities than are listed here. Refer to the parameter list for additional setting possibilities.

The following steps must always be carried-out when changing fail-safe functions:

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P0003 = 3 | **User access level***<br>3: Expert: For expert use only | | 1 | 0 | 4 |
| P0010 = 95 | **Commissioning parameter***<br>95: Commissioning the fail-safe functions | | 0 | 0 | 95 |
| P9761 | **SI input password**<br>The safety password is entered in this parameter to get access to change fail-safe function parameters. | - | 0 | 1000 | 99999 |
| **Change requested safety parameters, then finish the parameterization with the following steps:** | | | | | |
| P9799 | **Checksum for SI parameters**<br>Checksum of the fail-safe function parameters.<br>Enter value of r9798 | - | 000h | 000h | FFFFh |
| P9899 | **Checksum for SI parameters**<br>Checksum of the fail-safe function parameters.<br>Enter value of r9898 | - | 000h | 000h | FFFFh |
| P3900 = 10 | **End of the safety commissioning***<br>10: Accept changes of fail-safe function parameters<br>11: Cancel changes of fail-safe function parameters | | 0 | 0 | 11 |

### 5.8.5 Common safety flow charts

#### Change password

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9761 | **SI input password**<br>The safety password is entered in this parameter to get access to change the safety parameters. | - | 0 | 1000 | 99999 |
| P9762 | **SI change password**<br>Enter the new password. The password must have 5 digits but no leading zero (0). | - | 0 | 1000 | 99999 |
| P9763 | **SI change password confirmation**<br>The new password must be confirmed here. If P9762 and P9763 are the same, then this value is written into r9760. In the future, safety parameters can be accessed by entering this password into P9761. | - | 0 | 1000 | 99999 |

### Enabling fail-safe functions

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9601 = ? | **SI enable parameter**<br>Safety parameter for enabling the individual safety control functions.<br>Bit 00 = 1/0: Reserved<br>Bit 01 = 1/0: Activation/deactivation of the forced dynamisation after STO | - | 2 | 0 | 2 |
| P9801 = ? | **SI enable parameter**<br>Refer to P9601 | - | 2 | 0 | 2 |

### Enable fail-safe brake monitoring

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9602 = ? | **SI enable safe brake monitoring**<br>0: Disable monitoring of safe brake control<br>1: Enable monitoring of safe brake control | - | 0 | 0 | 1 |
| P9802 = ? | **SI enable safe brake monitoring**<br>Refer to P9602 | - | 0 | 0 | 1 |

### Select fail-safety command source

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9603 = ? | **SI Selection of Safety Source**<br>Safety parameter for selection of the safety input signals. The safety input signals can be taken either from PROFIsafe or from the digital inputs of G120.<br>Selects either safe digital inputs or PROFIsafe .<br>• Bit 00 = 1/0: SLS activated/deactivated via FDI1A and FDI1B<br>• Bit 01 = 1/0: SLS activated/deactivated via FDI0A and FDI0B<br>• Bit 02 = 1/0: SS1 activated/deactivated via FDI1A and FDI1B<br>• Bit 03 = 1/0: SS1 activated/deactivated FDI0A and FDI0B<br>• Bit 04 = 1/0: STO activated/deactivated FDI1A and FDI1B<br>• Bit 05 = 1/0: STO activated/deactivated FDI0A and FDI0B<br>• Bit 07 = 1/0: SLS, SS1 and STO activated/deactivated via PROFIsafe<br>**Note**:<br>• If Bit 07 = 1, all other bits must be set 0 | - | 0 | 0 | 128 |
| P9803 = ? | **Selection of safety command source**<br>Refer to P9603 | - | 0 | 0 | 128 |

## Consistency check time of fail-safe digital inputs

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9650 = ? | **Safe input debounce delay time**<br>Defines the maximum allowed debounce delay between the two safe digital input pins. If both safe digital inputs are not consistent after this time a fault will be generated (1600.108 or 1600.208). | ms | 50 | 0 | 2000 |
| P9850 = ? | **Safe input debounce delay time**<br>Refer to P9650. | s | 0.050 | 0.000 | 2.000 |

## Filter time of fail-safe digital inputs

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9651 = ? | **Safe input filter delay time**<br>Defines the response time delay of the safe digital inputs. Signals that are shorter than the specified time are not processed as fail-safe signals but ignored. Any noise occures shorter than filter time has no effect to level of fail-safe digital inputs | ms | 5 | 0 | 1000 |
| P9851 = ? | **Safe input filter delay time**<br>Refer to P9650. | s | 0.005 | 0.000 | 1.000 |

## Test stop interval setting

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9659 = ? | **SI maximum time until test stop***<br>The time interval between test stops is specified. The remaining time until a test stop is required is shown in r9660. When r9660 reaches zero, the time interval has expired and warning A1699 is activated. The warning solely informs that a test stop is required. The user should activate a test stop on the next occasion. The drive functionality will not be affected by the warning.<br>The test stop is activated in the following cases:<br>• after each power-up<br>• on selecting the STO when Bit 01 in P9601/P9801 is set<br>• when leaving the latched safe torque off (LSTO).<br>During the test stop the shutdown paths are checked and a processor selftest runs. The timer for the forced dynamisation (see r9660) is reset to the default value specified in P9659 and warning A1699 is cleared under the following conditions:<br>• after reducing P9659 below the current value in r9660,<br>• after each power-up<br>• on selecting the STO when Bit 01 in P9601/P9801 is set and the test is complete<br>• when leaving the LSTO when the test is complete.<br>The default value is 8 hours.<br>**Note:**<br>For safety reasons, it is necessary to initiate the safe standstill as a test at intervals of maximum 8 hours in order to check the operability of the safety system. Thus, 8 hours after the last activation of the safe standstill the inverter sets a status bit (r9772, Bit 15) and generates warning A1699. The process control (i.e. PLC) must then initiate the safe standstill at the next opportunity, for example, when the drive has already a short phase with zero speed. Provided the dynamisation has not been deactivated (see parameters P9601/P9801, Bit 01), the safety hardware is tested once the safe standstill is active. If the inverter returns the "Safe torque off (STO) selected" (r9772, Bit 01) status signal, the safe standstill can be released again since part of the test is continued in the background. The immediate switch-on will be inhibited for approximately 2.4 seconds. Once the self test is complete the dynamisation bit (Bit 15 of r9772) is cleared automatically. The higher level control (i.e. PLC) must log the setting and clearing of the status bit and the dynamisation bit. To detect errors while writing and storing safety-relevant data, the control should fetch cyclically at 8 hour intervals all safety-related parameters and compare them with the expected values. Should there be a difference, the safety signals (STO or SS1) should be used to initiate a safe standstill and to issue a fault message.<br>This action must also be logged appropriately. | h | 8.0 | 0.1 | 8760.0 |

## Safe Stop 1 setting

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9680 = ? | **SI braking ramp delay**<br>Time [in ms] between selecting the safe braking ramp (SBR) and the activation of the monitoring ramp. The actual frequency is compared to the frequency of the monitoring ramp when the SBR is active. If the actual frequency exceeds that of the monitoring ramp, an latched safe torge off (LSTO) is generated. For applications with changing loads, an increase of P9680/P9880 or P9691/P9891 is recommended. A larger deviation of the actual frequency from the reference is then acceptable.<br>**Note:**<br>A value of 99000 would deactivate the SBR monitoring, this value therefore is not allowed. Set P9880 accordingly. The ramping on selection of SLS or SS1 will however still follow the ramping time in P9681/P9881. | ms | 250 | 10 | 99000 |
| P9880 = ? | **SI braking ramp delay**<br>Refer to P9680. | s | 0.250 | 0.010 | 99.000 |
| P9681 = ? | **SI braking ramp-down time**<br>Defines the braking ramp-down time for the dafe braking ramp (SBR) in seconds. The ramp-down time is used for the SBR and the monitoring ramp. The total braking time Tx can be derived where fx is the current frequency according to the following formulas:<br>a) For activation of the SLS: Tx = P9681 * (fx - P9690)/200 Hz<br>b) For activation of SS1: Tx = P9681 * (fx - P9682)/200 Hz<br>**Note:**<br>In contrast to other ramping times (e.g. p1120, p1121), the safety braking time is referred to 200Hz and not to p1082. See formulas above. | ms | 10000 | 100 | 99000 |
| P9881 = ? | **SI braking ramp-down time**<br>Refer to P9681. | s | 10.000 | 0.100 | 99.000 |
| P9682 = ? | **SI minimum speed for standstill detection**<br>A speed below the threshold of P9682/P9882 is considered standstill. If the SS1 has been selected, the safe standstill (STO) will be activated. | Hz | 5.0 | 2.0 | 20.0 |
| P9882 = ? | **SI minimum speed for standstill detection**<br>Refer to P9682. | kHz | 0.005 | 0.002 | 0.020 |

## Safely-limited Speed

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| P9690 | **SI setpoint for SLS**<br>Speed setpoint that is used when the safely limited speed (SLS) is selected. Depending on the setting in P9692/P9892 the frequency of P9690/P9890 may also serve as a speed threshold instead of a setpoint (see P9692).<br>**Note:**<br>For applications with changing loads, an increase of P9680/P9880 or | Hz | 10.0 | 2.0 | 300.0 |

| Parameter | Description | Unit | Default | Min. | Max. |
|---|---|---|---|---|---|
| | P9691/P9891 is recommended. If the "safely limited speed" (SLS) is selected while the actual speed is below the setpoint value, Bit 04 and Bit 05 will be set simultanously in r9772. | | | | |
| P9890 | **SI setpoint for SLS**<br>Refer to P9690. | kHz | 0.010 | 0.002 | 0.300 |
| P9691 | **SI tolerance for SLS**<br>Upper tolerance margin for the SLS. If the actual frequency at initiation of the safely limited speed lies below the value of P9691/P9891 and later on exceeds that value an latched safe torque off (LSTO) is generated. The tolerance defined by the difference P9691 to P9690 (or P9891 to P9890) is also used for the monitoring ramp when the SBR is active. For applications with changing loads it is recommended to increase P9691/P9891.<br>**Note:**<br>The value in P9691 needs to be larger than the value in P9690. This condition is checked when leaving the safety commissioning. | Hz | 13.0 | 5.0 | 302.0 |
| P9891 | **SI tolerance for SLS**<br>Refer to P9691. | kHz | 0.013 | 0.005 | 0.302 |
| P9692 | **SI response to selecting SLS**<br>Response if, after the initiation of safely limited speed (SLS), the speed is higher than the limit value:<br>• 0:<br>Activation of the speed monitoring and disabling the set value channel. If the actual speed at initiation of SLS exceeds the parameterized speed limit the latched safe torque off is initiated.<br>• 1<br>Braking to the set speed with safe braking ramp, then activation of the monitoring function and disabling the set value channel.<br>• 2<br>The monitoring is activated at once. If the actual speed at initiation of SLS exceeds the parameterized speed limit the latched safe torque off is initiated. The set value channel is not disabled. | - | 1 | 0 | 2 |
| P9892 | **SI response to selecting SLS**<br>Refer to P9692. | - | 1 | 0 | 2 |

## 5.8.6 Safety factory reset

### Safety factory reset

The safety factory reset sets all safety-related parameters to its default value except the following:

- P9760 Safety-Integrated password
- P9761 Safety-Integrated password input
- P9762 New safety-integrated password input
- P9763 New safety-integrated password confirmation

### Procedure for resetting the fail-safe related parameters

| Parameter | **Description** (Factory setting: **bold**) |
|---|---|
| P0003 = 3 | **User access level***<br>1: Standard: Allows access into most frequently used parameters.<br>2: Extended: Allows extended access e.g. to inverter I/O functions<br>3: Expert: For expert use only |
| P0004 = 0 | **Parameter filter***<br>0: All parameters |
| P0010 = 30 | **Commissioning parameter***<br>0: Ready<br>30: Factory setting, parameter transfer |
| P9761 | **SI input password**<br>Enter the safety password |
| P0970 = 10 | **Factory reset***<br>**0: Disabled**<br>1: Parameter reset<br>10: Safety reset |
| BUSY (on OP) | The inverter carries-out a reset of the fail-safe related parameters (duration, approx. 10 s) and then automatically exists the reset menu and sets<br>P0010 = 0: Ready<br>P0970 = 0: Disabled |

## 5.8.7 Acceptance Test and Acceptance Log

### Description

In order to verify the parameters for the fail-safe functions, an acceptance test must be carried-out after commissioning, reset and also when changing a completely backed-up data set of the parameters for the fail-safe functions (e.g. by MMC). This acceptance test must be appropriately logged and documented. An example for an appropriate acceptance log is included in the Appendix. The acceptance logs should be adequately archived.

### Acceptance test

The machinery construction company (OEM) must carry-out an acceptance test for the fail-safe functions that have been activated at the machine.

### Authorized person, acceptance log

Appropriately authorized personnel must test each of the fail-safe functions. These must be documented/logged in an acceptance log and must be signed. The acceptance log must be inserted/attached in/to the logbook of the machine

Authorized in this case means a person from the machinery construction company (OEM) that as a result of their training and knowledge regarding the fail-safe functions, can appropriately carry-out an acceptance test.

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Note

The information/instructions and descriptive information regarding commissioning in Section "Commissioning the fail-safe applications" of this Manual must be carefully observed.

If parameters for the fail-safe functions are changed, then a new acceptance test must be carried-out and included as acceptance log.

The template for the acceptance log is provided in printed form as example or recommendation in this Operating Instructions.

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## Contents of a complete acceptance test

### Documentation

Documentation of the machine including the fail-safe functions.

- Machine description and overview/block diagram
- Fail-safe functions for each drive
- Description of the fail-safe devices/equipment.

### Function test

Checking the individual fail-safe functions that are used.

- "Safe Torque Off" (STO)
- "Safe Stop 1" (SS1)
- "Safely-Limited Speed" (SLS)
- "Safe Brake Control" (SBC).

### Completing the log

Document/log the commissioning phase and sign.

- Check the parameters of the fail-safe functions
- Document/log the checksums
- Provide proof that data has been backed-up/archived
- Sign.

### Attachment

Measuring traces/plots associated with the function test.

- Alarm logs
- Trace plots.

---

**Note**

A form for an acceptance log is attached in the appendix of the operating instructions.

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# 5.9 Commissioning with PROFIBUS DP

## 5.9.1 PROFIdrive Profile

### User data structure defined in PROFIdrive Profile 4.0

The SINAMICS G120 is controlled through the cyclical PROFIBUS DP channel. The structure of user data for the cyclical/acyclical channel is defined in the PROFIdrive Profile, version 4.0.

The PROFIdrive Profile defines for the inverters, the user data structure with which a master can access the inverter slaves using the cyclical data communication method.

## 5.9.2 Using the PROFIBUS DP interface

### Using the PROFIBUS DP interface

Prior to using the PROFIBUS DP interface, the address of the node (inverter) must be set.

### Setting the PROFIBUS DP address

There are two methods for setting the PROFIBUS DP address:

- Using the seven DIP-switches on the Control Unit or
- Using parameter "P0918".

**Caution**

The inverter power supply must be switched off before the DIP-switch settings are changed. DIP-switch setting changes do not take effect until the Control Unit has been powered-up again. The restart must be initiated by switching the power off and then on again, irrespective of whether the interface is supplied from the inverter mains supply or its own, separate 24 V connection.

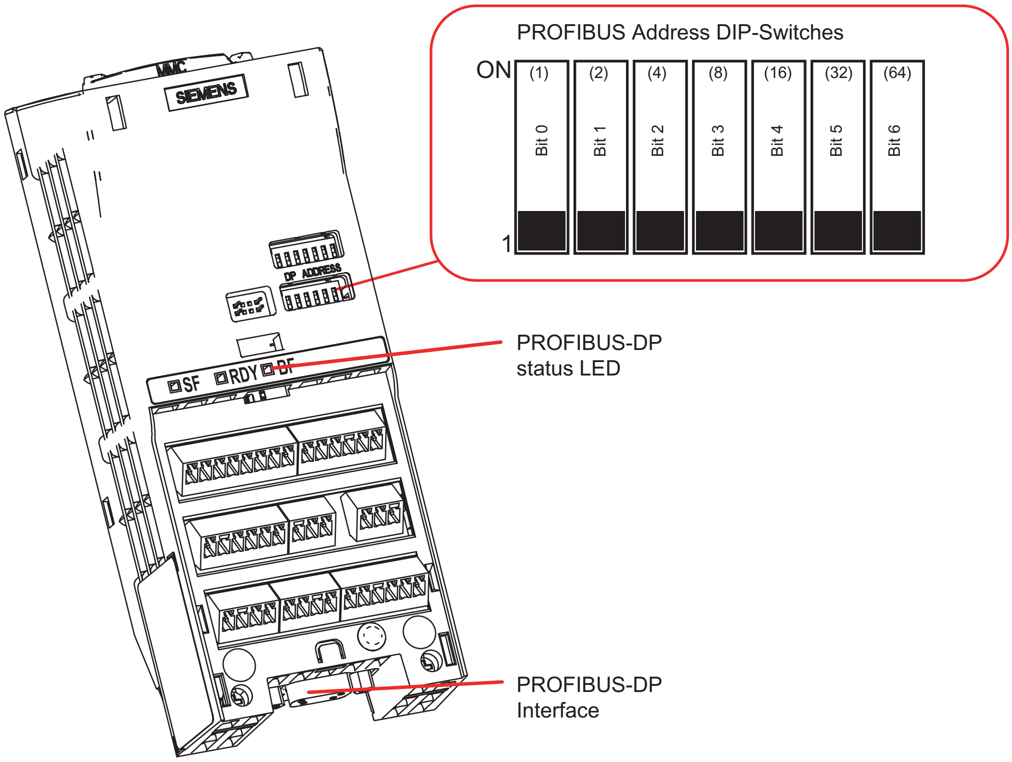


Figure 5-13 PROFIBUS DP address DIP-switches

The PROFIBUS DP address can be set between 1 and 125, as shown in the table below.

Table 5-19 Example address for the PROFIBUS DP interface

| DIP switch | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Add to address | 1 | 2 | 4 | 8 | 16 | 32 | 64 |
| Example 1: Address = 3 = 1 + 2 | | | | | | | |
| Example 2: Address = 88 = 8 + 16 + 64 | | | | | | | |

Some "addresses" have a specific purpose, as shown in the table below:

Table 5-20 PROFIBUS DP address

| Dip switch settings | Meaning |
|---|---|
| 0 | PROFIBUS DP address is determined by P0918 |
| 1 … 125 | Valid PROFIBUS DP address |
| 126, 127 | Invalid PROFIBUS DP address |

## PROFIBUS DP parameters

The following parameters must be set to start-up the PROFIBUS DP interface:

Table 5-21 PROFIBUS DP parameters

| Parameter | Content |
|---|---|
| P0918 | PROFIBUS address |
| P0700 | Fast selection command source |
| P0922 | Selects the PROFIBUS telegram standard |
| P1000 | Fast selection frequency setpoint |
| P2038 | Selects the communications profile |
| P2042 | Selects if native ident number or NAMUR ident number is send to the PLC |
| r2050 | Process data setpoint source (BICO) |
| P2051 | Process data actual values (BICO) |
| P2041 | Communication board functions |
| P2040 | Process data telegram failure time |
| P0927 | Modification source for parameters |
| r2054 | Communication board diagnostics |

### P0918 PROFIBUS Address

- If address 0 is set on the DIP-switches of the Control Unit (default setting), then the PROFIBUS DP address can be changed in parameter P0918. Valid settings are 1 to 125 (default = 3).
- Once a valid PROFIBUS DP address has been set on the DIP-switches, parameter P0918 can no longer be changed. In this case, the parameter displays the PROFIBUS DP address as set on the DIP-switches.

### P0700 and P1000 Fast selection

- The control word and setpoint sources can be selected quickly in parameters P0700 (select command source) and P1000 (select frequency setpoint) respectively.

### r2050 and P2051 BICO

- Much greater flexibility is afforded by the interconnection of process data using binectors/connectors.
- Detailed connection of setpoints and actual values to and from the PROFIBUS DP interface is parameterized in r2050 and P2051.
- The following table shows the parameters specific to the PROFIBUS DP interface relating to the connection of process data:

Table 5-22 Parameters for flexible interconnection of process data

| Telegram | PZD1 STW/ZSW | PZD2 HSW/HIW | PZD3 | PZD4 |
|---|---|---|---|---|
| Link values for setpoints master to inverter | r2050.00 | r2050.01 | r2050.02 | r2050.03 |
| Link parameters for actual values inverter to master | P2051.00 | P2051.01 | P2051.02 | P2051.03 |

**Note**

r2050 also acts as a display parameter through which the setpoints received by the PROFIBUS DP interface can be checked.

### P2041 PROFIBUS DP functions

A number of advanced property settings for the PROFIBUS DP interface can be accomplished using the indexed parameter P2041.

For most applications, however, the defaults values are adequate (value = 0). The following table shows the property setting options.

Table 5-23 PROFIBUS DP functions

| Parameter | Meaning | Value range |
|---|---|---|
| P2041.01 | OP parameter in EEPROM: Modifications to parameter settings via SIMATIC HMI are stored permanently in the EEPROM or as volatile data in the RAM. | 0: Permanent (EEPROM)<br>1: Volatile (RAM) |
| P2041.03 | Select displayed diagnostics screen. | 0: Standard diagnostics<br>>0: Special diagnostics (for SIEMENS internal use only) |

**Caution**

The watchdog function should not be deactivated! If the monitoring function is deactivated and the PROFIBUS DP interface fails, the inverter will not recognize a fault condition and continue to operate even if a fault condition exists.

### Process data monitoring

Two parameters determine how process data are monitored:

- watchdog function on the PROFIBUS DP interface (standard slave function according to PROFIBUS)
  The watchdog function on the PROFIBUS DP interface is normally activated. It can be deactivated by means of the PROFIBUS master configuring tool.
- Monitoring of the telegram failure time in the converter with parameter P2040

### P2040 Telegram failure time

Parameter P2040 defines the time after which a fault will be generated (F0070) if no telegram is received through the PROFIBUS DP interface.

- P2040 = 0 means: No monitoring
- P2040 > 0 means: The time in milliseconds after which a fault condition will be generated if a setpoint telegram has not been received.

The fault conditions (F0070) is activated if no new setpoints are received by the PROFIBUS DP interface within the telegram failure period.

**Caution**

Shutdown on faults can only take place if both monitoring functions are activated!

When the PROFIBUS DP interface is in operation, parameter P2040 should also be set to a value of > 0. The process data monitoring function is thus activated/deactivated solely using the PROFIBUS watchdog function. The monitoring time then corresponds to the watchdog time setting plus the time set in P2040.

**Note**

Process data whose complete control word (PZD1) is set to zero are not transferred from the PROFIBUS DP interface to the inverter.

Result: Alarm A0703 and possibly fault F0070.

**P0927 Modification source for parameters**

This parameter defines the interface through which parameters can be modified.

| Bit | Description | Index | |
|---|---|---|---|
| 0 | PROFIBUS DP | 0: No | 1: Yes |
| 1 | BOP | 0: No | 1: Yes |
| 2 | PC-Inverter Kit | 0: No | 1: Yes |
| 3 | RS485 | 0: No | 1: Yes |

The default setting for all bits is 1, i.e. parameters can be modified from all sources.

## 5.9.3 Data structures within PROFIdrive Profile

### User data structure defined in PROFIdrive Profile 4.0

The SINAMICS G120 is controlled through the cyclical PROFIBUS DP channel. The structure of user data for the cyclical/acyclical channel is defined in the PROFIdrive Profile, version 4.0.

The PROFIdrive Profile defines for the inverters, the user data structure with which a master can access the inverter slaves using the cyclical/acyclical data communication method.

### Extended configuration for the SINAMICS G120

Up to 6 process data words (PZD), with a different number of setpoints and actual values if desired, can be configured on the SINAMICS G120. They are combined to standard and manufacturer-specific telegrams.

### Telegrams

The selection of a telegram via P0922 determines on the drive unit side which process data is transferred between master and slave.

From the perspective of the slave, the received process data comprises the receive words and the process data to be sent the send words.

The receive and send words comprise the following elements:

- Receive words: Control words or setpoints
- Send words: Status words or actual values

### Used telegram types

The following telegrams can be set via parameter P0922:

#### Standard telegrams

The standard telegrams are structured in accordance with the PROFIdrive Profile. The internal process data links are set up automatically in accordance with the telegram number setting.

- Telegram 1 Speed control, 2 words
- Telegram 20 Speed control, VIK/NAMUR

#### Manufacturer-specific telegrams

The manufacturer-specific telegrams are structured in accordance with internal company specifications. The internal process data links are set up automatically in accordance with the telegram number setting.

- Telegram 350 Speed control, 4 words
- Telegram 352 Speed control, PCS7

#### Device-specific telegrams

The send and receive telegrams can be configured as required by using BICO technology to interconnect the send and receive process data.

- Telegram 999 Free interconnection via BICO (up to 6 dat words)

## 5.9.4 Telegram structure

### 5.9.4.1 Standard Telegram structure

#### BICO connection

When a telegram is selected, the corresponding BICO connection parameters will be fixed and cannot be changed (except P0701 and the following digital inputs). If P0922 = 999, it keeps the actual BICO connection parameters but now BICO parameters can be changed.

| Telegram | Function in the drive | PZD1 | PZD2 | PZD3 | PZD4 | PZD5 | PZD6 |
|---|---|---|---|---|---|---|---|
| 1 | Speed control, 2 words | STW1 | NSOLL_A | ⟸ Receive telegram from PROFIBUS | | | |
| | | ZSW1 | NIST_A | ⟹ Send telegram to PROFIBUS | | | |
| 350 | Speed control, 4 words | STW1 | NSOLL_A | M_LIM | STW2 | | |
| | | ZSW1 | NIST_A _GLATT | IAIST_ GLATT | ZSW2 | | |
| 352 | Speed control, PCS7 | STW1 | NSOLL_A | <3> | <3> | <3> | <3> |
| | | ZSW1 | NIST_A _GLATT | IAIST_ GLATT | MIST_ GLATT | FAULT_ CODE | WARN_ CODE |
| 999 | Free interconnection via BICO | STW1 <1> | Length can be freely selected via the central PROFIBUS configuring in master (max. 6 PZD) <2> | | | | |
| | | ZSW1 <1> | Length can be freely selected via the central PROFIBUS configuring in master (max. 6 PZD) <2> | | | | |

<1> In order to comply with the PROFIdrive profile, PZD1 must be used as STW1 or ZSW1
<2> Stucture like a standard telegram
<3> Placeholder for PCS7 process data

| | | | |
|---|---|---|---|
| STW1/2 (r2090/r2091) | Control word 1/2 | MIST (r0031) | Torque actual value |
| ZSW1/2 (r0052/r0053) | Status word 1/2 | PIST (r0032) | Active Power |
| NSOLL_A *) (P1070) | Speed setpoint A (16 bit) | M_LIM (P1522) | Torque limit |
| NIST_A *) (r0021) | Speed actual value A (16 bit) | FAULT_CODE (r2131) | Fault code |
| IA_IST (r0027) | Output current | WARN_CODE (r2132) | Warn code |

*) NSOLL_A, NIST_A are FSOLL and FIST for SINAMICS G120

Figure 5-14 Standard telegrams with different settings of P0922

### 5.9.4.2 VIK/NAMUR Telegram structure

## Description

| Telegram | Function in the drive | PZD1 | PZD2 | PZD3 | PZD4 | PZD5 | PZD6 |
|---|---|---|---|---|---|---|---|
| 20 | Speed control, VIK/NAMUR | STW1 | NSOLL_A | | | | |
| | | ZSW1 | NIST_A_GLATT | IAIST_GLATT | MIST_GLATT | PIST_GLATT | <1> |

<1> Freely interconnectable (default: P2051[5] = r3113 “Fault Bit Array”)

| | | | |
|---|---|---|---|
| STW1 (r2090/r2091) | Control word 1 | IA_IST (r0027) | Output current |
| ZSW1 (r0052/r0053) | Status word 1 | MIST (r0031) | Torque actual value |
| NSOLL_A *) (P1070) | Speed setpoint A (16 bit) | PIST (r0032) | Active Power |
| NIST_A *) (r0021) | Speed actual value A (16 bit) | | |

*) NSOLL_A, NIST_A are FSOLL and FIST for SINAMICS G120

Figure 5-15 Telegram structure VIK/NAMUR

If VIK/NAMUR telegram is selected with P0922 = 20, the parameter P2038 "Selection of actual profile" will be set to VIK/NAMUR automatically.

It is also necessary to set the ident number (GSD) via parameter P2042:

- SIMATIC Object Manager (Slave-OM)

  For drives configured with SIMATIC Object Manager (Slave-OM) parameter P2042 has to be set to 0 (default).

- VIK/NAMUR GSD (Device Data File)

  For all other configurations the setting of parameter P2042 must be changed to 1 (NAMUR). That means that the VIK/NAMUR ID of the PROFIBUS Nutzerorganisation (PNO) will be send to the PLC.

---

**Note**

To change back from VIK/NAMUR to Standard telegrams it is necessary to set P0922 = 999 (Free BICO connection) and then reset P2038 and P2042 to PROFIdrive Profile. If P0922 = 999, it keeps the actual BICO connection parameters but now BICO parameters can be changed.

---

### 5.9.4.3 PROFIsafe telegramm structure

#### Description

The fail-safe functions can be triggered via the fail-safe digital inputs FDI0 and FDI1 or via PROFIsafe signals (see P9603 and 9803).

To use PROFIsafe for triggering the fail-safe functions the G120 GSD file must be installed in the control system e.g. SIMATIC S7.

**Input and output address, 6 byte each (input and otuput address are identical)**

- Byte 0 (process data 0), Bit 0: STO 0 = selected 1 not selected
- Byte 0 (process data 0), Bit 1: SS1 0 = selected 1 not selected
- Byte 1 (process data 1), Bit 0: SLS 0 = selected 1 not selected

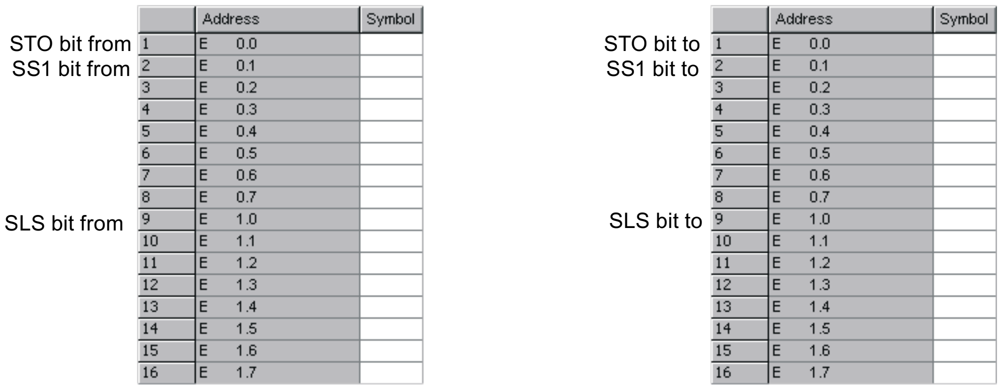


Figure 5-16 STEP7 dialogbox, fail-safe function settings

**PROFIsafe Parameters**

- F_Dest_Add: PROFIsafe address
- F_WD_Time: control time for the safety functions.

The other parameters cannot be changed.

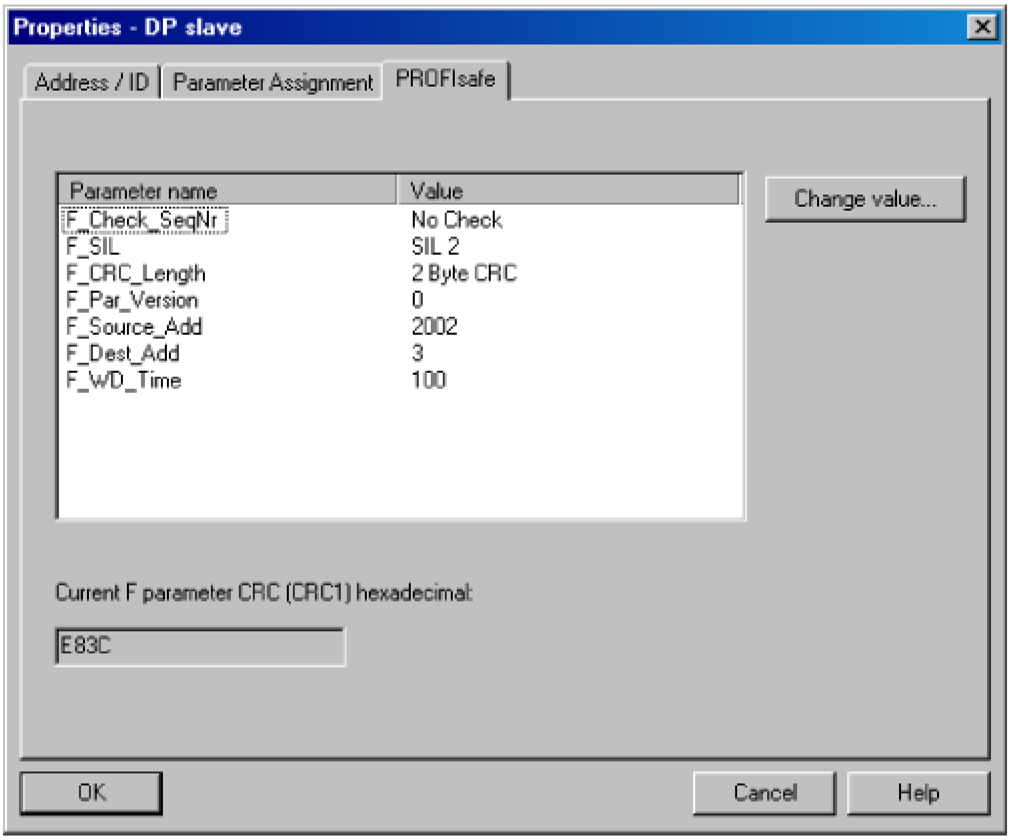


Figure 5-17 Dialog mask for safety functions

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Caution

F_Dest_Add

The PROFIsafe address is per default identical to the PROFIBUS address. Due to safety reasons it must be changed to a different value. It needs also to be changed in P9810 of the inverter.

F_WD_Time

In conjunction with the sync/freeze function, the watchdog-time should be increased.

---

### 5.9.4.4 Switch over behavior of Communication telegram

#### Switch over behavior

Table 5-24 Switch over behavior of telegram structures, Part 1

| P0922 = | 1 → 20 | | 1 → 350 | | 1 → 352 | | 1 → 999 | |
|---|---|---|---|---|---|---|---|---|
| | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 |
| P0820 = | 2032.15 | 2019.15 | unchanged | 2091.4 | unchanged | unchanged | unchanged | unchanged |
| P0821 = | unchanged | unchanged | unchanged | 2091.5 | unchanged | unchanged | unchanged | unchanged |
| P1035 = | 19.13 | 19.13 | unchanged | 2090.13 | unchanged | 2090.13 | unchanged | unchanged |
| P1036 = | 19.14 | 19.14 | unchanged | 2090.14 | unchanged | 2090.14 | unchanged | unchanged |

Table 5-25 Switch over behavior of telegram structures, Part 2

| P0922 = | 20 → 1 | | 20 → 350 | | 20 → 352 | | 20 → 999 | |
|---|---|---|---|---|---|---|---|---|
| | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 |
| P0820 = | 0.0 | 0.0 | unchanged | 2091.4 | 0.0 | 0.0 | unchanged | unchanged |
| P0821 = | unchanged | unchanged | unchanged | 2091.5 | unchanged | unchanged | unchanged | unchanged |
| P1035 = | unchanged | 2090.13 | unchanged | 2090.13 | unchanged | 2090.13 | unchanged | unchanged |
| P1036 = | unchanged | 2090.14 | unchanged | 2090.14 | unchanged | 2090.14 | unchanged | unchanged |

Table 5-26 Switch over behavior of telegram structures, Part 3

| P0922 = | 350 → 1 | | 350 → 20 | | 350 → 352 | | 350 → 999 | |
|---|---|---|---|---|---|---|---|---|
| | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 |
| P0820 = | 0.0 | 0.0 | 2032.15 | 2019.15 | 0.0 | 0.0 | unchanged | unchanged |
| P0821 = | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | unchanged | unchanged |
| P1035 = | unchanged | 2090.13 | 19.13 | 19.13 | unchanged | 2090.13 | unchanged | unchanged |
| P1036 = | unchanged | 2090.14 | 19.14 | 19.14 | unchanged | 2090.14 | unchanged | unchanged |

Table 5-27 Switch over behavior of telegram structures, Part 4

| P0922 = | 352 → 1 | | 352 → 20 | | 352 → 350 | | 352 → 999 | |
|---|---|---|---|---|---|---|---|---|
| | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 |
| P0820 = | 0.0 | 0.0 | 2032.15 | 2019.15 | unchanged | 2091.4 | unchanged | unchanged |
| P0821 = | unchanged | unchanged | unchanged | unchanged | unchanged | 2091.5 | unchanged | unchanged |
| P1035 = | unchanged | 2090.13 | 19.13 | 19.13 | unchanged | 2090.13 | unchanged | unchanged |
| P1036 = | unchanged | 2090.14 | 19.14 | 19.14 | unchanged | 2090.14 | unchanged | unchanged |

Table 5-28 Switch over behavior of telegram structures, Part 5

| P0922 = | 999 → 1 | | 999 → 20 | | 999 → 350 | | 999 → 352 | |
|---|---|---|---|---|---|---|---|---|
| | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 | if P0700 ≠ 6 | if P0700 = 6 |
| P0820 = | 0.0 | 0.0 | 2032.15 | 2019.15 | unchanged | 2091.4 | unchanged | unchanged |
| P0821 = | unchanged | unchanged | unchanged | unchanged | unchanged | 2091.5 | unchanged | unchanged |
| P1035 = | unchanged | 2090.13 | 19.13 | 19.13 | unchanged | 2090.13 | unchanged | 2090.13 |
| P1036 = | unchanged | 2090.14 | 19.14 | 19.14 | unchanged | 2090.14 | unchanged | 2090.14 |

### 5.9.5 Control and status words

#### Control and status words

The control and status words comply with the specifications for PROFIdrive Profile, version 4.0 for "Closed-loop speed control mode".

#### Control word 1 (STW1)

Control word 1 (bits 0 … 10 as per PROFIdrive Profile and VIK/NAMUR, bits 11 … 15 specific to SINAMICS G120).

Table 5-29 Assignment control word 1

| Bit | Value | Meaning | | Remarks |
|---|---|---|---|---|
| | | PROFIdrive Profile | VIK/NAMUR | |
| 0 | 1 | ON | ON | Sets the inverter to the "Ready to run" state, direction of rotation must be defined via bit 11. |
| | 0 | OFF1 | OFF1 | Shutdown, deceleration along RFG ramp, pulse disable when $f < f_{min}$. |
| 1 | 1 | No Coast Stop | No Coast Stop | All Coast Stop (OFF2) commands are withdrawn. |
| | 0 | Coast Stop (OFF2) | Coast Stop (OFF2) | Instantaneous pulse disable, drive coasts to a standstill |
| 2 | 1 | No Quick Stop | No Quick Stop | All Quick Stop (OFF3) commands are withdrawn. |
| | 0 | Quick Stop (OFF3) | Quick Stop (OFF3) | Rapid stop: Shutdown at fastest possible acceleration rate. |
| 3 | 1 | Enable Operation | Enable Operation | Closed-loop control and inverter pulses are enabled. |
| | 0 | Disable Operation | Disable Operation | Closed-loop control and inverter pulses are disabled. |
| 4 | 1 | Enable Ramp Generator | Enable Ramp Generator | -- |
| | 0 | Reset Ramp Generator | Reset Ramp Generator | Output of RFG is set to 0 (fastest possible braking operation), inverter remains in the ON state. |
| 5 | 1 | Unfreeze Ramp Generator | Unfreeze Ramp Generator | -- |
| | 0 | Freeze Ramp Generator | Freeze Ramp Generator | Setpoint currently supplied by the RFG is "frozen". |
| 6 | 1 | Enable Setpoint | Enable Setpoint | Value selected at the RFG input is activated. |
| | 0 | Disable Setpoint | Disable Setpoint | Value selected at the RFG input is set to 0. |
| 7 | 1 | Fault Acknowledge | Fault Acknowledge | Fault is acknowledged with a positive edge, inverter then switches to "starting lockout" state. |
| | 0 | No meaning | No meaning | -- |
| 8 | 1 | JOG 1 ON | JOG 1 ON | The drive runs up as quickly as possible to jogging setpoint (direction of rotation: CW). |
| | 0 | JOG 1 OFF | JOG 1 OFF | Drive brakes as quickly as possible. |
| 9 | 1 | JOG 2 ON | JOG 2 ON | The drive runs up as quickly as possible to jogging setpoint (direction of rotation: CCW). |
| | 0 | JOG 2 OFF | JOG 2 OFF | Drive brakes as quickly as possible. |
| 10 | 1 | Control by PLC | Control by PLC | Control via interface, process data valid. |
| | 0 | No Control by PLC | No Control by PLC | Process data not valid, expect Sign-Of-Life. |

| | | Meaning | | |
|---|---|---|---|---|
| 11 | 1 | Setpoint Inversion | Setpoint Inversion | Motor rotates CCW in response to positive setpoint. |
| | 0 | No Setpoint Inversion | No Setpoint Inversion | Motor rotates CW in response to positive setpoint. |
| 12 | - | Not used | Not used | -- |
| 13 | 1 | Motor potentio-meter UP | Not used | -- |
| 14 | 1 | Motor potentio-meter DOWN | Not used | -- |
| 15 | 1 | Command data set bit 0 | Drive data set bit 1 | -- |

## Information about Bit 15

On the SINAMICS G120 it is possible, using the function local/remote control, to change between the command data set (CDS) 0 and 1 of the control word 1 bit 15. This results in a switching of the command data sets. The command data set 0 is active in local operation and the command data set 1 for remote operation. Now in both command data sets the application-specific parameters for the command and target value sources can be set.

## An example

In the remote control operating mode the commands and target values come from a superior control system to the inverter by means of a PROFIBUS. By switching to local operation, the command and target value source is switched and operation is now performed locally on the system by means of digital inputs and the analog target values.

Local operation = Command data set 0: In this case the command code of the terminal strip P0700 Index 0 = 2 and the frequency target value is the analog target value P1000 Index 0 = 2.

Remote operation = Command data set 1: In this case the command code corresponds with the control word (word 0) received from the PROFIBUS P0700 Index 1 = 6 and the frequency target value corresponds with the control word 1 received from the PROFIBUS P1000 Index 0 = 6.

## Default assignment control word 2 (STW2)

The control word 2 is assigned as a default as follows. This can be changed by using BICO.

Table 5-30 Assignment control word 2 (for VIK/NAMUR not defined)

| Bit | Value | Meaning | P0922 = 1 | P0922 = 350 | P0922 = 352 |
|---|---|---|---|---|---|
| 0 | 1 | Fixed frequency selection Bit 0 | P1020 depends on P070x | = P1020 | P1020 depends on P070x |
| 1 | 1 | Fixed frequency selection Bit 1 | P1021 depends on P070x | = P1021 | P1021 depends on P070x |
| 2 | 1 | Fixed frequency selection Bit 2 | P1022 depends on P070x | = P1022 | P1022 depends on P070x |
| 3 | 1 | Fixed frequency selection Bit 3 | P1023 depends on P070x | = P1023 | P1023 depends on P070x |
| 4 | – | Not used | -- | -- | -- |
| 5 | – | Not used | -- | -- | -- |
| 6 | – | Not used | -- | -- | -- |
| 7 | – | Not used | -- | -- | -- |
| 8 | 1 | Enable Technology Controller | 0.0 | = P2200 | 0.0 |
| 9 | 1 | Enable DC Brake | 0.0 | = P1230 | 0.0 |
| 10 | – | Not used | -- | -- | -- |
| 11 | 1 | Enable Droop Speed Controller | Enable Droop | Enable Droop | Enable Droop |
| 12 | 1 | Torque Control | 0.0 | = P1501 | 0.0 |
| | 0 | Speed Control | | | |
| 13 | 0 | External Fault 1 | 1.0 | = P2106 | 1.0 |
| 14 | – | Not used | -- | -- | -- |
| 15 | – | Not used | -- | -- | -- |

## Status word 1 (ZSW1)

Status word 1 (bits 0 to 10 as per PROFIdrive Profile and VIK/NAMUR, bits 11 to 15 specific to SINAMICS G120).

Table 5-31 Bit assignments status word 1 (for all PROFIdrive and VIK/NAMUR telegrams)

| Bit | Value | Meaning | Remarks |
|---|---|---|---|
| 0 | 1 | Ready to switch on | Power supply is switched on, electronics initialized, pulses disabled. |
| | 0 | Not ready to switch on | -- |
| 1 | 1 | Ready to operate | Inverter is switched on (ON command is applied), no fault is active, inverter can start when "Enable operation" command is issued. See control word 1, bit 0. |
| | 0 | Not ready to operate | -- |
| 2 | 1 | Operation enabled | Drive follows setpoint. See control word 1, bit 3. |
| | 0 | Operation disabled | -- |
| 3 | 1 | Fault present | Drive has faulted. Drive is faulty and thus inoperative, switches to starting lockout state after successful correction and acknowledgement of fault. |
| | 0 | No fault | -- |
| 4 | 1 | Coast Stop not activated | -- |
| | 0 | Coast Stop activated | Coast Stop (OFF 2) command is present. |
| 5 | 1 | Quick Stop not activated | -- |
| | 0 | Quick Stop activated | Quick Stop (OFF 3) command is present. |
| 6 | 1 | Switching on inhibited | The drive goes only again in the "Switched On" condition with "No Coast Stop AND No Quick Stop" followed by "ON". |
| | 0 | Switching on not inhibit | -- |
| 7 | 1 | Warning present | Drive still works; warning in the service/maintenance parameter; no acknowledgement, see alarm parameter r2110. |
| | 0 | No warning | There is no warning or the warning has disappeared again. |
| 8 | 1 | Speed error within tolerance range | Setpoint/actual value deviation within tolerance range. |
| | 0 | Speed error out 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 control. |
| 10 | 1 | Maximum frequency reached or exceeded | Inverter output frequency is higher or equal to the maximum frequency. |
| | 0 | Maximum frequency not reached | -- |
| 11 | 1 | -- | -- |
| | 0 | Warning: Motor at current/torque limit | -- |
| 12 | 1 | Motor holding brake active | Signal can be used to control a holding brake. |
| | 0 | -- | -- |
| 13 | 1 | -- | Motor data indicate overload condition. |
| | 0 | Motor overload | -- |
| 14 | 1 | CW rotation | -- |
| | 0 | CCW rotation | -- |
| 15 | 1 | -- | -- |
| | 0 | Inverter overload | e.g. current or temperature. |

## Status word 2 (ZSW2)

Status word 2 has the following default assignment: This can be modified using BICO.

Table 5-32 Assignment status word 2 (for VIK/NAMUR not defined)

| Bit | Value | Meaning | Description |
|---|---|---|---|
| 0 | 1 | DC Braking Active | DC current brake active |
| 1 | 1 | n_act < P2167 | Drive inverter frequency < Shutdown limit |
| 2 | 1 | n_act ≧ P1080 | Actual frequency > min. frequency |
| 3 | 1 | i_act ≧ P2170 | Current ≥ Limit |
| 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 Finished | -- |
| 10 | 1 | Techn. Controller Output ≦ P2292 | PI frequency < Threshold value |
| 11 | 1 | Techn. 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 | -- |

## 5.9.6 Acyclic data transmission

### Extended PROFIBUS DP functionality (DPV1)

The PROFIBUS DP extensions DPV1 include the definition of an acyclic data exchange which can take place in parallel to cyclical data transmissions.

Acyclic data transfer mode allows:

- Large quantities of user data (up to 240 bytes) to be exchanged
- 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:

- Acyclical data exchange with the same class 1 master use of DPV1 functions READ and WRITE. The content of the transferred data block (DS) corresponds in this case to the structure of the acyclical parameter channel according to PROFIdrive Profile, version 4.0 () (with data block 47 (DS47)).
- Acyclical 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.
- Acyclical 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 acyclical parameter channel according to PROFIdrive Profile version 4.0 (with DS47) can access the inverter.

### Properties of the DPV1 parameter channel

- One 16-bit address each for parameter number and subindex.
- Concurrent access by several PROFIBUS masters (class 2 master, e.g. commissioning tool).
- Transfer of different parameters in one access (multiple parameter request).
- Transfer of complete arrays or part of an array possible.
- Only one parameter request is processed at a time (no pipelining).
- A parameter request/response must fit into a data set (max. 240 bytes).
- The task or response header are user data.

### Structure of parameter request and parameter response

A parameter request consists of three segments:

- Request header

  ID for the request and number of parameters which are accessed.

- Parameter address

  Addressing of a parameter. If several parameters are accessed, there are correspondingly many parameter addresses. The parameter address appears only in the request, not in the response.

- Parameter value

  Per addressed parameter, there is a segment for the parameter values. Depending on the request ID, parameter values appear only either in the request or in the reply.

Table 5-33 Parameter request

| | Word | |
|---|---|---|
| | Byte | Byte |
| Request header | Request Reference | Request ID |
| | Drive object ID | No. of Parameters |
| 1st Parameter Address | Attribute | No. of elements |
| | Parameter Number (PNU) | |
| | Subindex | |
| … | | |
| nth Parameter Address | Attribute | No. of elements |
| | Parameter Number (PNU) | |
| | Subindex | |
| 1st Parameter Value(s) (only for request "Change parameter") | Format | No. of Values |
| | Values | |
| | … | |
| … | | |
| nth Parameter Value(s) | Format | No. of Values |
| | Values | |
| | … | |

Table 5-34 Parameter response

| | Word | |
|---|---|---|
| | **Byte** | **Byte** |
| **Response header** | Request Reference mirrored | Response ID |
| | Drive object ID mirrored | No. of Parameters |
| **1st Parameter Value(s)** (only after request "Request") | Format | No. of Values |
| | Values or Error Values | |
| | … | |
| … | | |
| **nth Parameter Value(s)** | Format | No. of Values |
| | Values or Error Values | |
| | … | |

## Description of fields in DPV1 parameter request and response

Table 5-35 Description of fields in parameter request

| Field | Data type | Values | Note |
|---|---|---|---|
| Request reference | Unsigned8 | 0x01 … 0xFF | |
| | Unique identification of the request/response pair for the master. The master changes the request reference with each new request. The slave mirrors the request reference in its response. | | |
| Request ID | Unsigned8 | 0x01<br>0x02 | Read request<br>Write request |
| | Specifies the type of request.<br>In the case of a write request, the changes are made in a volatile memory (RAM). A save operation is needed in order to transfer the data to the non-volatile memory (P0971). | | |
| Drive object ID | Unsigned8 | 0x00 … 0xFF | Number |
| | Setting for the drive object number with a drive unit with more than one drive object. Different drive objects with separate parameter number ranges can be accessed over the same DPV1 connection. | | |
| No. of Parameters | Unsigned8 | 0x01 … 0x27 | No. 1 … 39<br>Limited by DPV1 telegram length |
| | Defines the number of adjoining areas for the parameter address and/or parameter value for multi-parameter requests.<br>The number of parameters = 1 for single requests. | | |
| Attribute | Unsigned8 | 0x10<br>0x20<br>0x30 | Value<br>Description<br>Text (not implemented) |
| | Type of parameter element accessed. | | |
| No. of Elements | Unsigned8 | 0x00<br>0x01 … 0x75 | Special function<br>No. 1 … 117<br>Limited by DPV1 telegram length |
| | Number of array elements accessed. | | |
| Parameter number | Unsigned16 | 0x0001 … 0xFFFF | No. 1 … 65535 |

| Field | Data type | Values | Note |
|---|---|---|---|
| | Addresses the parameter to be accessed. | | |
| Subindex | Unsigned16 | 0x0000 … 0xFFFF | No. 0 … 65535 |
| | Addresses the first array element of the parameter to be accessed. | | |
| Format | Unsigned8 | 0x02<br>0x03<br>0x04<br>0x05<br>0x06<br>0x07<br>0x08<br>Other values<br><br>0x40<br><br>0x41<br>0x42<br>0x43<br>0x44 | Data type Integer 8<br>Data type Integer 16<br>Data type Integer 32<br>Data type Unsigned 8<br>Data type Unsigned 16<br>Data type Unsigned 32<br>Data type Floating Point<br>See PROFIdrive Profile<br><br>Zero (without values as a positive subresponse to a write request)<br>Byte<br>Word<br>Double word<br>Error |
| | The format and number specify the adjoining space containing values in the telegram.<br>Data types in conformity with PROFIdrive Profile shall be preferred for write access. Bytes, words and double words are also possible as a substitute. | | |
| No. of Values | Unsigned8 | 0x00 … 0xEA | No. 0 … 234<br>Limited by DPV1 telegram length |
| | Specifies the number of subsequent values. | | |
| Values | Unsigned16 | 0x0000 … 0x00FF | |
| | The values of the parameter for read or write access.<br>If the values make up an odd number of bytes, a zero byte is appended. This ensures the integrity of the word structure of the telegram. | | |

Table 5-36 Description of fields in parameter response

<table>
<tr><th>Field</th><th>Data type</th><th>Values</th><th colspan="2">Note</th></tr>
<tr><td>Request reference</td><td colspan="4">See Table above</td></tr>
<tr><td rowspan="3">Response ID</td><td rowspan="2">Unsigned8</td><td rowspan="2">0x01<br>0x02<br>0x81<br>0x82</td><td rowspan="2">Read request (+)<br>Write request (+)<br>Read request (–)<br>Write request (–)</td><td>Request positive, status ok</td></tr>
<tr><td>Request negative, fault status</td></tr>
<tr><td colspan="4">Mirrors the request identifier and specifies whether request execution was positive or negative.<br>Negative means:<br>Cannot execute part or all of request.<br>The error values are transferred instead of the values for each subresponse.</td></tr>
<tr><td>Drive object ID</td><td colspan="4">See Table above</td></tr>
<tr><td>No. of Parameters</td><td colspan="4">See Table above</td></tr>
<tr><td>Format</td><td colspan="4">See Table above</td></tr>
<tr><td>No. of Values</td><td colspan="4">See Table above</td></tr>
<tr><td>Values</td><td colspan="4">See Table above</td></tr>
<tr><td rowspan="2">Error Values</td><td>Unsigned16</td><td>0x0000 … 0x00FF</td><td colspan="2">Meaning of the error values see next Table</td></tr>
<tr><td colspan="4">The error values in the event of a negative response.<br>If the values make up an odd number of bytes, a zero byte is appended. This ensures the integrity of the word structure of the telegram.</td></tr>
</table>

---

**Note**

Drive ES SIMATIC provides function blocks for parameter write/read tasks within standard block libraries and some examples.

---

## Error values in DPV1 parameter responses

Table 5-37 Error values in DPV1 parameter responses

| Error value | Meaning | Note | Extra info |
|---|---|---|---|
| 0x00 | Illegal parameter number | Access to a parameter which does not exist. | – |
| 0x01 | Parameter value cannot be changed | Modification access to a parameter value which cannot be changed. | Subindex |
| 0x02 | Lower or upper value limit exceeded | Modification access with value outside | Subindex |

| Error value | Meaning | Note | Extra info |
|---|---|---|---|
| | | value limits. | |
| 0x03 | Invalid subindex | Access to a subindex which does not exist. | Subindex |
| 0x04 | No array | Access with subindex to an unindexed parameter. | – |
| 0x05 | Wrong data type | Modification access with a value which does not match the data type of the parameter. | – |
| 0x06 | Illegal set operation (only reset allowed) | Modification access with a value not equal to 0 in a case where this is not allowed. | Subindex |
| 0x07 | Description element cannot be changed | Modification access to a description element which cannot be changed. | Subindex |
| 0x09 | No description data | Access to a description which does not exist (the parameter value exists). | – |
| 0x0B | No operating priority | Modification access with no operating priority. | – |
| 0x0F | No text array exists | Access to a text array which does not exist (the parameter value exists). | – |
| 0x11 | Request cannot be executed due to operating status | Access is not possible temporarily for unspecified reasons. | – |
| 0x14 | Illegal value | Modification access with a value which is within the limits but which is illegal for other permanent reasons (parameter with defined individual values). | Subindex |
| 0x15 | Response too long | The length of the present response exceeds the maximum transfer length. | – |
| 0x16 | Illegal parameter address | Illegal or unsupported value for attribute, number of elements, parameter number, subindex or a combination of these. | – |
| 0x17 | Illegal format | Write request: illegal or unsupported parameter data format. | – |
| 0x18 | No. of values inconsistent | Write request: a mismatch exists between the number of values in the parameter data and the number of elements in the parameter address. | – |
| 0x19 | Drive object does not exist | Access to a drive object which does not exist. | – |
| 0x20 | Parameter text element cannot be changed | Change access to a parameter text element that cannot be changed. | Subindex |

## 5.9.7 Configuration Example with SIMATIC S7

### 5.9.7.1 SIMATIC S7

#### Installing a G120 GSD file

The inverter can be integrated into a higher level control device, e.g. SIMATIC S7 via the GSD.

The GSD must be installed in the engineering software of the higher level control device. The following example shows how to install the GSD in HW Config of SIMATIC S7.

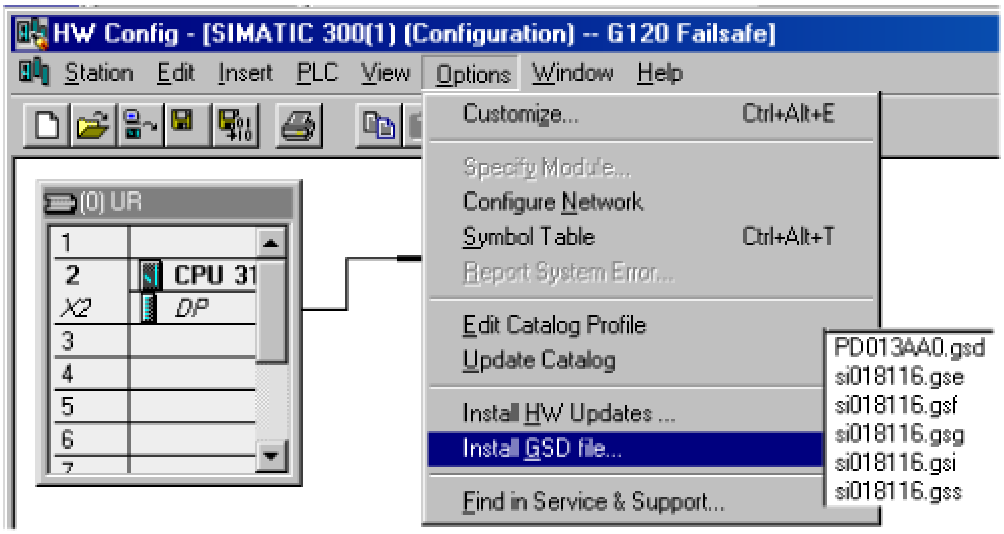



Figure 5-18 Installing the G120 GSD in HW Config of SIMATIC S7

Install the *.GS* file in the desired language (english, french, german, italian or spanish) from the folder where you have stored these data.

The following figure shows how to integrate an inverter with integrated fail-safe functions (CU240S DP-F) and a SIEMENS standard telegramm in a SIMATIC S7.

The inverter gives the possibility to work with different kind of telegrams. The selection of the telegram is made by the parameter P0922 during drive commissioning. The received telegram is in r2050[8] and transmit telegram is decided by parameter P2051[8].

---

**Note**

Take care that the PROFIsafe Module is installed in slot 1. In the following slot a SIEMENS telegram or a standard telegram can be installed.

---

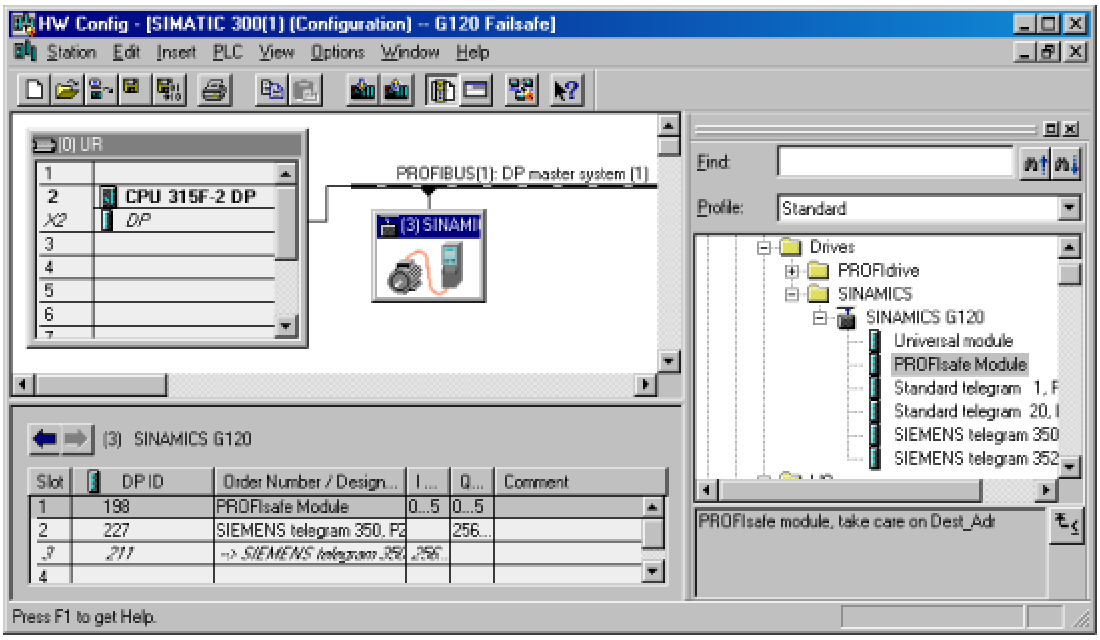



Figure 5-19 G120 inverter with fail-safe functions and a standard protocol in HW Config of SIMATIC S7

The described examples can be downloaded from http://support.automation.siemens.com/WW/view/en/22339653/133000 .

### 5.9.7.2 Read Parameters

#### Requirements

- The PROFIBUS master has been commissioned and is fully operational.
- PROFIBUS communication between master and slave is operational.
- The master can read and write data sets in conformance with PROFIBUS DPV1.

#### Task description

Following the occurrence of at least one fault (ZSW1.3 = 1) the first 8 active fault codes must be read from the fault buffer r0947[0] … r0947[7]. The accompanied faults values of the fault code are important for the user. These must be read from parameter r0949 [0] ...r0949[7].

The request is to be handled using a request and response data block.

## Procedure

1. Create a request data block e.g. DB1 to read the parameters

| Address | Name | Type | Initial val | Comment |
|---|---|---|---|---|
| 0.0 | | STRUCT | | |
| +0.0 | Request_reference | BYTE | B#16#1 | request number |
| +1.0 | Request_ID | BYTE | B#16#1 | request parameter = 1; change parameter = 2 |
| +2.0 | DO_ID | BYTE | B#16#0 | DO_ID |
| +3.0 | No_of_parameters | BYTE | B#16#2 | read out two parameters (r0947[64] and r0949[64] |
| +4.0 | Attribute_parameter_01 | BYTE | B#16#10 | value |
| +5.0 | No_of_elements_01 | BYTE | B#16#8 | number of indicies 8 |
| +6.0 | parameter_number_01 | WORD | W#16#3B3 | parameter r0947[64] only 8 from 64 error codes |
| +8.0 | Subindex_01 | WORD | W#16#0 | subindex |
| +10.0 | Attribute_parameter_02 | BYTE | B#16#10 | value |
| +11.0 | No_of_elements_02 | BYTE | B#16#8 | number of indicies 8 |
| +12.0 | parameter_number_02 | WORD | W#16#3B5 | parameter r0949[64] only 8 from 64 error values |
| +14.0 | Subindex_02 | WORD | W#16#0 | subindex |
| =16.0 | | END_STRUCT | | |

Figure 5-20 Request data block e.g. DB1 to read the parameters

Table 5-38 Parameter request

| | | |
|---|---|---|
| **Request header** | Request_reference = 0x01 | Request_ID = 0x01 |
| | Drive_object_ID = 0x00 | No_of_parameters = 0x02 |
| **Parameter Address_01** | Attribute_parameter_01 = 0x10 | No_of_elements_01 = 0x08 |
| | parameter_number_01 (PNU) = 03B3 (= 947 dec, P0947) | |
| | Subindex_01 = 0x00 | |
| **Parameter Address_02** | Attribute_parameter_02 = 0x10 | No_of_elements_02 = 0x08 |
| | parameter_number_02 (PNU) = 03B5 (= 949 dec, P0949) | |
| | Subindex_02 = 0x00 | |

Information about the parameter request:

- Request_reference:

  The value is selected at random from the valid value range. The request reference establishes the relationship between request and response.
- Request_ID:

  0x01 --> This identifier is required for a read request.
- Drive_object_ID:

  0x00 -> Device-Representative.
- No_of_parameters:

  0x02 --> Two parameters are read.
- Attribute_parameter_01:

  0x10 --> The parameter values are read.
- No_of_elements_01:

  0x08 --> The current fault incident with 8 faults is to be read.
- Parameter_number_01:

  03B3 --> P0947 (last fault code) is read.

- Subindex_01:
  0x00 --> Read access starts at index 0
- Attribute_parameter_02:
  0x10 --> The parameter values are read.
- No_of_elements_02:
  0x08 --> The current fault incident with 8 faults is to be read.
- Parameter_number_02:
  03B5 --> P0949 (last fault code) is read.
- Subindex_02:
  0x00 --> Read access starts at index 0.

1. Create a response data block e.g. DB2 for the response

| Address | Name | Type | Initial val | Comment |
|---|---|---|---|---|
| 0.0 | | STRUCT | | |
| +0.0 | Request_reference_mirror | BYTE | B#16#0 | request number mirrored |
| +1.0 | Response_ID | BYTE | B#16#0 | request parameter |
| +2.0 | DO_ID_mirrored | BYTE | B#16#0 | DO-ID mirrored |
| +3.0 | No_of_parameters | BYTE | B#16#0 | response about number of parameter |
| +4.0 | Format_parameter_1 | BYTE | B#16#0 | response about parameter 1 format |
| +5.0 | No_of_values_parameter_1 | BYTE | B#16#0 | response about number of value of parameter 1 |
| +6.0 | error_code_01 | WORD | W#16#0 | error code from index 0 |
| +8.0 | error_code_02 | WORD | W#16#0 | error code from index 1 |
| +10.0 | error_code_03 | WORD | W#16#0 | error code from index 2 |
| +12.0 | error_code_04 | WORD | W#16#0 | error code from index 3 |
| +14.0 | error_code_05 | WORD | W#16#0 | error code from index 4 |
| +16.0 | error_code_06 | WORD | W#16#0 | error code from index 5 |
| +18.0 | error_code_07 | WORD | W#16#0 | error code from index 6 |
| +20.0 | error_code_08 | WORD | W#16#0 | error code from index 7 |
| +22.0 | Format_parameter_2 | BYTE | B#16#0 | response about parameter 2 format |
| +23.0 | No_of_values_parameter_2 | BYTE | B#16#0 | response about number of value of parameter 2 |
| +24.0 | error_value_01 | DWORD | DW#16#0 | error value from index 0 |
| +28.0 | error_value_02 | DWORD | DW#16#0 | error value from index 1 |
| +32.0 | error_value_03 | DWORD | DW#16#0 | error value from index 2 |
| +36.0 | error_value_04 | DWORD | DW#16#0 | error value from index 3 |
| +40.0 | error_value_05 | DWORD | DW#16#0 | error value from index 4 |
| +44.0 | error_value_06 | DWORD | DW#16#0 | error value from index 5 |
| +48.0 | error_value_07 | DWORD | DW#16#0 | error value from index 6 |
| +52.0 | error_value_08 | DWORD | DW#16#0 | error value from index 7 |
| =56.0 | | END_STRUCT | | |

Figure 5-21 Response data block e.g. DB2 for the response

Table 5-39 Parameter response

| | | |
|---|---|---|
| **Response header** | Request_reference mirror = 0x01 | Response_ID = 0x01 |
| | Drive_object_ID_mirrored = 0x00 | No_of_parameters = 0x02 |
| **Parameter Value(s)** | Format_parameter_1 = 0x06 | No_of_values_parameter_1 = 0x08 |
| | error_code_01 = 0x054B (= 1355 dec, F1355) | |
| | error_code_02 = 0x0000 | |
| | … | |
| | error_code_08 = 0x0000 | |
| **Parameter Value(s)** | Format_parameter_2 = 0x06 | No_of_values_parameter_2 = 0x08 |
| | error_value_01 = 0x054B (= 1355 dec, F1355) | |
| | error_value_02 = 0x00 | |
| | … | |
| | error_value_08 = 0x00 | |

Information about the parameter response:

- Request_reference_mirror:
  This response belongs to the request with request reference 0x01.
- Response_ID:
  0x01 --> Read request positive, values stored as 1st value.
- Drive_object_ID_mirrored:
  The values correspond to the values from the request.
- No_of_parameters:
  The values correspond to the values from the request.
- Format_parameter_1:
  0x06 --> Parameter values are in Unsigned16 format.
- No_of_values_parameter_1:
  0x08 --> 8 parameter values are available.
  – 1. value … 8. value:
    error_codes_01
    …
    error_codes_08
- Format_Parameter_2:
  0x06 --> Parameter values are in Unsigned16 format.
- No. of values_Parameter_2:
  0x08 --> 8 parameter values are available.
  – 1. value … 8. value:
    error_values_01
    …
    error_values_08.

1. For the acyclic communication in OB1 a read/write request must be send to the drive with RD_REC (SFC 59) and WR_REC (SFC 58)

```
Network 2 : Title:

With SFC58 "WR_REC" (write record), you transfer the data record contained in
the RECORD (DB1) to the addressed module.

      CALL  SFC   58
       REQ    :=M8.0                  // write request
       IOID   :=B#16#54               // ID of the address area peripherial input (PI)
       LADDR  :=W#16#100              // logical adress of the modul from the HW Config address 256(dec)
       RECNUM :=B#16#2F               // Data record number
       RECORD :=P#DB1.DBX0.0 BYTE 16  // Data record
       RET_VAL:=MW10                  // If an error occurs while the function is active, the return value contains an error code
       BUSY   :=M8.1                  // BUSY = 1; Writing is not yet completed

      U     M      8.1                // if writing is active
      R     M      8.0                // no new request available

Network 3 : Title:

With SFC59 "RD_REC" (read record), you read the data record with the number
RECNUM from the addressed module. The data record read is entered in the
destination area (DB2), which is indicated by the RECORD parameter.

      CALL  SFC   59
       REQ    :=M8.2                  // read request
       IOID   :=B#16#54               // ID of the address area peripherial input (PI)
       LADDR  :=W#16#100              // logical adress of the modul from the HW Config address 256(dec)
       RECNUM :=B#16#2F               // Data record number
       RET_VAL:=MW12                  // If an error occurs while the function is active, the return value contains an error code
       BUSY   :=M8.3                  // BUSY = 1; Reading is not yet completed
       RECORD :=P#DB2.DBX0.0 BYTE 56  // Destination area for the data record read

      U     M      8.3                // if reading is active
      R     M      8.2                // no new request available
```

Figure 5-22 Acyclic communication for request and response data block in OB1

### 5.9.7.3 Write Parameters

#### Requirements

- The PROFIBUS master has been commissioned and is fully operational.
- PROFIBUS communication between master and slave is operational.
- The master can read and write data sets in conformance with PROFIBUS DPV1.

#### Task description (multiple parameter request)

The maximum frequency (parameter P1082) shell change from 50 Hz (default value) to 100 Hz.

## Procedure

1. **Create a request data block e.g. DB1 to write the parameter**

| Address | Name | Type | Initial val | Comment |
|---|---|---|---|---|
| 0.0 | | STRUCT | | |
| +0.0 | Request_reference | BYTE | B#16#1 | request number |
| +1.0 | Request_ID | BYTE | B#16#2 | request parameter = 1; change parameter = 2 |
| +2.0 | Drive_object_ID | BYTE | B#16#0 | |
| +3.0 | No_of_parameters | BYTE | B#16#1 | number of parameter which should change |
| +4.0 | Attribute | BYTE | B#16#10 | value = 10; description = 20; text = 30 |
| +5.0 | No_of_elements | BYTE | B#16#1 | number of indicies |
| +6.0 | Parameter_number | WORD | W#16#43A | parameter P1082; 1082 dec = 43A hex |
| +8.0 | Subindex | WORD | W#16#0 | index 0 |
| +10.0 | Format | BYTE | B#16#43 | data type of parameter P1080 = Float (see parameter list) |
| +11.0 | No_of_values | BYTE | B#16#1 | number of values = number_of_elements |
| +12.0 | Value | REAL | 1.000000e+0 | maximum frequency from 50 Hz (default) to 100 Hz |
| =16.0 | | END_STRUCT | | |

Figure 5-23 Request data block e.g. DB1 to write the parameter

Information about the parameter request:

- Request_reference:

  The value is selected at random from the valid value range. The request reference establishes the relationship between request and response.
- Request_ID:

  0x02 --> This identifier is required for a write request.
- Drive_object_ID:

  0x00 -> Device-Representative.
- No_of_parameters:

  0x01 --> One parameter request.
- Attribute:

  0x10 -> The parameter value are to be written.
- No_of_elements:

  0x01 -> 1 array element is written.
- Parameter_number:

  043A -> Parameter P1082 (max. frequency); 043A hex = 1082 dec.
- Subindex:

  0x00 -> ID for the first array element.
- Format:

  0x43 -> Floating Point data type (refer to the Parameter List).
- No_of_values:

  0x01 -> One value is written to the parameter in the specified format.
- Value:

  1.000000e+002 -> maximum frequency 100 Hz.

1. For the acyclic communication in OB1 a write request must be send to the drive with WR_REC (SFC 58)

```
Network 2: Title:
Comment:

        CALL  "WR_REC"                          // write request
         REQ    :=M8.0                          // start signal with M8.0 in VAT_1
         IOID   :=B#16#54                       //
         LADDR  :=W#16#100                      // hardwareaddress in Hex; 256 dec = 100 hex
         RECNUM :=B#16#2F                       // data set 47 (DS47); 47 dec = 2F hex
         RECORD :=P#DB1.DBX0.0 BYTE 16          // ANYPOINTER to the request data block DB1
         RET_VAL:=MW10                          // return value
         BUSY   :=M8.1                          // request active

        U     M      8.1
        R     M      8.0
```

Figure 5-24 Acyclic communication in OB1

# 5.10 Encoder Commissioning

## Commissioning the Encoder Interface

**Warning**

Before installing and commissioning, please read these safety instructions and warning carefully and all the warning labels attached to the equipment. Make sure that the warning labels are kept in a legible condition and replace missing or damaged labels.

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

Non-Compliance with Warnings or failure to follow the instructions contained in this manual can result in loss of life, severe personal injury or serious damage to property.

Only suitably qualified personnel should work on this equipment, and only after becoming familiar with all safety notices and maintenance procedures contained in this manual.

The successful and safe operation of this equipment is dependent upon its proper handling, storage, installation, operation and maintenance.

National safety regulations are also applicable.

The actions required to commission the encoder depend upon the type (HTL or TTL) that is connected to the encoder interface. The following table gives an overview about the single steps depending on the type of encoder.

## Encoder commissioning

To commission the Encoder, the following procedure should be performed:

Table 5-40 Commissioning the Encoder

| Step | Description | TTL | HTL |
|---|---|---|---|
| 1. | Ensure the Inverter is switched off. | X | X |
| 2. | Connect the Channel A wire from the encoder to terminal 70 (ENC AP) on the Control Unit. | X | X |
| 3. | Connect the Channel A inverted wire from the encoder to terminal 71 (ENC AN) on the Control Unit. | X | X |
| 4. | Connect the Channel B wire from the encoder to terminal 72 (ENC BP) on the Control Unit. | X | X |
| 5. | Connect the Channel B inverted wire from the encoder to terminal 73 (ENC BN) on the Control Unit. | X | X |
| 6. | Connect the Channel Z wire from the encoder to terminal 74 (ENC ZP) on the Control Unit. | X | X |
| 7. | Connect the Channel Z inverted wire from the encoder to terminal 75 (ENC ZN) on the Control Unit. | X | X |
| 8. | Connect the positive power cable to terminal 33 (ENC+ SUPPLY) on the Control Unit. | X | X |
| 9. | Connect the negative power cable to terminal 28 (U0V) on the Control Unit. | X | X |
| 10. | Switch the general I/O DIP-switch 4 (5 V) to the ON position (TTL) | X | |
| 11. | Switch the general I/O DIP-switch 3 (24 V) to the ON position. (HTL) | | X |
| 12. | Check that all the connections have been made correctly and the DIP-switch is in the correct position. | X | X |
| 13. | Switch the inverter ON. | X | X |
| 14. | The Encoder interface now requires to be parameterized. A flow chart that shows the required parameters is given in the following section. | X | X |

**Note**

The cable from the encoder to the Encoder Module should be one complete length.

**TTL-encoder specific**

If the encoder type is a TTL differential and a long cable length is required (>50 m), DIP switches 5, 6, and 7 may be set to ON.

If the encoder type is a TTL single-ended encoder, there will be a three wires for the ‘A’, 'B' and 'Z' Channels.

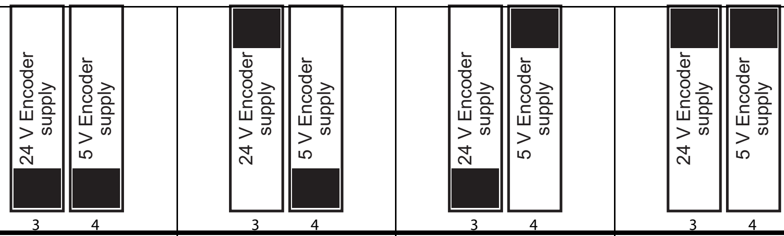
**HTL-encoder specific**

The terminating impedance which is selected using the DIP-switches must not be used in conjunction with an HTL encoder.

The encoder voltage is using the general I/O DIP switches 3 and 4.

The following table shows the possible settings:

Table 5-41 Encoder voltage settings

| | | | | |
|---|---|---|---|---|
| On<br>OFF |  | | | |
| Encoder supply voltage | 0 V | 24 V | 5 V | 24 V |
| Encoder type | No encoder | HTL encoder | TTL encoder | HTL encoder |



**Warning**

DIP switches 3 and 4 in ON position provide a supply voltage of 24 V to the encoder. Therefore it is not allowed to connect a TTL encoder to the inverter if both DIP switches, 3 and 4 are in ON position.

## 5.10.1 Parameterizing the Encoder Interface

### Encoder parameterization

To enable the Encoder to function correctly with the inverter, the parameters in the table below, must be modified.

Table 5-42 Encoder parameters

| Parameter | Name | Values | | |
|---|---|---|---|---|
| r0061 | Rotor speed | Indicates the speed of the rotor. Used to check that the system is working correctly. | | |
| r0090 | Rotor angle | Indicates the current angle of the rotor. This function is not available on single input channel encoders. | | |
| P0400[3] | Encoder type | • 0: No encoder<br>• 2 or12: Quadrature encoder (channel A + B) – the term "quadrature" means two periodic functions separated by a quarter cycle or 90 degrees | | |
| r0403 | Status word of encoder | Displays status word of encoder in bit format: | | |
| | Bit 00 - Encoder module active | | 0 | No |
| | | | 1 | Yes |
| | Bit 01 - Encoder error | | 0 | No |
| | | | 1 | Yes |
| | Bit 02 - Signal OK | | 0 | No |

| Parameter | Name | Values | | |
|---|---|---|---|---|
| | | | 1 | Yes |
| | Bit 03 - Encoder low speed loss | | 0 | No |
| | | | 1 | Yes |
| | Bit 05 - Single edge measurement | | 0 | No |
| | | | 1 | Yes |
| P0405 | Encoder pulse types | Enables selection of various pulse types. Only bits 04 and 05 are used for the SINAMICS G120. See parameter list. | | |
| P0408[3] | Pulses per revolution | Specifies the number of encoder pulses per revolution | | |
| P0491[3] | Reaction on speed signal loss | Selects reaction on loss of speed signal. Settings:<br>0: Do not change to SLVC<br>1: Change to SLVC | | |
| P0492[3] | Allowed speed difference | Used for high speed encoder loss detection.<br>Selects the allowable difference in calculated speed signals between samples before it is considered to have lost the speed signal feedback. (Default = Calculated from inertia, range from 0 to 100.00)<br>Dependency: Parameter is updated when P0345 Motor start-up time is changed or when a speed loop optimization is performed (P1960 = 1).<br>There is a fixed delay of 40 mS before acting upon loss of encoder at high speeds.<br>Caution: When allowed speed difference is set to 0, then both high speed and low speed encoder loss detection is disabled, encoder loss will not be detected.<br>If encoder loss detection is disabled and encoder loss occurs, then operation of the motor may become unstable. | | |
| P0493[3] | Speed difference | Allowed difference between encoder and observer. | | |
| P0494[3] | Delay speed loss reaction | Used for low speed encoder loss detection.<br>If the motor shaft speed is less than the value in P0492 then encoder loss is detected using a low speed encoder loss detection algorithm.<br>This parameter selects the delay between loss of encoder at low speed and reaction to the encoder loss. (Default = Calculated from inertia, Range from 0 to 64.000s).<br>Dependency: This parameter is updated when P0345 Motor start-up time is changed or when a speed-loop optimization is performed (P1960 = 1).<br>Caution: When this delay is set to 0, then low speed encoder loss detection is disabled and low speed encoder loss cannot be detected (high speed encoder loss detection will still operate if P0492 > 0). If low speed encoder loss detection is disabled and encoder should be lost at low speed, then operation of motor may become unstable. | | |
| P1300 | Control Mode | 21: Closed loop speed control<br>23: Closed loop torque control | | |

**Caution**

Once the correct parameters values have been entered, it is recommended to operate the inverter in V/f mode (P1300 = 0) before speed/torque control with the encoder feedback is used and check that it functions correctly.

The user must observe the motor shaft to check the direction of rotation.

The direction of rotation must be checked against the value displayed in r0061.

If the direction of rotation does not match, then the output phases of the inverter or the encoder channels have to transposed to prevent unstable operation of the inverter in closed-loop control mode.

Setting P1820 to 1 can be used to reverse the motor rotation without transposing the output phases.

Ramp times (P1120 and 1121 cause F90 (encoder feedack loss).

**Note**

The encoder resolution (pulses per revolution) which may be entered will be limited by the maximum pulse frequency of the encoder option port ($f_{max} =$ 300 kHz ).

The following equation calculates the encoder frequency depending on the encoder resolution and the rotational speed (rpm). The encoder frequency has to be less than the maximum pulse frequency:

$$f_{max} > f = \frac{\text{Pulses per revolution x r.p.m. } [\frac{1}{\text{min}}]}{60}$$

Example: An Encoder may have 1024 pulses per revolution. It rotates at $n_N$ = 2850 $min^{-1}$. This delivers f = 48,64 kHz < $f_{max}$ = 300 kHz, therefore the Encoder can be used with the Encoder Interface.

P0492 is measured in Hz per milliseconds. If the inverter output frequency varies faster than the maximum allowable change in output frequency, it will trip with a fault condition F0090.

## 5.10.2 Encoder fault codes

### Encoder fault codes

The Encoder Interface has only one fault code, – F0090. This condition occurs when the allowed frequency rate of change, set in P0492[3] is exceeded or when low speed encoder loss is detected.

---

**Note**

The reason for the encoder loss will be given in the level 3 parameter P0949:

P0949 = 1 means encoder loss of channel A or channel B or channel A and channel B at high speed (shaft speed > P0492)

P0949 = 2 means encoder loss of channel A or channel A and channel B at low speed (shaft < P0492)

P0949 = 7 means excessive flux variance which may cause motor instability - possible due to encoder loss.

---

### Remedial action on fault condition

Should the encoder give a fault message F0090 the following remedial action should be performed:

1. Check that an encoder is fitted. If the encoder is not fitted, set P0400 = 0 and select SLVC mode (P1300 = 20 or 22).
2. Check the connections between the encoder and the inverter.
3. Check the encoder is not faulty (select P1300 = 0 and run at a fixed speed then check the encoder feedback signal using r0061). Check for correct magnitude and direction of speed.
4. Increase the encoder loss threshold in P0492.
5. Increase encoder low speed loss detection delay in P0494.

# Operation 6

## 6.1 General Operation behaviour

### Overview

The operation and start-up behavior depends on the settings during commissioning of the inverter.

As specific operation features the "Normal start-up behavior" and "Swap behavior" as well as "up and download of parameter sets" are described in this section.

## 6.2 Start-up Behavior

### Overview

When starting-up the inverter checks, wether an MMC is plugged in or not.

If it is plugged and no swap has been taken place the start-up runs according the "Normal start-up behavior". If a component (CU or PM) has been replaced, this is called a swap and the start-up will be performed according the "Swap behavior" of the inverter.

## 6.2.1 Normal Start-up behavior of the Inverter

### Normal start-up behavior of the inverter

A normal start-up is a start-up after a power-cycle or a black-out. It can be performed with or without MMC.

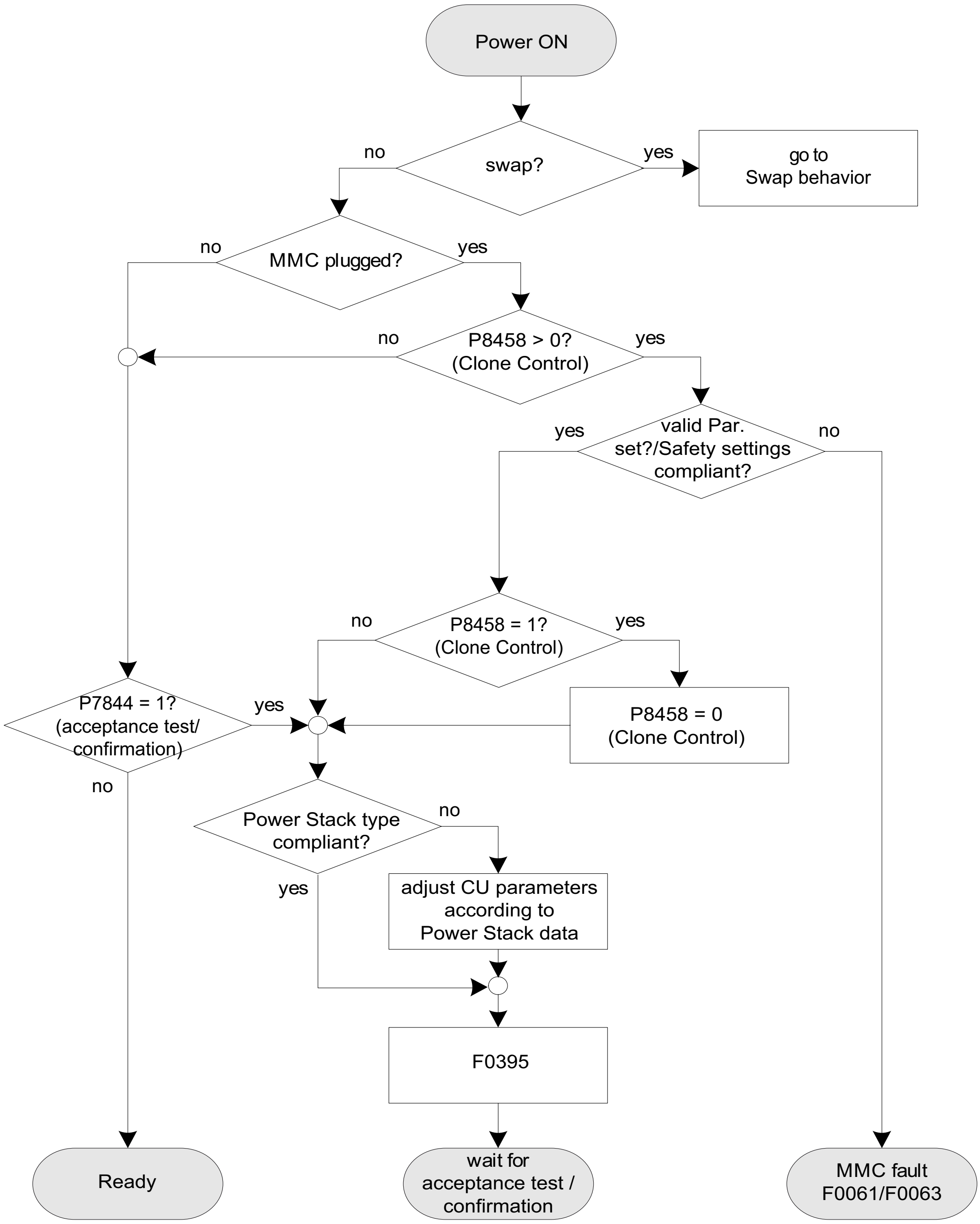



Figure 6-1 Normal start-up behavior

### Normal start-up behavior without MMC

After a power-cycle or a black-out the inverter reads the parameters from EEPROM to RAM.

### Normal start-up behavior with MMC

The CUs have been designed to detect automatically whether an MMC is present in the CU. The interaction between the CU and the MMC is controlled using parameter P8458.

The possible settings for P8458 and their functions are given below.

| | |
|---|---|
| P8458 = 0: | No automatic parameter download from the MMC. |
| P8458 = 1: | Automatic parameter download from the MMC (if present) only at the first start-up of the CU (default setting). |
| P8458 = 2: | Automatic parameter download from the MMC (if present) after each start-up of the control unit. |

On completion of the automatic download parameter P8458 will be set to 0 (if it was 1 before download) to prohibit any further automatic download parameters. In this case the MMC can be withdrawn after an automatic parameter download.

The setting P8458 = 1 is only meaningful for new CUs. It enables the user to commission the inverter by an automatic parameter download from a MMC.

If parameter P8458 is set to 1 or 2 and no MMC is present the inverter starts with the parameters of the EEPROM without alarm or fault message.

---

Note

**MMC for "automatic download"**

For an automatic download always the file clone00.bin will be used.

The user has to take care, that clone00.bin (saved as "clone00.bin" with STARTER on PC or via setting P0804 = 00 with the OP) is available on the MMC, used for an automatic parameter download at start-up. Otherwise automatic download will not be porocessed.

---

### Successful automatic download

After a successful automatic download, F0395 will be displayed.

- In case of a standard CU a confirmation is necessary.
- In the case of CUs with safety integrated functions, an acceptance test must be performed.

**Confirmation**

On standard CUs the current parameter set needs to be checked and confirmed by clearing F0395. It can be cleared via:

- Digital input or PLC signal (depends on the settings of P0700)
- setting P7844 = 0.

**Warning**

The user is responsible for ensuring that the parameters held in the CU are the correct parameters for their application.

### Acceptance test

On CUs with integrated fail-safe functions it is necessary to do an acceptance test (refer to the "Safety-Integrated functions" section in this manual). To clear F0395 on CUs with integrated fail-safe functions the following procedure has to be followed:

- P0010 = **30**
- P9761 = fail-safe password
- P7844 = 0

### Automatic download fault

If the automatic download process fails, the CU will return to the parameter set previously held in the EEPROM and the following fault codes are generated:

Table 6-1 Automatic download fault codes

| Fault code | Description |
|---|---|
| F0061 | Automatic download of parameters was not successful. |
| F0063 | Automatic download of parameters was not successful (e.g. wrong CU). |

In this case check, wether the MMC is defective or a parameter set clone00.bin is available or the parameter set is valid.

## 6.2.2 Swap Behavior of the Inverter

### Swap behavior of the inverter

The SINAMICS G120 inverter comprises of Power Modules (PM) and Control Units (CU)

Both, PM and CU, can be replaced e.g. to change a defective component. The exchange of either a PM or a CU is called a "swap".

The following swaps are possible:

- PM hotswap with powered CU (CU is powered via external 24 V source)
- CU swap
- PM swap, including a CU power cycle

---

Note

A standard CU will not accept a parameter set from a CU with fail-safe functions and vice versa.

---

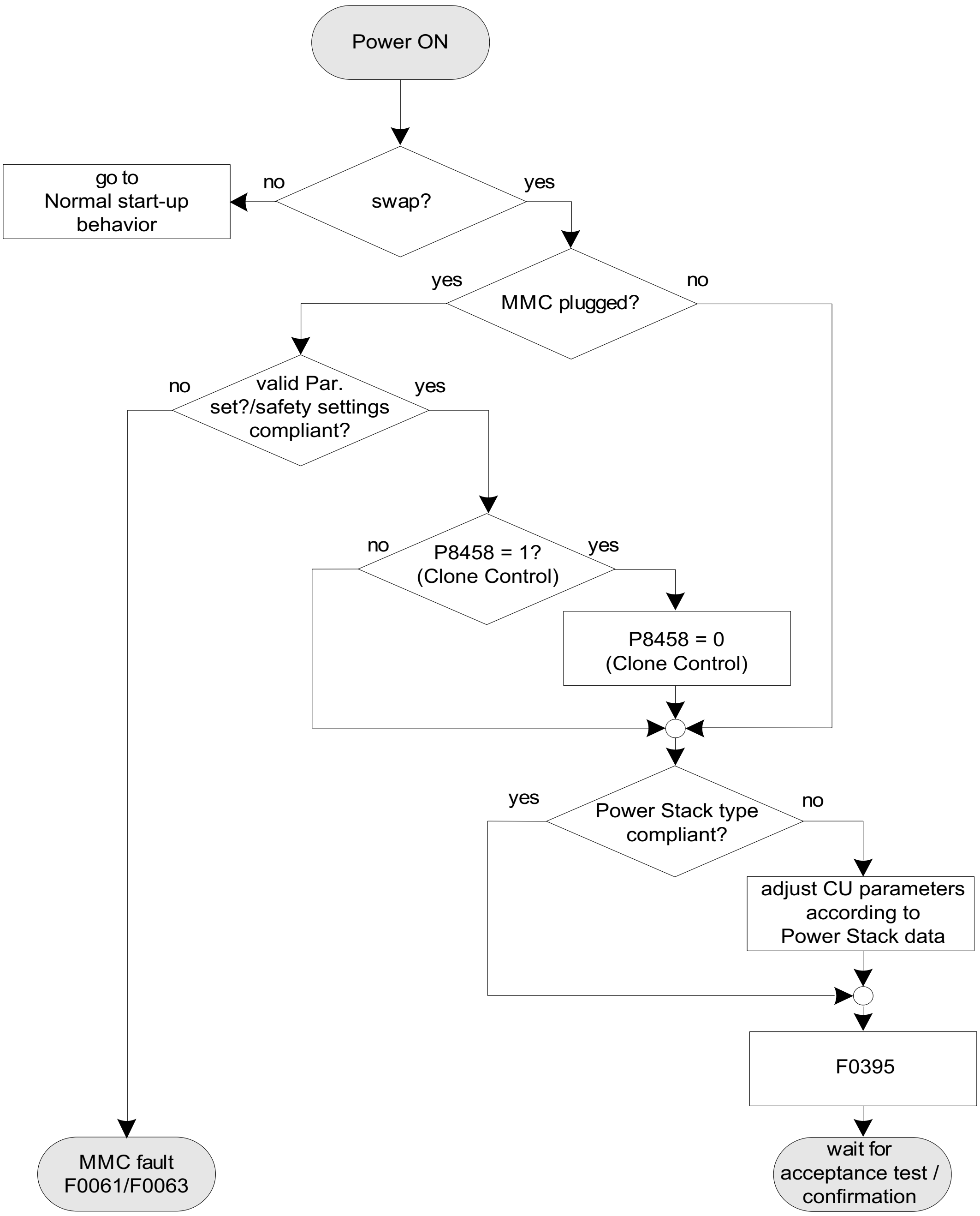



Figure 6-2 Swap behavior of the inverter

## PM hotswap with powered CU

**Caution**

Before performing a hotswap, make sure that all parameters are stored in the EEPROM of the Control Unit (see P0014 or P0971).

In this case the power module can be hot swapped without power cycling the CU. A parameter set either from MMC or from CU EEPROM is loaded into the CU RAM to prevent faults.

A successful swap is indicated by F0395, a swap fault by F0061 or F0063. See description below.

## CU swap

A CU swap always results in a power cycle of the CU. This causes a demand for loading a parameter set either from MMC or from CU EEPROM into the CU RAM. If an MMC with a valid parameter set is plugged, the CU loads the parameter set from the MMC, if no MMC is plugged, the parameter set from the CU EEPROM is loaded.

A successful swap is indicated by F0395, a swap fault by F0061 or F0063. See description below.

**Caution**

Before snap-on the Control Unit to the Power Module while hot swap connect 24 V supply to the terminals.

**Warning**

When carrying out a CU swap it is not allowed to replace a CU with fail-safe functions with a CU without fail-safe functions. Replacing a CU with fail-safe functions with a CU without fail-safe functions disables all potentially implemented fail-safe functions and therefore can lead to personal injury and damage to the machine.

A replacement of CU with fail-safe functions with a CU without fail-safe functions has to be assumed as completely new application.

## PM swap, including a power cycle

Same behavior as CU swap

## Successful swap

After a successful swap, F0395 will be displayed.

- In case of a standard CU a confirmation is necessary.
- In the case of CUs with safety integrated functions, an acceptance test must be performed.

### Confirmation

On standard CUs the current parameter set needs to be checked and confirmed by clearing F0395. It can be cleared via:

- Digital input or PLC signal (depends on the settings of P0700)
- setting P7844 = 0.

**Warning**

The user is responsible for ensuring that the parameters held in the CU are the correct parameters for their application.

### Acceptance test

On CUs with integrated fail-safe functions it is necessary to do an acceptance test (refer to the "Safety-Integrated functions" section in this manual). To clear F0395 on CUs with integrated fail-safe functions the following procedure has to be followed:

- P0010 = 95
- P9761 = fail-safe password
- P7844 = 0

## Swap fault

A swap fault is indicated if the automatic download fails. In this case, the CU will return to the parameter set previously held in the EEPROM and the following fault codes are generated:

Table 6-2 Automatic download fault codes

| Fault code | Description |
|---|---|
| F0061 | Automatic download of parameters was not successful. |
| F0063 | Automatic download of parameters was not successful (e.g. wrong CU). |

In this case check, wether the MMC is defective or a parameter set clone00.bin is available or the parameter set is valid.

## 6.3 Upload and download of parameter sets

### Upload of parameter sets

With an upload, a parameter set can be saved in one of the following devices:

- PC (via STARTER)
- MMC
- OP

An upload can be triggered via

- PROFIBUS,
- OP
- STARTER

A detailed description is given in "Series Commissioning" in the commissioning section.

### Download of parameter sets

In the case of a parameter download it is important to distinguish between the following possibilities:

- Manual download
- Automatic download.

**Caution**

Parameter download between different types of control units and of different firmware versions is not recommended.

Basically, it is possible to download parameter sets off different CU types, however, as the parameter sets might differ, the user is fully responsible for the consistency of the downloaded parameter set.

Therefore, the customer has to confirm his responsibility in case of an automatic download by acknowledging F0395.

## Manual download

A manual download can be performed similar to an upload via

- PC (STARTER)
- MMC
- OP

It can be triggered - like upload - via

- PROFIBUS,
- OP
- STARTER

With a manual download a parameter set without the safety related parameters is downloaded from one of the above mentioned devices into the inverter.

A detailed description is given in "Series Commissioning" in the commissioning section.

## Automatic download

An automatic download needs a MMC to be performed. It is not possible to perform an automatic download from a PC or from the OP.

The automatic download starts according to the settings in P8458 after power cycle or a after a swap (see "Start-up behavior" in this section).

Contrary to a manual download even the safety parameters are downloaded with an automatic download.

---

**Note**

**Manual and automatic download**

With a manual download all necessary parameters excluding the safety parameters (only with fail-safe CUs) are downloaded into the inverter. A detailed description is given in "Series Commissioning" in the commissioning section.

With an automatic download even the safety parameters are downloaded into the inverter. An automatic download can only be performed with an MMC at Start-up or after a swapping an inverter component (CU or PM). A detailed description is given in "Start-up behavior" of this section.

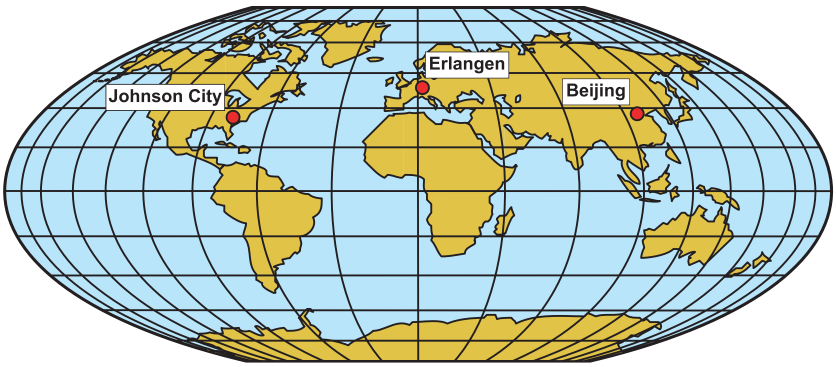
---

# Service and maintenance 7

## 7.1 Service and support information

### A&D Technical support

24-hour technical support is provided by three main centres worldwide.




A&D Global service and support

### Europe/Africa (Erlangen)

Tel: +49 (180) 5050 222

Fax: +49 (180) 5050 223

Email: adsupport@siemens.com

### America (Johnson City)

Tel: +1 (423) 262 2552

Fax: +1 (423) 262 2589

Email: simatic.hotline@sea.siemens.com

### Asia/Pacific (Beijing)

Tel: +86 (1064) 757 575

Fax: +86 (1064) 747 474

Email: adsupport.asia@siemens.com

### China (Beijing)

Tel: +86 (1064) 71 9990

Fax: +86 (1064) 71 9991

Email: adscs.china@siemens.com

### Online Service and support

Comprehensive information and support tools are available from the Service and Support internet site at:

http://support.automation.siemens.com

### Contact address

Should any questions or problems arise while reading this manual, please contact Siemens at the following address:

Siemens AG
Automation & Drives
A&D SD SPA PM4
Postfact 3269
D-91050 Erlangen
Germany

Email: documentation.sd@siemens.com

### Regional contacts

For questions regarding services, prices and conditions of technical support, please contact your local Siemens partner.

# 7.2 Faults and Alarms

## Faults

In the event of a failure, the inverter switches off and the red LED "SF" will be on. The fault code will be displayed via OP, STARTER or Communication interface (if fitted, resp. connected).

---

Note

To reset the fault code, one of three methods listed below can be used:

1. Cycle the power to the inverter.
2. Press the **Fn** button on the OP
3. Use digital input 2 (default setting).

---

Fault messages are stored in parameter r0947 under their code number (e.g. F0003 = 3). The associated error value is found in parameter r0949. The value 0 is entered if a fault has no error value. It is possible to read out the point in time that a fault occurred (r0948) and the number of fault messages (P0952) stored in parameter r0947.

A detailed description of the fault messages is provided in the Parameter List.

The fault state indication by LED is shown in the following sections.

## Alarm messages

The alarm code will be displayed via OP, STARTER or Communication interface (if fitted, resp. connected). Alarm messages are stored in parameter r2110 under their code number (e.g. A0503 = 503) and can be read out from there. A detailed description of the alarm messages is provided in the Parameter List.

# 7.3 LED Overview

## Status display via LED

The SINAMICS G120 inverters provide multiple functions and operating states which are indicated via LED.

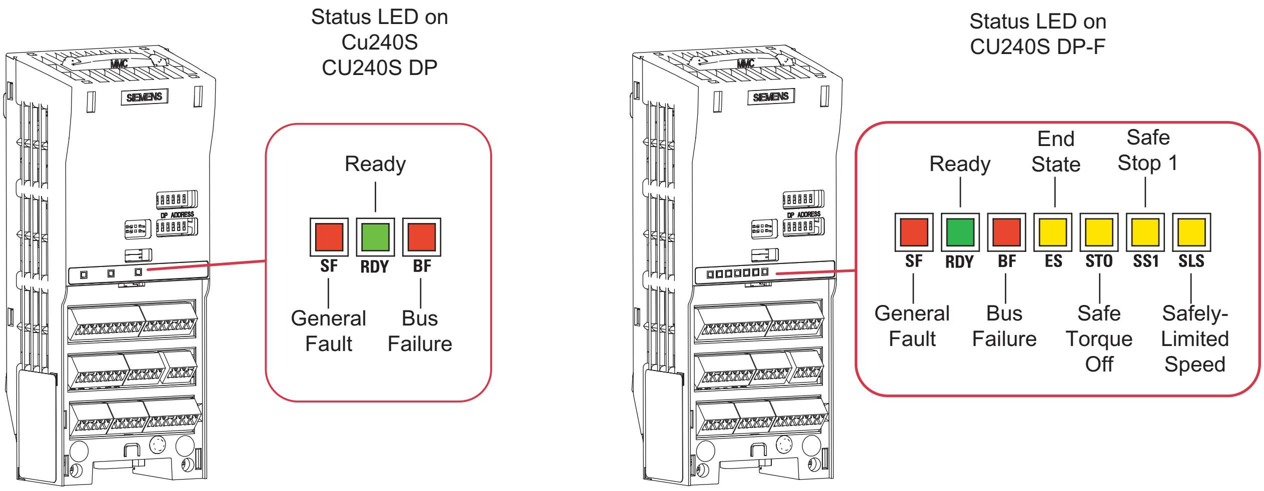
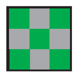
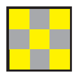



Figure 7-1 State LED on the CU240S, CU240S DP, CU240S DP-F

## Colours

The colours of the LEDs are self explanatory. The Status of the inverter is displayed by the following different LED colors and states:

| Meaning | Color | State | | |
|---|---|---|---|---|
| | | on | off | Temporary state (flashing 0.5 Hz) |
| Fault indication LED<br>• SF<br>• BF | Red |  |  |  |
| Ready LED<br>• RDY | Green |  |  |  |
| Fail-safe LED<br>• ES<br>• STO, SS1, SLS | Yellow |  |  |  |

If for a certain state it is indifferent whether the LED is ON, OFF or flashing it is mentioned as "not relevant".

## LED description

- System-Fault LED (SF)

  The system-fault LED indicates a general system error either software or hardware related.
- Ready LED (RDY)

  The ready LED indicates whether the inverter is ready to operate by transmitting a control-word.
  This LED does not indicate whether the drive is running or not. For that purpose an OP would be more convenient. The information of interest is the actual speed, which can be displayed on an OP which can be easily plugged in and out at any time during operation.
- Bus-Failure LED (BF)

  The Bus-failure LED indicates if any bus failure occurred. A bus failure can be characterised as corrupted communication (e.g. a frame of the PROFIBUS) due to signalling problems on the bus itself.
  Note that faults according to the inner data structure of the transmitted communication frames (e.g. CRC check of PROFIsafe telegram) are not denoted as bus failure. Thus, such failures have to be indicated by the general fault LED.

  The Bus-failure LED indicates the following states:

  – Bus-failure LED off: no Bus failure
  – Bus-failure LED on: no connection to the DP-Master (searching for baud rate)
  – Bus-failure LED flashing 0.5 Hz: I/O device is not configured or is wrongly configured (baud rate found, no data exchange).
- End-state LED (ES)

  The end-state LED indicates if the end state of a triggered fail-safe function has been reached
- Safe Torque Off LED (STO)

  The safe torque off LED indicates the fail-safe function Safe Torque Off.
- Safe Stop 1 LED (SS1)

  The safe stop 1 LED indicates the fail-safe function Safe Stop 1.
- Safely-Limited Speed LED (SLS)

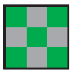
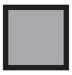
  The safely-limited speed LED indicates the fail-safe function Safely-Limited Speed.

For fail-safe functions please refer to section Function.

# 7.4 Normal Status LEDs

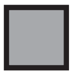
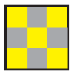
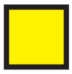
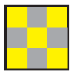
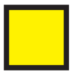
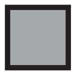
## Normal Status LEDs

Table 7-1 Status display

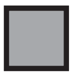
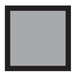
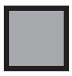
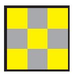
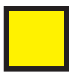
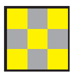
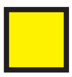
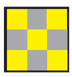
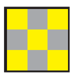
| LED | | | Description |
|---|---|---|---|
| SF | RDY | BF | |
| red | green | red | |
|  |  | not relevant | Ready or running, conection to bus master ok |
|  |  |  | Ready or running, no connection to the bus master |
|  |  | not relevant | Commissioning |
|  |  | not relevant | General fault |
| not relevant | not relevant |  | Bus failure (search baud rate) |
| not relevant | not relevant |  | Bus failure (no data) |
|  |  |  | No supply available |

# 7.5 Fail-Safe Function Status LEDs

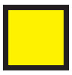
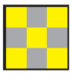
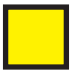
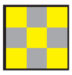
## STO Fail-safe function states via LED

| LED | | | | | | | Description |
|---|---|---|---|---|---|---|---|
| SF | RDY | BF | ES | STO | SS1 | SLS | |
| red | green | red | yellow | | | | |
| not relevant | not relevant | not relevant |  |  | not relevant | not relevant | STO parameterized |
| not relevant | not relevant | not relevant |  |  | not relevant | not relevant | STO triggered |
| not relevant | not relevant | not relevant |  |  | not relevant | not relevant | STO reached |
| not relevant | not relevant | not relevant |  |  |  |  | LSTO triggered |

## SS1 Fail-safe function states via LED

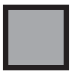
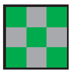
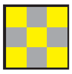
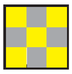
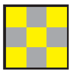
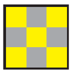
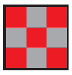
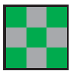
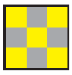
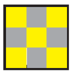
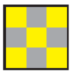
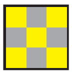
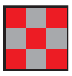
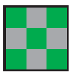
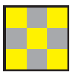
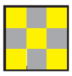
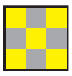
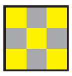
| LED | | | | | | | Description |
|---|---|---|---|---|---|---|---|
| SF | RDY | BF | ES | STO | SS1 | SLS | |
| red | green | red | yellow | | | | |
| not relevant | not relevant | not relevant |  |  |  |  | SS1 parameterized |
| not relevant | not relevant | not relevant |  | not relevant |  | not relevant | SS1 triggered |
| not relevant | not relevant | not relevant |  | not relevant |  | not relevant | SS1 reached |
| not relevant | not relevant | not relevant |  |  |  | not relevant | STO reached,<br>end state for SS1 |

### SLS Fail-safe function states via LED

| LED | | | | | | | Description |
|---|---|---|---|---|---|---|---|
| SF | RDY | BF | ES | STO | SS1 | SLS | |
| red | green | red | yellow | | | | |
| not relevant | not relevant | not relevant |  |  |  |  | SLS parameterized |
| not relevant | not relevant | not relevant |  | not relevant | not relevant |  | SLS triggered |
| not relevant | not relevant | not relevant |  | not relevant | not relevant |  | SLS reached |

## 7.6 Further indication for LEDs

### Further states, displayes via LED

| LED | | | | | | | Description |
|---|---|---|---|---|---|---|---|
| SF | RDY | BF | ES | STO | SS1 | SLS | |
| red | green | red | yellow | | | | |
|  |  | not relevant |  |  |  |  | Safety commissioning |
|  |  | not relevant |  |  |  |  | Firmware update from MMC |
|  |  | not relevant |  |  |  |  | Parameter download from MMC |

# 7.7 Troubleshooting with the PROFIBUS DP

## Overview

There are three types of diagnostic display:

- LED – see previous section.
- Alarm Numbers
- Diagnostic parameters.

## Diagnostics using alarm numbers

If a Basic Operator Panel (BOP) is fitted to the Control Unit and a alarm or fault condition occurs, the BOP will display the appropriate alarm or fault number.

If an alarm occurs, the alarm number will be displayed and the inverter will continue to run, although it is possible that it may run in an unexpected manner depending upon the alarm condition.

If a fault occurs, the fault number will be displayed and normally the inverter will be stopped.

Table 7-2 Alarm numbers, cause and remedy

| Alarm Number | Meaning | |
|---|---|---|
| A0700 | Cause | The parameter or configuring settings by the PROFIBUS master are invalid. |
| | Remedy | Correct the PROFIBUS configuration |
| A0702 | Cause | The link to the PROFIBUS is interrupted. |
| | Remedy | Check connector, cable and PROFIBUS master. |
| A0703 | Cause | No setpoints or invalid setpoints (control word = 0) are being received from the PROFIBUS master. |
| | Remedy | Check setpoints from the PROFIBUS master. Switch SIMATIC CPU to “RUN”. |
| A0704 | Cause | At least one configured internode transmitter is not yet active, or has failed. |
| | Remedy | Activate internode transmitter. |
| A0705 | Cause | No actual values received from inverter. |
| | Remedy | None (fault is with the inverter). |
| A0706 | Cause | PROFIBUS-DP software error. |
| | Remedy | None diagnostic parameter r2041. |
| A0710 | Cause | Inverter has detected failure of PROFIBUS communications link. |
| | Remedy | Communication interface on Control Unit may be broken. |
| A0711 | Cause | Invalid value of PROFIBUS parameter. |
| | Remedy | Check P0918 address and P2041. |
| F0070 | Cause | No communication via PROFIBUS. Triggered by A0702, A0703 and A0704. The telegram failure time set in P2040 has run out. Details see section "Faults and Alarns" in the Parameter List. |
| | Remedy | Check connection of the communication devices and ensure that a valid control word is being used. |

## Identification of the communications components

The read-only parameter r2053 shows the information by which the various firmware components of the PROFIBUS-DP interface can be identified.

Table 7-3 Identification of communications firmware

| Parameter | Meaning |
|---|---|
| r2053.00 | 0: Inverter cannot identify the communications interface |
| | 1: PROFIBUS DP detected |
| | 2: No assigned |
| | 56: Undefined communications error |
| r2053.01 | Firmware version |
| r2053.02 | Constant "0" |
| r2053.03 | Firmware date (year) |
| r2053.04 | Firmware date (day and month) |

## Standard diagnostics

When the parameter P2041.03 = 0, then by using the read-only parameter r2054 and it's indices, it is possible to obtain detailed diagnostic information regarding the PROFIBUS-DP interface. This information is listed in table below.

Table 7-4 Standard diagnostics

| Parameter | Meaning |
|---|---|
| r2054.00 | PROFIBUS-DP status: |
| | 0: Off |
| | 1: Baud rate search |
| | 2: Baud rate found |
| | 3: Cyclical data exchange |
| | (> 100: other diagnostic screen active) |
| r2054.02 | Number of acyclical links with class 2 master (PC, OP): 0 … 2 |
| r2054.03 | Error number of last unsuccessful parameter access operation through an acyclical link. |
| r2054.04 | Parameter number of last unsuccessful parameter access operation |
| r2054.05 | Sub-index of last unsuccessful parameter access operation |

When parameter accessing errors occur, r2054.03 display the appropriate error number, these are listed in table below.

Table 7-5 Parameter accessing error numbers

| Number | Cause | Remedy |
|---|---|---|
| 0 … 199: | Parameter access has been converted to a PKW request. Error detected in the inverter. Additional information is in r2054.05 and r2054.06: Parameter number, index word | |
| 0 | Parameter number does not exist | Check data block number |
| 1 | Parameter number cannot be modified | -- |
| 2 | Minimum/maximum not reached or exceeded | -- |
| 3 | Sub-index does not exist | Check data block offset |
| 4 | Access of single value with array identifier | Set data block offset = 0 |
| 5 | Access to word with double word request or vice versa | Use correct data type<br>(e.g. INT for word, DINT for double word) |
| 6 | Setting not allowed (resetting only) | -- |
| 7 | Descriptive element cannot be modified | -- |
| 11 | No status as master control | -- |
| 12 | Key word missing | -- |
| 17 | Request cannot be processed due to operating state | -- |
| 101 | Parameter number currently deactivated | -- |
| 102 | Channel not wide enough | -- |
| 104 | Illegal parameter value | -- |
| 106 | Request not implemented | -- |
| 200/201 | Modified minimum or maximum not reached or exceeded. | Minimum or maximum can be further limited in operation |
| 240 … 249: | Parameter access is incorrectly formatted. Error detected on the PROFIBUS DP Additional information in r2054.05 and r2054.06: Parameter number or S7 data block number, sub-index or S7 data block offset. | |
| 240 | Error in variable address (no additional information) | Legal: “Data block” area |
| 241 | Data block number illegally formatted | Legal: 1 … 31999 |
| 242 | Data block offset illegally formatted | Legal: 0 … 116 |
| 243 | Illegal “type” | Legal: CHAR, BITE, INT, WORD, INT, DWORD, REAL |
| 244 | Illegal “Number of elements” on accessing parameter value | Legal: Effectively 2 or 4 bytes |
| 248 | Illegal text/description modification | -- |
| 249 | Inconsistency in write request: “Type” and “Number of elements” does not match “Data type” and “Data length” | Error in communication device |
| 250: | Parameter access has been converted to a PKW request. Response from inverter is seen as incorrect. Error detected on the PROFIBUS-DP. Additional information can be seen in r2054.05 and r2054.06. | |
| 250 | PKW response does not match request | Error in the inverter |
| 251: | Error detected on the PROFIBUS-DP; no additional information | |
| 251 | Response too long for response telegram | Error in communication device |

# 7.8 Troubleshooting with the OP

## Troubleshooting with the OP

If the motor fails to start when the ON command has been given:

- Check that P0010 = 0.
- Check the inverter state via r0052
- Check command and setpoint source (P0700 and P1000)

Warnings and faults are displayed on the OP with Axxx and Fxxx respectively. The individual messages are shown in the Parameter List.

---

**Note**

Motor data must relate to the inverter data power range and voltage.

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# Functions

# 8

## 8.1 BICO Technology

### Interconnecting signals (BICO)

A state-of-the-art inverter must be able to interconnect internal and external signals (setpoint or actual values and control or status signal). This interconnection functionality must have a high degree of flexibility in order to be able to adapt the inverter to new applications. Further, a high degree of usability is required, which also fulfills standard applications. This is the reason that within the SINAMICS G120 series of inverters, BICO technology (⇒ flexibility) and fast parameterization using parameters P0700/P1000 (⇒ usability) have been introduced to be able to fulfill both of these requirements.

### 8.1.1 Selection of command/setpoint source P0700 and P1000

### Description

The following parameters can be used to quickly interconnect setpoints and control signals:

- P0700 Selection of command source
- P1000 Selection of setpoint source

These parameters are used to define through which interface the inverter receives the setpoint or the power-on/power-off command. The interfaces, shown in the table below can be selected for the command source P0700.

Table 8-1 Parameter P0700

| Parameter Values | Significance/command source |
|---|---|
| 0 | Factory default |
| 1 | Operator Panel (OP) |
| 2 | Terminal |
| 4 | USS on RS232 |
| 5 | USS on RS485 |
| 6 | Fieldbus |

The following internal or external sources or interfaces can be selected for the frequency setpoint source P1000. In addition to the main setpoint (second position), a supplementary setpoint (first position) can be selected. This is shown in the table below.

Table 8-2 Parameter P1000

| Parameter Values | Significance | |
|---|---|---|
| | Main setpoint source | Supplementary setpoint source |
| 0 | No main setpoint | -- |
| 1 | MOP setpoint (motorized potentiometer) | -- |
| 2 | Analog setpoint | -- |
| 3 | Fixed frequency | -- |
| 4 | USS on RS232 | -- |
| 5 | USS on RS485 | -- |
| 6 | Fieldbus | -- |
| 7 | Analog setpoint 2 | -- |
| 10 | No main setpoint | MOP setpoint |
| 11 | MOP setpoint | MOP setpoint |
| 12 | Analog setpoint | MOP setpoint |
| … | … | … |
| 77 | Analog setpoint 2 | Analog setpoint 2 |

**Note**

The complete list of all the possible settings is contained within Parameter List (see P1000).

In this case, the selection of the command source is made independently of the selection of the frequency setpoint source. This means that the source to enter the setpoint does not have to match the source to enter the power-on/power-off command (command source). This means, for example, that the frequency setpoint P1000 = 6 can be connected using an external device and ON/OFF is entered using digital inputs DI (terminals, P0700 = 2).

**Caution**

When P0700 or P1000 are modified, then the frequency inverter also changes the subordinate BICO parameters (refer to the Parameter List for P0700 or P1000 in the appropriate tables).

There is no prioritization (priority assignment) between direct BICO parameterization and P0700/P1000. The last modification is valid.

## 8.1.2 Using BICO technology

### Description

Using BICO technology (Binector Connector Technology), process data can be freely interconnected using the "standard" inverter parameterization. In this case, all values which can be freely interconnected (for example, frequency setpoint, frequency actual value, current actual value, etc.) can be defined as "Connectors" and all digital signals which can be freely interconnected (for example, status of a digital input, ON/OFF, message function when a limit is violated etc.) can be defined as "Binectors".

There are many input and output quantities as well as quantities within the closed-loop control which can be interconnected in a inverter. It is possible to adapt the inverter to the various requirements using BICO technology.

A binector is a digital (binary) signal without any units and which can either have the value of 0 or 1. Binectors always refer to functions whereby they are sub-divided into binector inputs and binector outputs (see the table below). In this case, the binector input is always designated using a "P" parameter (e.g. P0840 BI: ON/OFF1), while the binector output is always represented using an "r" parameter (e.g. r1025 BO: FF status).

As can be seen from the examples above, the binector parameters have the following abbreviations in front of the parameter names:

### BI: Binector Input, signal sink ("P" parameters)

The BI parameter can be interconnected with a binector output as a source, by entering the parameter number of the binector output (BO parameter) as a value in the BI parameter.

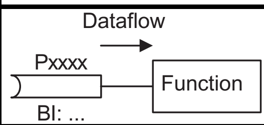
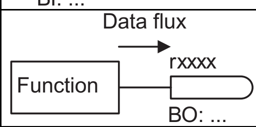
### BO: Binector Output, signal source ("r" parameters)

The BO parameter can be used as a source for BI parameters. For a particular interconnection the BO parameter number must be entered into the BI parameter.

### Example

Interconnecting the BO parameter r1025 with BI parameter P0840: → P0840 = 1025

Table 8-3 Binectors

| Abbreviation and symbol | Name | Function |
|---|---|---|
| BI | Binector input<br>(signal sink) |   |
| BO | Binector output<br>(signal source) |   |

A connector has a value (16 or 32 bit), which can include a normalized quantity (without dimension) as well as a quantity with associated units. Connectors always refer to functions whereby they are sub-divided into connector inputs and connector outputs. Essentially it is the same as for the binectors, the connector inputs are characterized by a "P" parameter (e.g. P0771 CI: AO (analog output)); while the connector outputs are always represented using an "r" parameter (e.g. r0021 CO: Act. frequency).

As can be seen from the examples above, connector parameters have the following abbreviations in front of the parameter names:

## CI: Connector Input, signal sink ("P" parameters)

The CI parameter can be interconnected with a connector output as a source, by entering the parameter number of the connector output (CO parameter) as a value in the CI parameter.

## CO: Connector Output, signal source ("r" parameters)

The CO parameter can be used as source for CI parameters. For a particular interconnection, the CO parameter number must be entered in the CI parameter.

## Example

Interconnecting the CO parameter r0021 with CI parameter P0771: → P0771 = 21

Further, SINAMICS G120 has "r" parameters where several binector outputs are combined in a word (e.g. r0052 CO/BO: Status word 1). This feature reduces, on one hand, the number of parameters and simplifies parameterization using the serial interface (data transfer). This parameter is further characterized by the fact that it does not have any units and each bit represents a digital (binary) signal.

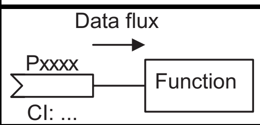
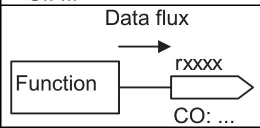
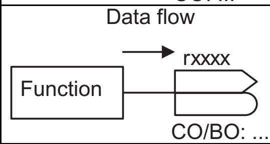
As can be seen from the examples of parameters, these combined parameters have the following abbreviation in front of the parameter names:

## CO/BO: Connector Output/Binector Output, signal source ("r")

CO/BO parameters can be used as a source for CI parameters and BI parameters:

- In order to interconnect all of the CO/BO parameters, the parameter number must be entered into the appropriate CI parameter (e.g. P2016[0] = 52).
- When interconnecting a single digital signal, in addition to the CO/BO parameter number, the bit number must also be entered into the CI parameter (e.g. P0731 = 52.3)

Table 8-4 Connectors

| Abbreviation and symbol | Name | Function |
|---|---|---|
| CI | Connector input<br>(signal sink) |  |
| CO | Connector output<br>(signal source) |  |
| CO<br>BO | Binector/connector output<br>(signal source) |  |

In order to interconnect two signals, a BICO setting parameter (signal sink) must be assigned the required BICO monitoring parameter (signal source). A typical BICO interconnection is shown using the following examples (see figure below):

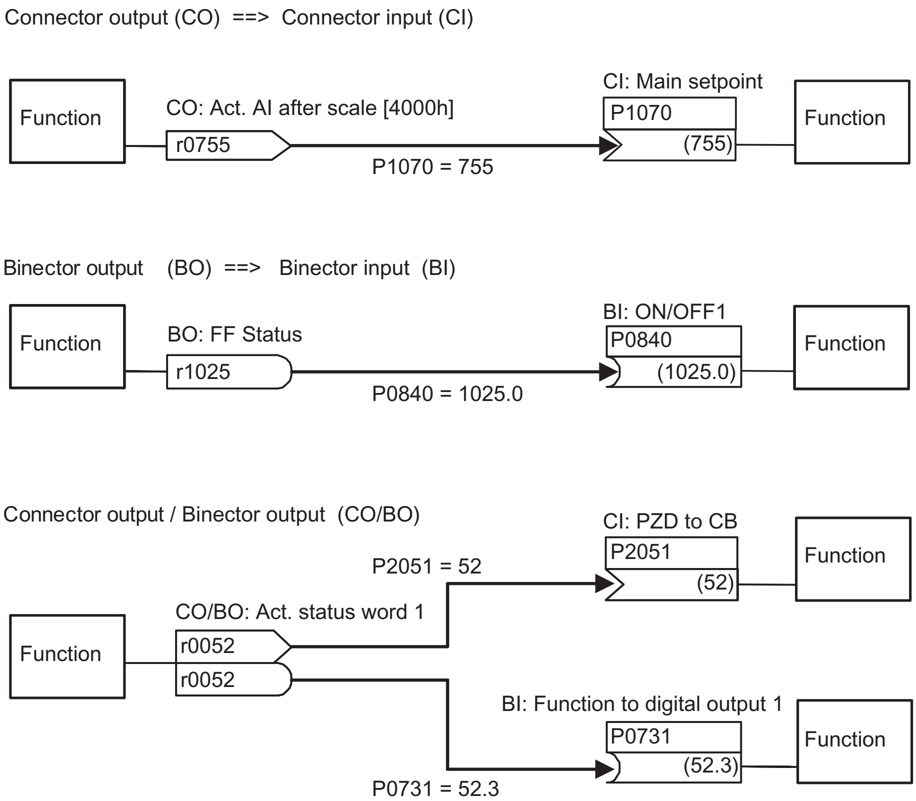



Figure 8-1 BICO connections

---

**Note**

BICO parameters with the CO, BO or CO/BO attributes can be used a number of times.

---

# 8.2 Data Sets

## Description

For many applications it is advantageous if several parameters can be simultaneously changed, during operation or in the ready state, using an external signal.

This functionality can be elegantly implemented using indexed parameters. In this case, as far as the functionality is concerned, the parameters are combined to form groups/data sets and are indexed. By using indexing, several different settings can be saved for each parameter which can be activated by changing-over the data set (i.e. toggling between data sets).

The following data sets apply:

- Command Data Set CDS
- Drive Data Set DDS

Three independent settings are possible for each data set. These settings can be made using the index of the particular parameter:

- CDS0 … CDS2
- DDS0 … DDS2

## Command Data Set

Those parameters (connector and binector inputs) which are used to control the inverter and enter a setpoint, are assigned to the command data set (CDS). The signal sources for the control commands and setpoints are interconnected using BICO technology. In this case, the connector and binector inputs are assigned as signal sources corresponding to the connector and binector outputs. A command data set includes:

| Command sources and binector inputs for control commands (digital signals) e.g. | |
|---|---|
| Selects the command source | P0700 |
| ON/OFF1 | P0840 |
| OFF2 | P0844 |
| JOG Enable | P1057 |
| Enable JOG right | P1055 |
| Enable JOG left | P1056 |

| Setpoint sources and connector inputs for setpoints (analog signals) e.g. | |
|---|---|
| Selection of frequency setpoint | P1000 |
| Selection of main setpoint | P1070 |
| Selection of additional setpoint | P1075 |

The parameters, combined in a command data set, are designated with [x] in the parameter list in the index field.

| Index | |
|---|---|
| Pxxxx[0] | Command data set 0 (CDS0) |
| Pxxxx[1] | Command data set 1 (CDS1) |
| Pxxxx[2] | Command data set 2 (CDS2) |

**Note**

A complete list of all of the CDS parameters is contained in the Parameter List.

It is possible to parameterize up to three command data sets. This makes it easier to toggle between various pre-configured signal sources by selecting the appropriate command data set. A frequent application involves, for example, the ability to toggle between automatic and manual operation.

**Note**

The parameters will be altered during data set switchover in the state "Ready" and "Run", except P1522, P1523 and P2200 in the state "Run".

SINAMICS G120 has an integrated copy function which is used to transfer command data sets.

This can be used to copy CDS parameters corresponding to the particular application. P0809 is used to control the copy operation as follows:

| Copy operation controlled with P0809 | |
|---|---|
| P0809[0] | Number of the command data set which is to be copied (source) |
| P0809[1] | Number of the command data set into which data is to be copied (target) |
| P0809[2] | Copying is started, if P0809[2] = 1 |
| | Copying has been completed, if P0809[2] = 0 |

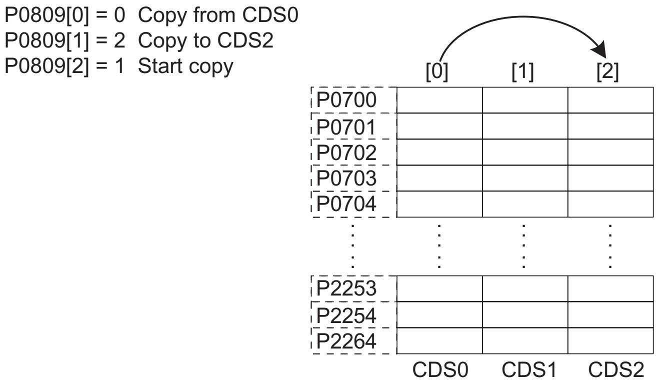



Figure 8-2 Copying from a CDS

The command data sets are changed-over using the BICO parameters P0810 and P0811, whereby the active command data set is displayed in parameter r0050 (see figure below). Changeover is possible both in the "Read" as well as in the "Run" states.

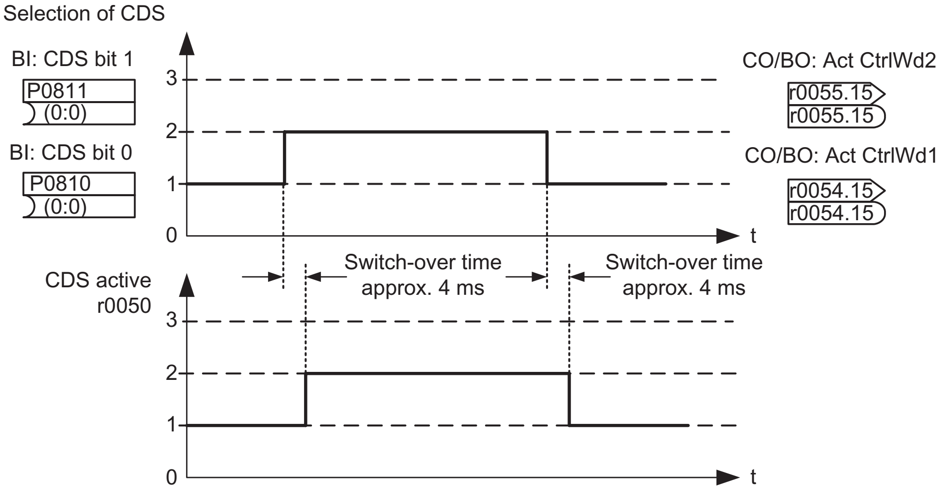



Figure 8-3 Changing-over a CDS

The currently active command data set (CDS) is displayed using parameter r0050:

| | selected CDS | | active CDS |
|---|---|---|---|
| | r0055 Bit15 | r0054 Bit15 | r0050 |
| CDS0 | 0 | 0 | 0 |
| CDS1 | 0 | 1 | 1 |
| CDS2 | 1 | 0 | 2 |
| CDS2 | 1 | 1 | 2 |

Figure 8-4 Active command data set (CDS)

### Example

The command source (e.g. terminals → OP) or setpoint (frequency) source (e.g. AI → MOP) should be changed-over using a terminal signal (e.g. DI3) as a function of an external event (e.g. the higher-level control unit fails). A typical example in this case is a mixer, which may come to an uncontrolled stop when the control fails.

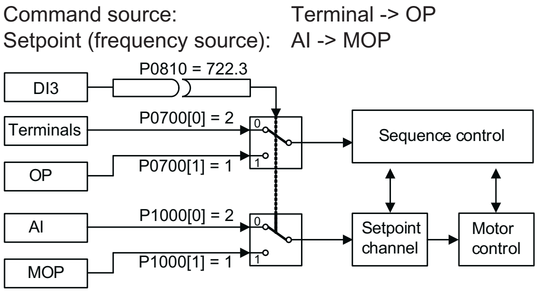



Figure 8-5 Changing-over between the control and setpoint source

CDS0: Command source via terminals and setpoint source via analog input (AI)

CDS1: Command source via OP and setpoint source via MOP

CDS changeover is realized using digital input 3 (DI3)

### Steps:

1. Carry-out commissioning for CDS0 (P0700[0] = 2 and P1000[0] = 2)
2. Connect P0810 (P0811 if required) to the CDS changeover source (P0704[0] = 99, P0810 = 722.3)
3. Copy from CDS0 to CDS1 (P0809[0] = 0, P0809[1] = 1, P0809[2] = 1)
4. Adapt CDS1 parameters (P0700[1] = 1 and P1000[1] = 1)

## Drive data set

The drive data set (DDS) contains various setting parameters which are of significance for the open-loop and closed-loop control of a motor:

| Drive and encoder data, e.g. | |
|---|---|
| Select motor type | P0300 |
| Rated motor voltage | P0304 |
| Main inductance | P0360 |
| Select encoder type | P0400 |

| Various closed-loop control parameters, e.g. | |
|---|---|
| Fixed frequency 1 | P1001 |
| Min. frequency | P1080 |
| Ramp-up time | P1120 |
| Control mode | P1300 |

The parameters, combined in a drive data set, are designated with an [x] in the parameter list in the index field:

| Index | |
|---|---|
| Pxxxx[0] | Drive data set 0 (DDS0) |
| Pxxxx[1] | Drive data set 1 (DDS1) |
| Pxxxx[2] | Drive data set 2 (DDS2) |

**Note**

A complete list of all of the DDS parameters is contained in the Parameter List.

It is possible to parameterize several drive data sets. This makes it easier to toggle between various inverter configurations (control mode, control data, motors) by selecting the appropriate drive data set (see figure below).

Just like the command data sets, it is possible to copy drive data sets within the SINAMICS G120. P0819 is used to control the copy operation as follows:

| Copy operation controlled with P0819 | |
|---|---|
| P0819[0] | Number of the drive data set which is to be copied (source) |
| P0819[1] | Number of the drive data set into which data is to be copied (target) |
| P0819[2] | Copying is started, if P0819[2] = 1 |
| | Copying has been completed, if P0819[2] = 0 |

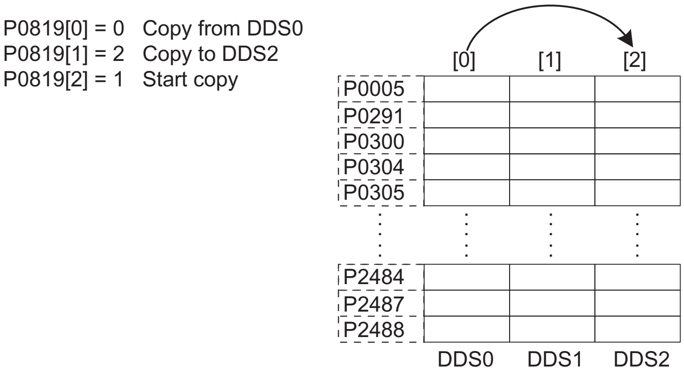



Figure 8-6 Copying from a DDS

Drive data sets are changed-over using the BICO parameter P0820 and P0821 whereby the active drive data set is displayed in parameter r0051 (see figure below). Drive data sets can only be changed-over in the "Ready" state and this takes approximately 50 ms.

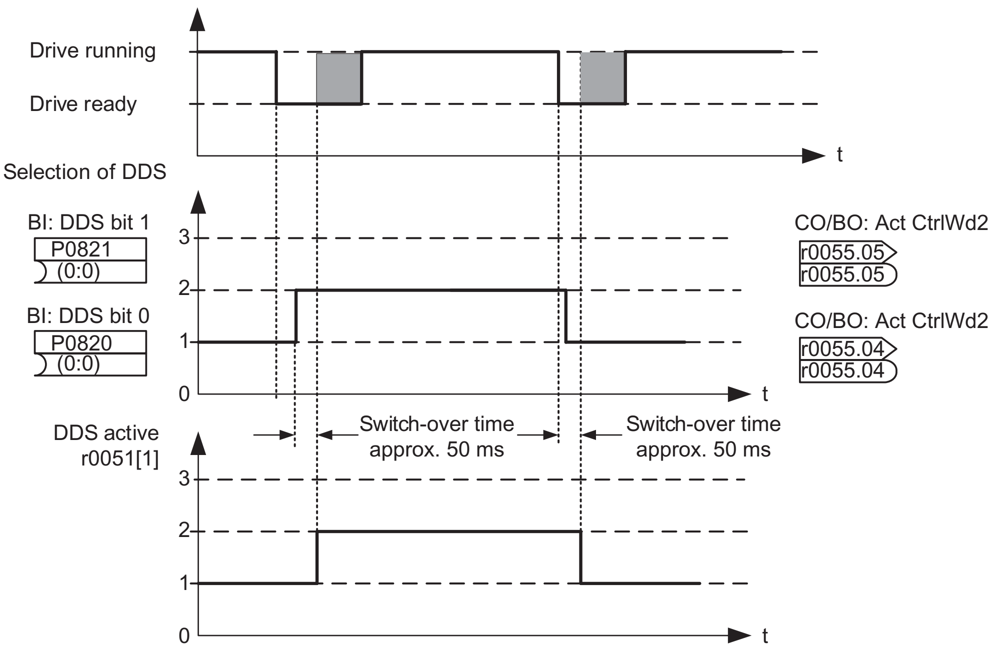



Figure 8-7 Changing-over a DDS

The currently active drive data set (DDS) is displayed using parameter r0051[1]:

| | selected DDS | | | active DDS |
|---|---|---|---|---|
| | r0055 Bit05 | r0055 Bit04 | r0051 [0] | r0051 [1] |
| DDS0 | 0 | 0 | 0 | 0 |
| DDS1 | 0 | 1 | 1 | 1 |
| DDS2 | 1 | 0 | 2 | 2 |
| DDS2 | 1 | 1 | 2 | 2 |

Figure 8-8 Active drive data set (DDS)

### Example

The inverter should be switched-over from motor 1 to motor 2.

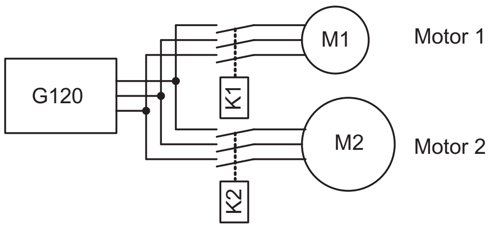



Figure 8-9 Changeover from motor 1 to motor 2

Commissioning steps with 2 motors (motor 1, motor 2):

Carry-out commissioning at DDS0 with motor 1; adapt the remaining DDS0 parameters.

Connect P0820 (P0821 if required) to the DDS changeover source
(e.g. via DIN4: P0705[0] = 99, P0820 = 722.4).

Changeover to DDS1 (check using r0051).

Carry-out commissioning at DDS1 with motor 2; adapt the remaining DDS1 parameters.

# 8.3 Digital inputs (DI)

## Description

| | |
|---|---|
| Number: | 9 + 2 |
| Parameter range: | P0701 … P0709, P0712, P0713<br>r0722 … P0724 |
| Function chart number: | FP2000, FP2200 |
| Features: | |
| • cycle time: | 2 ms |
| • switch-on threshold: | 9.6 V |
| • switch-out threshold: | 8.6 V |
| • electrical features: | electrically isolated, short-circuit proof |

External control signals are required for an inverter to be able to operate autonomously. These signals can be entered using a serial interface as well as using digital inputs (see figure below). The SINAMICS G120 has 9 digital inputs which can be expanded to a total of 11 by using the 2 analog inputs. The digital inputs can be freely programmed to create a function. Regarding the programming, it is possible to directly assign the function using parameters P0701 … P0713 or to freely program the function using BICO technology.

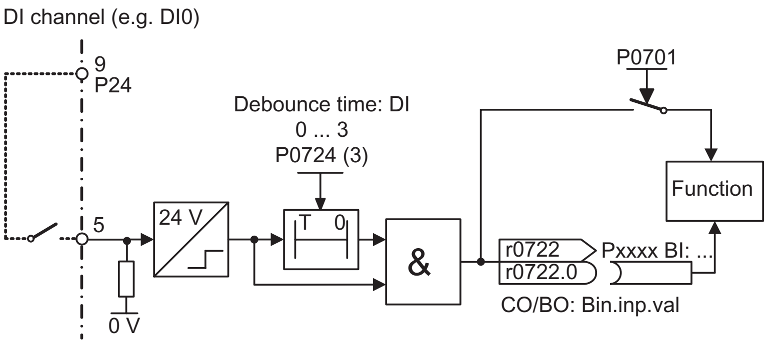



Figure 8-10 Digital inputs

The logical states of the digital inputs can be de-bounced using P0724 and read-out using parameter r0722 (BICO monitoring parameter). Further, this parameter is used to parameterize BICO for the digital inputs (refer to BICO parameterization in the following section).

## P0701 … P0709 (digital inputs 0 … 8) or P0712, P0713 (analog inputs 0, 1)

The possible settings of the individual inputs are listed in the table below.

Table 8-5 Parameters P0701 … P0709 (and P0712, P0713 for AI used as digital inputs)

| Parameter Value | Significance |
|---|---|
| 0 | Digital input disabled |
| 1 | ON/OFF1 |
| 2 | ON_REV/OFF1 |
| 3 | OFF2 – coast to standstill |
| 4 | OFF3 – quick ramp-down |
| 9 | Fault acknowledge |
| 10 | JOG right |
| 11 | JOG left |
| 12 | Reverse |
| 13 | MOP up (increase frequency) |
| 14 | MOP down (decrease frequency) |
| 15 | Fixed frequency selector Bit 0 |
| 16 | Fixed frequency selector Bit 1 |
| 17 | Fixed frequency selector Bit 2 |
| 18 | Fixed frequency selector Bit 3 |
| 25 | Enable DC braking |
| 27 | Enable PID |
| 29 | External trip |
| 33 | Disable additional frequency setpoint |
| 99 | Enable BICO parameterization |

## Example

An ON/OFF1 command is to be accomplished using digital input DI0.

- P0700 = 2   Control enabled using the terminal strip (digital inputs)
- P0701 = 1   ON/OFF1 using digital input 0 (DI0).

---

**Note**

If an analog input has been configured as a digital input, then the following limit values apply:

- Voltage > 4 V = logical 1
- Voltage < 1.6 V = logical 0

---

## BICO parameterization

If the setting 99 (BICO) is entered into parameters P0701 to P0709, then the BICO wiring is enabled for the appropriate digital input. The output parameter number of the function (the parameter, included in the parameter text BO) should be entered into the command source (the parameter which contains the code BI in the parameter text).

## Example

A relay is to be controlled directly using DI0.

- P0700 = 2 Control enabled using digital inputs
- P0701 = 99 Enable BICO parameterization on DI0
- P0731.0 = 722.0 Relay 1 controlled directly.

This can be useful when the normal relay functions and digital inputs are not required so the user can use them for their own purposes.

---

**Note**

Only experienced users should use the BICO parameterization and for applications where the possibilities provided by P0701 … P0709 are no longer adequate.

If P0701 … P0709 are set to 99, then the command source can only be changed by the use of P0700. For example, changing P0701 from 99 to 1 will not change the command source or alter the existing BICO settings.

---

# 8.4 Digital outputs (DO)

## Description

| | |
|---|---|
| Number: | 3 |
| Parameter range: | r0730 … P0748 |
| Function chart number: | FP2100 |
| Features: | |
| • cycle time: | 10 ms |

Three output relays are provided which can be programmed to indicate a variety of states of the inverter, such as faults, warnings, current limit conditions, etc.

Some of the more popular settings are pre-selected (see table below), but others can be allocated using the BICO internal connection feature.

**Relay:**

| | |
|---|---|
| max. opening/closing time: | 5/10 ms |
| voltage/current | 30 V DC/0.5 A maximum |

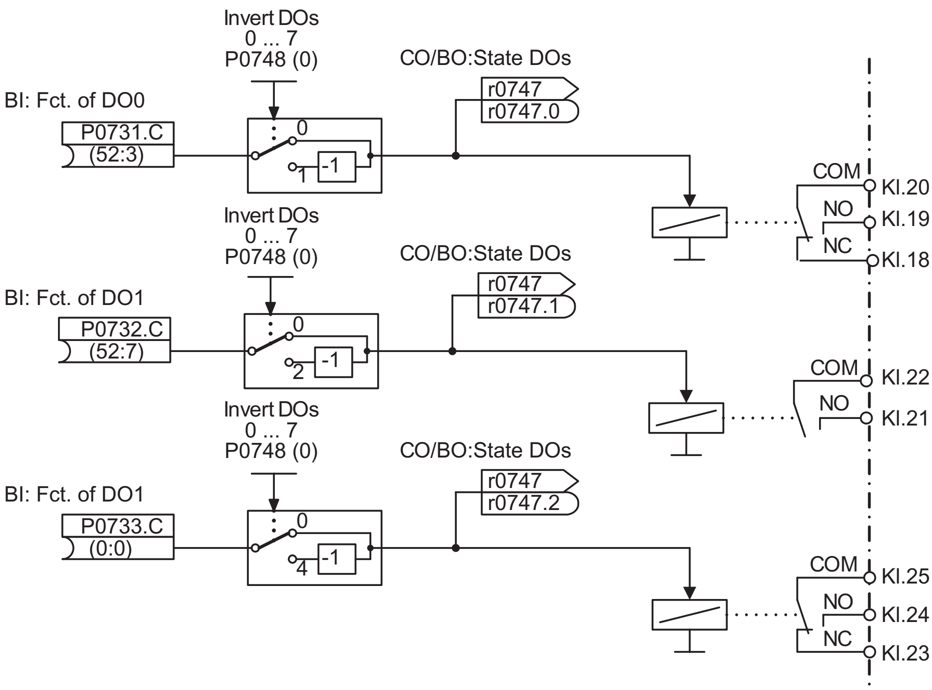



Figure 8-11 Digital outputs

The states, which are to be output, are defined using the "BI" parameters P0731 (digital output 1), P0732 (digital output 2) and P0733 (digital output 3). For the definition, the "BO" parameter number or "CO/BO" parameter number and the bit number of the particular state should be entered into P0731 … P0733. Frequently used states including the parameter number and bit are shown in the table below.

Table 8-6 Parameters P0731 to P0733 (frequently used functions/states)

| Parameter value | Significance |
|---|---|
| 52.0 | Motor ready |
| 52.1 | Motor ready to run |
| 52.2 | Motor running |
| 52.3 | Motor fault active |
| 52.4 | OFF2 active |
| 52.5 | OFF3 active |
| 52.6 | Switch-on inhibit active |
| 52.7 | Motor warning active |
| 52.8 | Deviation, setpoint/actual value |
| 52.9 | PZD control (Process Data Control) |
| 52.A | Maximum frequency reached |
| 52.B | Warning: Motor current limit |
| 52.C | Motor holding brake (MHB) active |
| 52.D | Motor overload |
| 52.8 | Deviation, setpoint/actual value |
| 52.E | Motor running direction right |
| 52.F | Inverter overload |
| 53.0 | DC brake active |
| 53.1 | Actual frequency f_act ≥ P2167 (f_off) |
| 53.2 | Actual frequency f_act > P1080 (f_min) |
| 53.3 | Actual current r0027 ≥ P2170 |
| 53.6 | Actual frequency f_act ≥ setpoint |

**Note**

For complete list of all of the binary status parameters (refer to "CO/BO" parameters) in the Parameter List.

# 8.5 Analog inputs (A/D converter)

## Description

| | |
|---|---|
| Number: | 2 |
| Parameter range: | P0750 … P0762 |
| Function chart number: | FP2200 |
| Features: | |
| • cycle time: | 4 ms |
| • resolution: | 10 bits |
| • accuracy: | 1 % referred to 10 V / 20 mA |
| • electrical features: | incorrect polarity protection, short-circuit proof |

Analog setpoints, actual values and control signals are read-into the inverter using the appropriate analog inputs and are converted into digital signals or values using the A/D converter.

The setting as to whether the analog input is a voltage input (10 V) or a current input (20 mA) must be selected using the general I/O DIP switch on the control unit as well as also using parameter P0756 (for details refer to Chapter "Installing/Mounting" Section "Connecting the Control Unit via terminals").

---

**Note**

The setting of P0756 (analog input type) must match that selection on the DIP switch on the control unit.

The bipolar voltage input is only possible with analog input 1 (AI0).

---

Depending on the AI type or source, the appropriate connection must be made. Using, as an example, the internal 10 V voltage source, a connection is shown in the figure below.

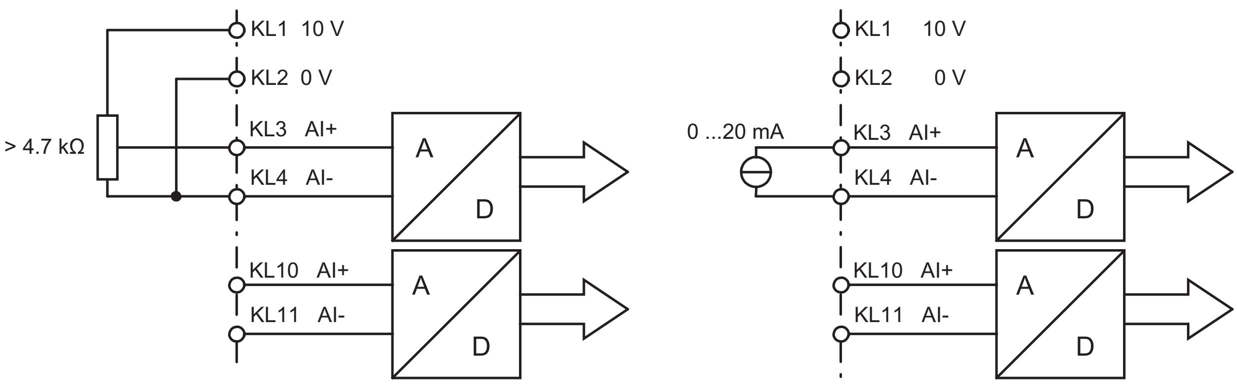



Figure 8-12 Example of a connection for AI voltage and current input

The AI channel has several function units (filter, scaling, dead zone, see figure below).

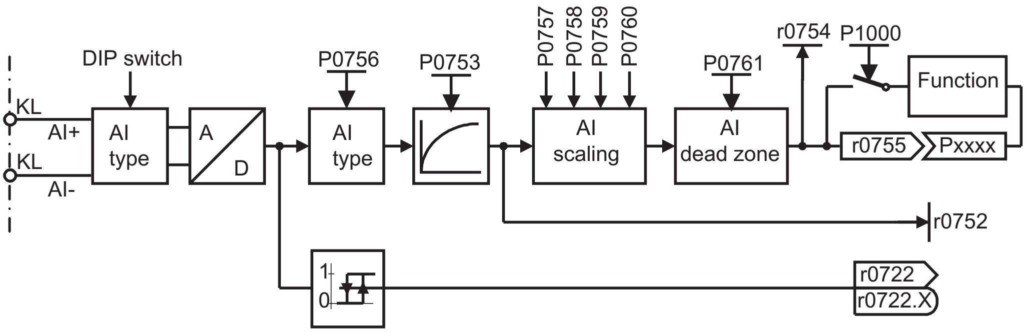



Figure 8-13 AI channel

---

**Note**

When the filter time constant P0753 (AI-PT1) is increased, this smooths the AI input signal therefore reducing the ripple. When this function is used within a control loop, this smoothing has a negative impact on the control behaviour and immunity to noise (the dynamic performance deteriorates).

---

**Note**

The analog inputs can be used as digital inputs. Setting P0712 and P0713 > 0 assign digital input functions to the analog inputs.

---

## 8.6 Analog outputs (D/A converter)

| | |
|---|---|
| Number: | 2 |
| Parameter range: | r0770 … P0785 |
| Function chart number: | FP2300 |
| Features: | |
| • cycle time: | 4 ms |
| • resolution: | 12 bit |
| • accuracy: | 1 % referred to 20 mA |

An analog output is provided which can be programmed to indicate a variety of variables. Some of the more popular settings are pre-selected (see table below), but others (BICO outputs) can be allocated using the BICO internal connection feature.

Table 8-7 Pre-set analog outputs

| Parameter | Description |
|---|---|
| r0020 | CO: Frequency setpoint before RFG |
| r0021 | CO: Actual filtered frequency |
| r0024 | CO: Actual filtered output frequency |
| r0025 | CO: Actual filtered output voltage |
| r0026 | CO: Actual filtered DC-link voltage |
| r0027 | CO: Actual filtered output current |
| … | … |
| r0052 | CO/BO: Actual status word 1 |
| r0053 | CO/BO: Actual status word 2 |
| r0054 | CO/BO: Actual control word 1 |
| … | … |

In order to adapt the signal, the D/A converter channel has several function units (filter, scaling, dead zone) which can be used to modify the digital signal before conversion (see figure below).

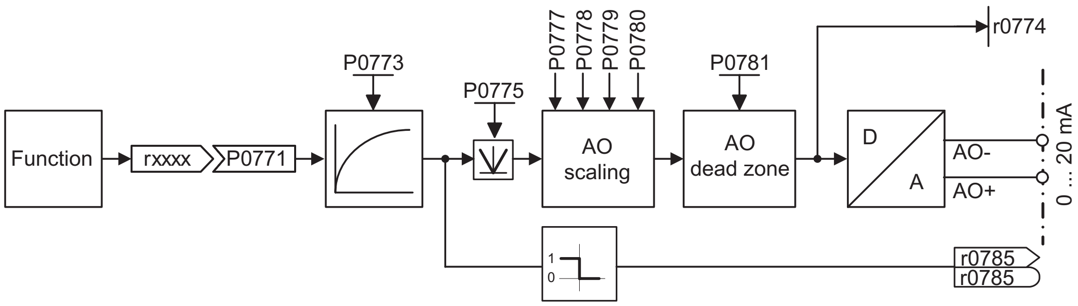



Figure 8-14 D/A converter channel

**Note**

The analog output 0 (AO0) can be changed-over from current output (P0776 = 0) to voltage output (P0776 = 1).

The analog output 1 (AO1) only provide current output (0 … 20 mA). The 0 … 10 V voltage signal can be generated by connecting a 500 Ω resistor across the outputs. The voltage drop across the resistor can be read using parameter r0774 if the parameter P0776 is changed-over from current output (P0776 = 0) to voltage output (P0776 = 1). The D/A scaling parameters P0778, P0780 and the D/A converter dead zone must still be entered in mA (0 … 20 mA).

With setting parameter P0775 = 1 it is possible to detect negative values on the input side of the D/A converter channel. If enabled, this parameter will take the absolute value of the value to be outputed (the AO-linear characteristic is mirrored on the y axis). If the value was originally negative then the corresponding bit in r0785 is set.

## 8.7 Fixed frequencies

### Description

| | |
|---|---|
| Number: | 15 |
| Parameter range: | P1001 … P1025 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP3200, FP3210 |

The fixed frequency functionality allows to enter a setpoint to the drive. This is an alternative option to enter a setpoint with using the analog inputs, the serial communication interfaces, the JOG function or the motorized potentiometer. The fixed frequencies are defined using parameters P1001 … P1015 and selected and combined using binector inputs P1020 … P1023. The effective fixed frequency setpoint is available through connector output r1024. If this is to be used as setpoint source, then parameter P1000 should be modified or connector output r1024 should be connected to the main setpoint P1070 or supplementary setpoint P1075.

There are two modes to select fixed frequencies, which are set via the parameter P1016:

- Direct selection (P1016 = 1)
- Binary-coded selection (P1016 = 2)

The fixed frequency status bit r1025 (binector output) allows to combine the two selection modes for fixed frequencies with an ON command. For this, P0840 should be set to 1025. Please note that the meaning of P0840 may change with using the 2-/3-wire control functionality.

### Direct selection (P1016 = 1)

In this particular mode, a control signal directly selects the fixed frequency. This control signal is entered using the binector inputs P1020 … P1023. For this selection a permanent signal at the parameters P1020 … P1023 is necessary. If several fixed frequencies are simultaneously active, then the selected frequencies are added.

The control signal for selection of the fixed frequencies can be any binary output (BO) parameter such as a serial communication interface or in most cases a digital input. When selecting fixed frequencies with digital inputs, two connection methods are available:

- Standard method
- BICO method

---

**Note**

The standard method has priority over the BICO method.

---

### Examples

- Standard method:
  P0704 = 15, P0705 = 16, P0706 = 17, P0707 = 18 (default)
  Each digital input (P0701 and the following) can be connected to each fixed frequency selector input (P1020 … P1023) with the settings 15, 16, 17 or 18. The different settings can only be chosen once. If the same setting of a digital input is chosen for more than one digital input, then only the last setting is valid and the previous digital input setting is reset to 0.
- BICO method:
  P0704 … P0707 = 99, P1020 … P1023 = 722.3 … 722.6 (default)
  (example: DI3 connects to selector P1023 → P0704 = 99, P1023 = 722.3)
  Each digital input (P0701 and the following) can be BICO connected to each fixed frequency selector input (P1020 … P1023). If the same setting of a digital input is chosen for more than one digital input, then only the last setting is valid and the previous digital input setting is reset to 0.

Table 8-8 Example of direct selection using digital inputs

| FF number | Frequency | P1023 | P1022 | P1021 | P1020 |
|---|---|---|---|---|---|
| FF0 | 0 Hz | 0 | 0 | 0 | 0 |
| FF1 | P1001 | 0 | 0 | 0 | 1 |
| FF2 | P1002 | 0 | 0 | 1 | 0 |
| FF3 | P1003 | 0 | 1 | 0 | 0 |
| FF4 | P1004 | 1 | 0 | 0 | 0 |
| FF1+FF2 | | 0 | 0 | 1 | 1 |
| FF1+FF2+FF3 | | 0 | 1 | 1 | 1 |
| FF1+FF2+FF3+FF4 | | 1 | 1 | 1 | 1 |

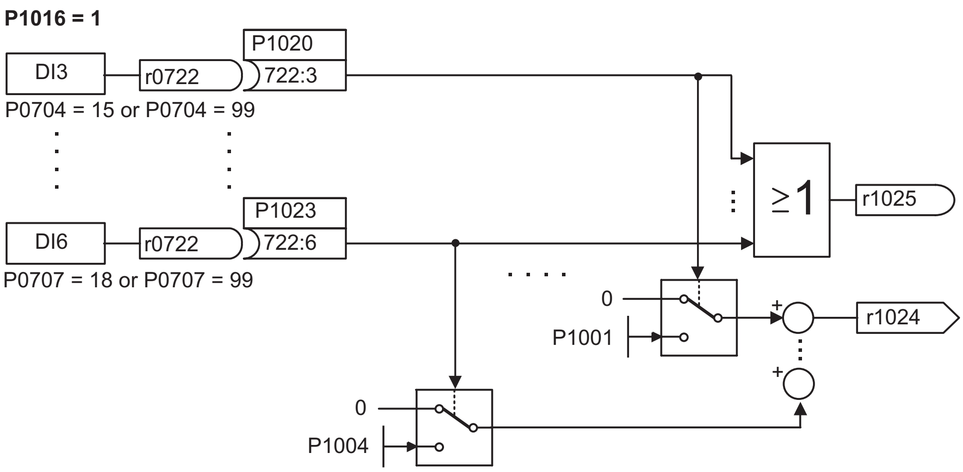



Figure 8-15 Example of directly selecting FF1 using DI3 to FF4 using DI6

## Binary-coded selection (P1016 = 2)

Using this technique up to 16 fixed frequencies can be selected using four control signals. The fixed frequencies are indirectly selected using the binary coding. The connection methods to the fixed frequency selector inputs (P1020 … P1023) are as for the direct selection mode.

### Example

- Standard method:
  P0704 = 15, P0705 = 16, P0706 = 17, P0707 = 18
- BICO method:
  P0704 … P0707 = 99, P1020 … P1023 = 722.3 … 722.6

Table 8-9 Example of binary-coding using digital inputs

| FF number | Frequency | P1023 | P1022 | P1021 | P1020 |
|---|---|---|---|---|---|
| FF0 | 0 Hz | 0 | 0 | 0 | 0 |
| FF1 | P1001 | 0 | 0 | 0 | 1 |
| FF2 | P1002 | 0 | 0 | 1 | 0 |
| … | … | … | … | … | … |
| FF14 | P1014 | 1 | 1 | 1 | 0 |
| FF15 | P1015 | 1 | 1 | 1 | 1 |

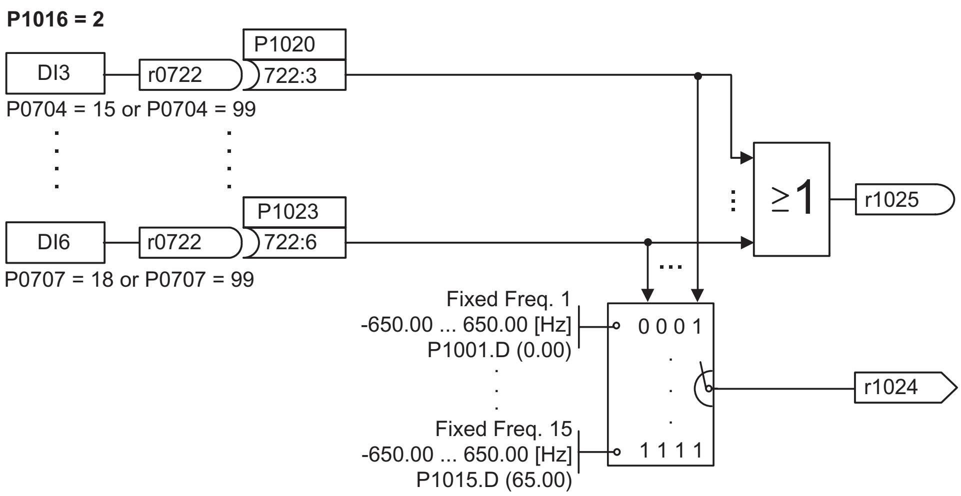



Figure 8-16 Example of binary-coded selection of fixed frequencies

# 8.8 2-/3-wire control

## Description

Note

---

**Note**

**Automatic restart function**

When a 2-/3-wire control methods is selected, the automatic restart function (P1210) is disabled. If the automatic restarted function is required, the user must specifically enable this function. For further details, please see the Parameter List.

---

The different types of 2-/3-wire control are enabled using parameter P0727 and selecting one of the following options:

## Default value

- P0727 = 0: Siemens standard control (ON/OFF1, REV).

## Other settings

- P0727 = 1: 2-wire control (ON_FWD, ON_REV)
- P0727 = 2: 3-wire control (FWDP, REVP, STOP)
- P0727 = 3: 3-wire control (ON_PULSE, REV, OFF1/HOLD)

When any of the control functions are selected using P0727, the settings for the digital inputs (P0701 … P0709 and P0712, P0713 for AI used as DI) are redefined as shown in the table below.

Table 8-10 Redefined digital inputs

| Settings<br>P0701 … P0709<br>(P0712, P0713) | P0727 = 0<br>Siemens Standard | P0727 = 1<br>2-wire control | P0727 = 2<br>3-wire control | P0727 = 3<br>3-wire control |
|---|---|---|---|---|
| 1 | ON/OFF1 | ON_FWD | STOP | ON_PULSE |
| 2 | ON_REV/OFF1 | ON_REV | FWDP | OFF1/HOLD |
| 12 | REV | REV | REVP | REV |
| "P" denotes "Pulse"; "FWD" denotes "Forward"; "REV" denotes "Reverse" | | | | |

Each of the control methods shown in the table above will be explained individually.

### BICO connections

The different 2-/3-wire control methods can also be accomplished using BICO connections. A summary is given in the table below.

Table 8-11 BICO Connections

| Functions of BICO parameter | P0727 = 0<br>Siemens Standard | P0727 = 1<br>2-wire control | P0727 = 2<br>3-wire control | P0727 = 3<br>3-wire control |
|---|---|---|---|---|
| P0840 | ON/OFF1 | ON_FWD | STOP | ON_PULSE |
| P0842 | ON_REV/OFF1 | ON_REV | FWDP | OFF1/HOLD |
| P1113 | REV | REV | REVP | REV |
| "P" denotes "Pulse"; "FWD" denotes "Forward"; "REV" denotes "Reverse" | | | | |

## 8.8.1 Siemens standard control (P0727 = 0)

### Description

With P0727 = 0 there are two possibilities of control available using the following signals

1. ON/OFF1 and REV.
2. ON/OFF1 and ON_REV/OFF1.

### ON/OFF1 and REV

This method allows the inverter to be started and stopped using the ON/OFF1 command and the direction of the inverter changed using the REV command. These commands can be assigned to any of the digital inputs through parameters P0701 … P0709 (and P0712, P0713 for AI used as DI) or BICO connections.

The REV commands can be given at any time, independent of the frequency output of the inverter.

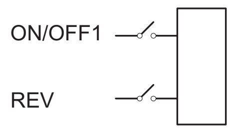
### Function

On receiving an ON/OFF1 command the inverter will run the motor in a forward direction and ramp-up the motor to the frequency setpoint.

When a REV command is issued, the inverter will ramp-down the frequency through 0 Hz and run the motor in the reverse direction. When the REV command is removed the inverter will ramp-up through 0 Hz and run in a forward direction until the frequency setpoint is reach.

When the ON/OFF1 command is removed, the inverter will stop the motor by performing an OFF1.

The REV command initiated by itself cannot start the motor.



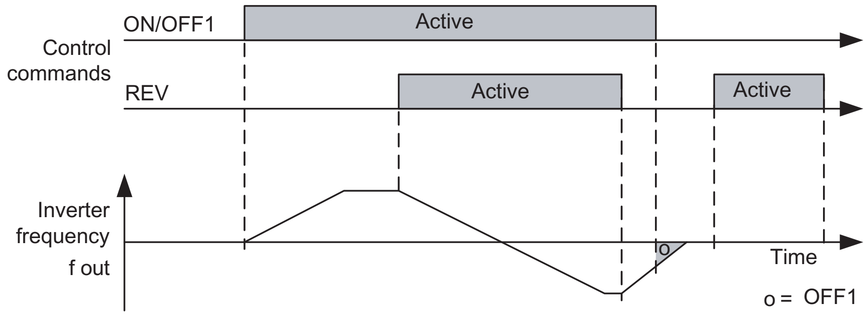




Figure 8-17 Siemens standard control using ON/OFF1 and REV

## ON/OFF1 and ON_REV/OFF1

This method allows the inverter to run the motor in a forward direction (run right) using the ON/OFF1 command and in the opposite direction (run left) using the ON_REV/OFF1.

However, for a direction reversal the drive will first have to decelerate with OFF1 and when reaching 0 Hz the reverse signal can be applied.

## Function

The ramp down phase can be interrupted by start command in the same direction: if the drive was operating in forward and OFF1 was applied, an ON/OFF1 will work correctly and accelerate again the drive up to the setpoint speed. The same is valid for reverse and ON_REV/OFF1

Giving a start command for the opposite direction of which the inverter frequency output is ramping down, the drive ignores the new setting and the drive will ramp down to 0 Hz and then remain at standstill.

Without any control signal enabled the drive will ramp down to a stop and remain at standstill.

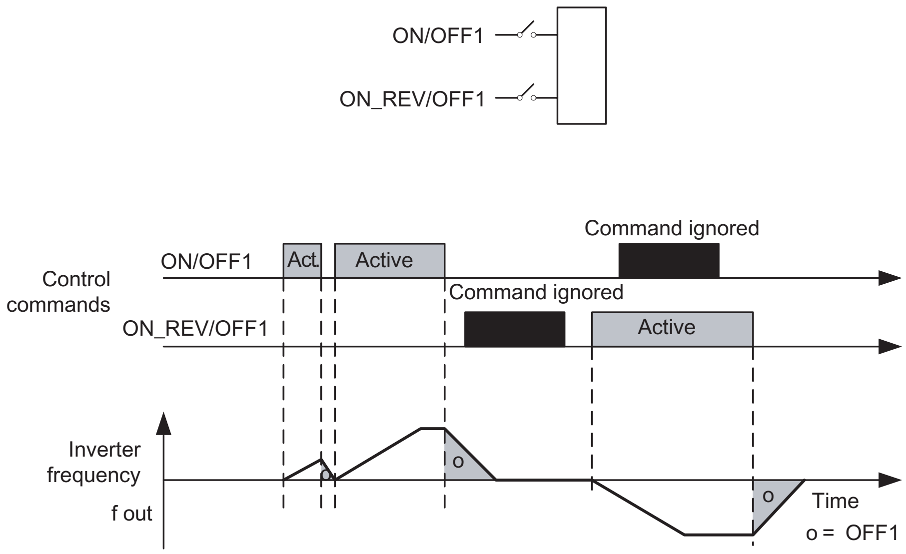



Figure 8-18 Siemens standard control using ON/OFF1 and ON_REV/OFF1

## 8.8.2 2-wire control (P0727 = 1)

### Description

This method uses two maintained signals, ON_FWD and ON_REV which start/stop the inverter and determine the direction of the motor.

The advantage of this method of control is that ON_FWD and ON_REV can be switched at any time, independently of the setpoint or frequency output or direction of rotation, and there is no requirement of the motor to ramp-down to 0 Hz before the command is performed.

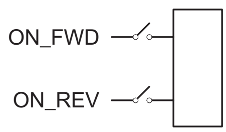
### Function

With ON_FWD closed and maintained closed the drive is ON and runs in forward direction.

Applying only ON_REV (and keeping the contact closed) the drive is ON and runs in reverse direction.

If both signals are however enabled (contacts are closed) the drive will perform an OFF1 and ramp down to a stop.

If both signals are disabled the drive is in OFF1 state.



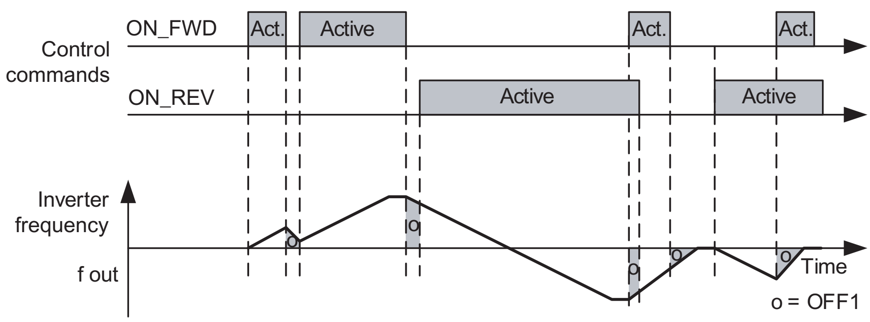




Figure 8-19 2-wire control using ON_FWD and ON_REV

## 8.8.3 3-wire control (P0727 = 2)

### Description

This method uses three commands to control the operation of the motor:

1. STOP: Causes on OFF1 command to be performed by the inverter.
2. FWDP: Causes the motor to run in a forward direction (run right).
3. REVP: Causes the motor to run in the reverse direction (run left).

### Function

The STOP signal uses negative logic: Opening the contact or maintaining it open causes an OFF1 condition and the drive stops. The STOP contact will need to be maintained closed to start and run the inverter.

Then a momentary closure (positive edge) of the FWDP or REVP contact latches and starts the inverter.

A momentary closure (positive edge) of the FWDP contact will set the forward direction.

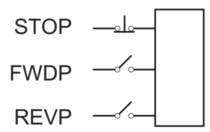
A momentary closure of the REVP contact will change to the reverse direction.

Closing FWDP and REVP will cause a Stop (OFF1).

The ramp down can be interrupted by a single new pulse FWDP or REVP.

A momentary closure of the FWDP or REVP contacts while the drive is operating in the respective direction will not cause any change.

Only by opening the STOP contact the drive will switch off regularly, apart from the special case that both signals FWDP and REVP are present.



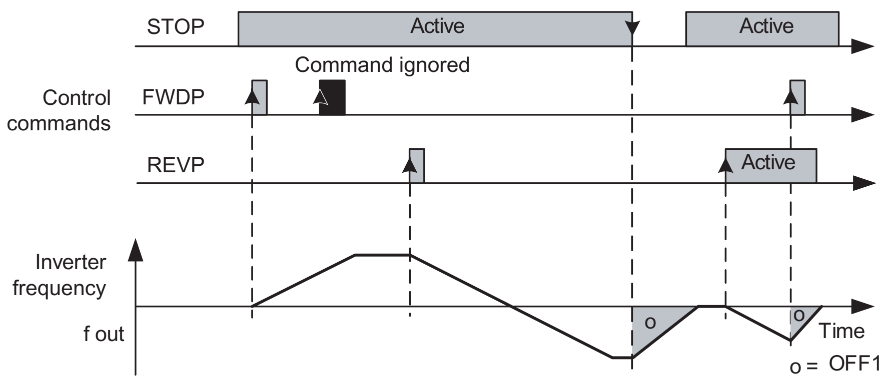




Figure 8-20 3-wire control using FWDP, REVP and STOP

## 8.8.4 3-wire control (P0727 = 3)

### Description

There are three signals associated with this function:

| | |
|---|---|
| OFF1/HOLD: | Being maintained closed the opening of the contact will switch the inverter OFF and cause a ramp down to 0 Hz. |
| ON_PULSE: | This will run the motor in a forward direction (run right). |
| REV: | This will change the direction of the motor to reverse (run left). |

### Function

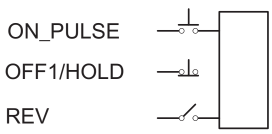
The switch OFF1/HOLD uses negative logic: the contact will need to be maintained closed in order to switch the inverter ON or keep it running.

A momentary closure (positive edge) of the ON_PULSE switch latches and starts the inverter if it was OFF before.

The direction can be determined and changed any time using the REV signal.

Opening or closing the ON_PULSE switch while the drive runs has no effect.

Only enabling (i.e. Opening) OFF1/HOLD will unlatch the run-state and then stop the inverter.



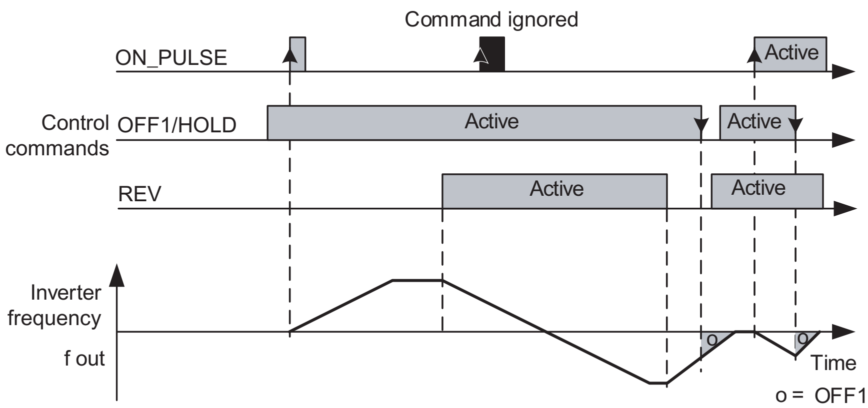




Figure 8-21 3-wire control using ON_PULSE, OFF1/HOLD and REV

# 8.9 Motorized potentiometer (MOP)

## Description

| | |
|---|---|
| Parameter range: | P1031 – r1050 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP3100 |

This function emulates an electromechanical potentiometer to enter setpoints. The motorized potentiometer (MOP) value is adjusted using the "Raise" and "Lower control signal" which is selected using BICO parameters P1035 and P1036. The value which has been set is available through connector output r1050 so that it can be utilized and connected.

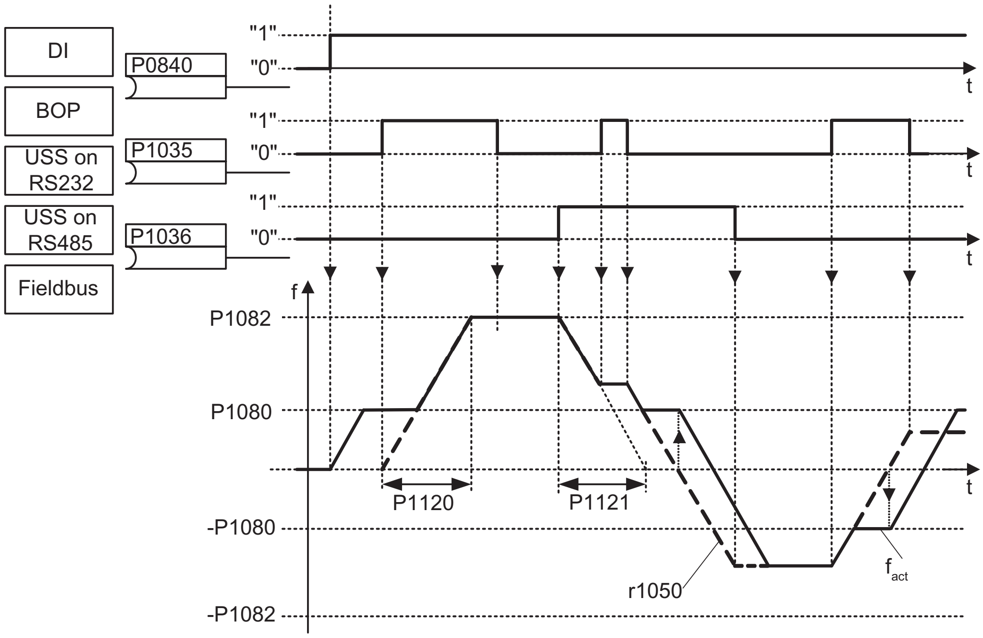



Figure 8-22 Motorized potentiometer

The behavior of the MOP also depends on the duration of the up and down command:

- P1035 (P1036) = 1 for < 1 s :
  Frequency changes in steps of 0.1 Hz.
- P1035 (P1036) = 1 for > 1 s :
  Frequency ramps up (down) with the time of P1120 (P1121) but not faster than 2 s.

The MOP functionality can be selected using the operator panel, digital inputs or the serial interface. Parameterization is also possible directly using BICO parameters P1035 and P1036 as well as parameter P0700. In this case, for a value assigned to P0700, the BICO parameter is appropriately modified.

## Example

| Command source via "USS RS232" (using the PC connection kit on the option port) | |
|---|---|
| Standard method | P0700 = 4 |
| BICO method | P1035 = 2032.13 |
| | P1036 = 2032.14 |
| | …<br>(for a complete list refer to Parameter List P0700) |

If the motorized potentiometer is to be used as a setpoint source, then parameter P1000 should be modified or the BICO parameter r1050 should be connected to the main setpoint P1070 or supplementary setpoint P1075. When parameter P1000 is modified, this implicitly changes BICO parameters P1070, P1075.

## Example

| Setpoint via the motorized potentiometer (MOP) | |
|---|---|
| Standard method | P1000 = 1 |
| BICO method | P1070 = 1050 |
| | P1075 = 0 |

The MOP is configured using the following parameters and has the modes of operation as shown in the table below.

- Limits using the minimum frequency P1080 or maximum frequency P1082
- Ramp-up/ramp-down time P1120 or P1121
- Inhibits MOP reversing function P1032
- Saves the MOP setpoint P1031
- MOP setpoint P1040

Table 8-12 MOP modes of operation

| Motorized potentiometer | | Function |
|---|---|---|
| Lower | Raise | |
| 0 | 0 | Setpoint is frozen |
| 0 | 1 | Raise setpoint |
| 1 | 0 | Lower setpoint |
| 1 | 1 | Setpoint is frozen |

# 8.10 JOG

## Description

| | |
|---|---|
| Parameter range: | P1055 … P1061 |
| Warnings: | A0923 |
| Faults: | - |
| Function chart number: | FP5000 |

The JOG function is used as follows:

- To check the functionality of the motor and inverter after commissioning has been completed (the first traversing motion, checking the direction of rotation, etc.)
- Positioning a motor or a motor load into a specific position
- Traversing a motor, e.g. after a program has been interrupted

The motor is traversed using this function by entering fixed frequencies P1058, P1059. The JOG mode can be selected using the operator panel, digital inputs or the serial interface. An ON/OFF command is not used to move the motor, but instead when the "JOG keys" are pressed movement takes place. These "JOG keys" are selected using the BICO parameters P1055 and P1056. The JOG function can be disabled via P1057.

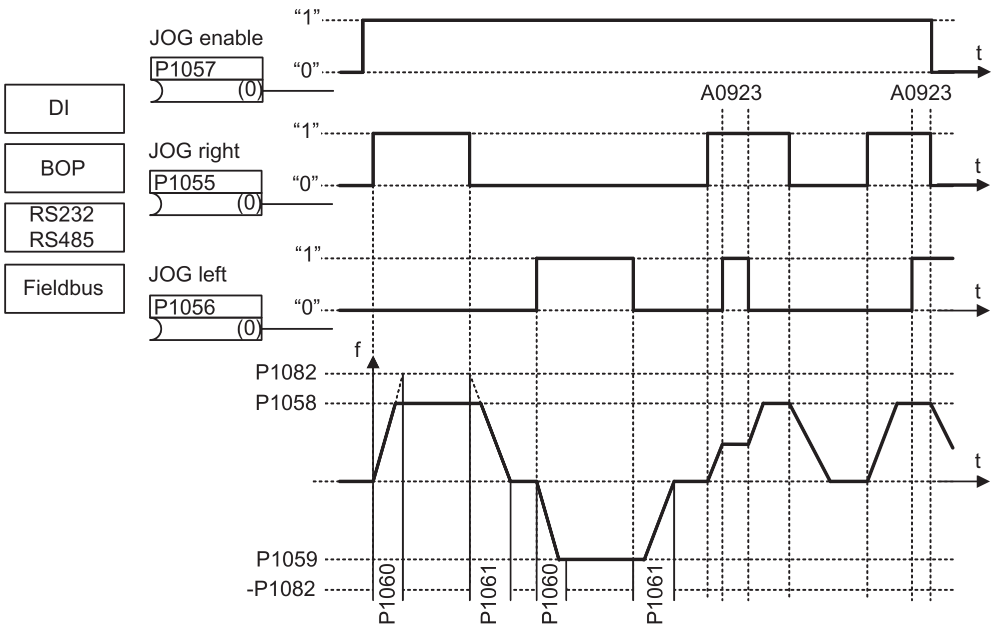



Figure 8-23 JOG counter-clockwise and JOG clockwise

Pressing the appropriate key accelerates the motor to the frequency in P1058 (JOG left) or P1059 (JOG right) at the ramp rate set in P1060. When the key is released, the motor stops, decelerating at the rate set in P1061. If JOG right and JOG left signals are given at the same time, there is no reaction, and a warning A0923 is raised. Internal BICO connections may also be used to select other settings and control methods.

## Example

| Command source via "USS RS232" interface (using the PC connection kit on the option port) | |
|---|---|
| Standard method | P0700 = 4 |
| BICO method | P1055 = 2032.8 |
| | P1056 = 2032.9 |
| | …<br>(for a complete list refer to Parameter List P0700) |

---

**Note**

The JOG fuction as used in the SINAMICS G120 inverter does not correspond to the definition in PROFIdrive profile.

---

# 8.11 PID Controller

## Description

| | |
|---|---|
| Parameter range: | P2200, P2201 … P2355 |
| Warnings: | A0936 |
| Faults: | F0221, F0222 |
| Function chart number: | FP3300, FP3400, FP5100 |
| Features: | |
| - cycle time: | 8 ms |

The SINAMICS G120 has an integrated technology controller (PID controller, enabled through P2200). This can be used to process basic higher-level closed-loop control functions. These typically include:

- Closed-loop pressure control for extruders
- Closed-loop water level control for pump motors
- Closed-loop temperature control for fan motors
- Closed-loop dancer roll position control for winder applications
- And similar control tasks

The technology controller setpoints and actual values can be entered using the PID motorized potentiometer (PID-MOP), PID fixed setpoint (PID-FF), analog inputs (AI) or through the serial interface as shown in the figure below. The appropriate parameterization of the BICO parameter defines which setpoints or actual values are to be used.

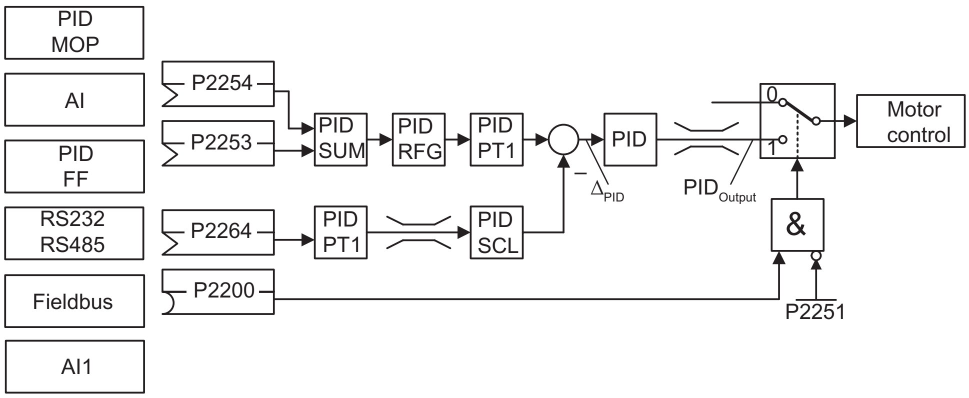



Figure 8-24 Structure of the technology controller

## Example

| PID controller enable and PID setpoint input via PID fixed frequencies and PID actual value via the analog input | |
|---|---|
| Permanent PID enable | P2200 = 1.0 |
| Setpoint input via PID-FF | P2253 = 2224 |
| Actual value input via analog input AI | P2264 = 755 |
| Setpoint input via PID | P2251 = 0 |

The supplementary (additional) setpoint is added to the main setpoint (PID-SUM) and the sum is fed to the setpoint filter (PID-PT1) at the setpoint-actual value summation point through the PID ramp-function generator (PID-RFG). The source of the supplementary setpoint (BICO parameter P2254), the ramp-up/ramp-down times of the PID ramp-function generator (P2257, P2258) as well as the filter time (P2261) can be adapted to the particular application by appropriately parameterizing the corresponding parameters.

Similar to the PID setpoint branch, the actual value branch of the technological controller has a filter (PID-PT1) which can be set using parameter P2265. In addition to the smoothing, the actual value can be modified using a scaling unit (PID-SCL).

The technological controller can be parameterized as either P, I, PI or PID controller using parameters P2280, P2285 or P2274.

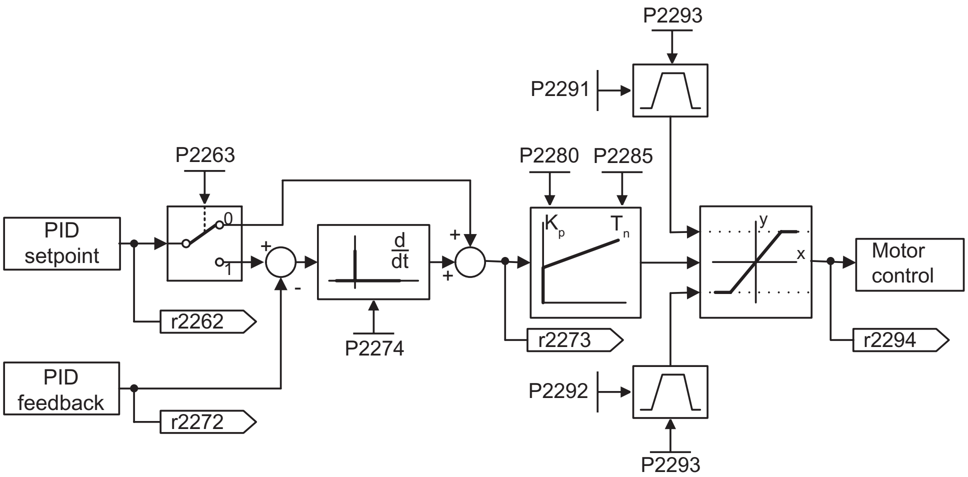



Figure 8-25 PID controller

For specific applications, the PID output quantity can be limited to defined values. This can be achieved using the fixed limits - P2291 and P2292. In order to prevent the PID controller output exercising large steps at power-on, these PID output limits are ramped-up with ramp time P2293 from 0 to the corresponding value P2291 (upper limit for the PID output) and P2292 (lower limit for the PID output). As soon as these limits have been reached, the dynamic response of the PID controller is no longer limited by this ramp-up/ramp-down time (P2293).

## 8.11.1 PID motorized potentiometer

### Description

| | |
|---|---|
| Parameter range: | P2231 … r2250 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP3400 |

The PID controller has a PID motorized potentiometer (PID-MOP) which can be separately adjusted. The functionality is identical with the motorized potentiometer, whereby the PID parameters are emulated in the range from P2231 … r2250.

Table 8-13 Correspondence between the parameters

| PID motorized potentiometer | | Motorized potentiometer | |
|---|---|---|---|
| P2231[3] | Setpoint memory of PID-MOP | P1031[3] | Setpoint memory of the MOP |
| P2232 | Inhibit rev. direct. of PID-MOP | P1032 | Inhibit reverse direction of MOP |
| P2235[3] | BI: Enable PID-MOP (UP-CMD) | P1035[3] | BI: Enable MOP (UP command) |
| P2236[3] | BI: Enable PID-MOP (DOWN-CMD) | P1036[3] | BI: Enable MOP (DOWN command) |
| P2240[3] | Setpoint of PID-MOP | P1040[3] | Setpoint of the MOP |
| r2250 | CO:Output setpoint of PID-MOP | r1050 | CO: Act. output freq. of the MOP |

For more detail refer to Section "Motorized potentiometer (MOP)" in this Chapter.

## 8.11.2 PID fixed setpoint

### Description

| | |
|---|---|
| Number: | 15 |
| Parameter range: | P2201 … P2225 |
| Warnings: | - |
| Faults : | - |
| Function chart number: | FP3300, FP3310 |

Similar to the fixed frequencies, the PID controller has separate programmable PID fixed setpoints (PID-FF). The values are defined using parameters P2201 … P2215 and are selected and combined using binector inputs P2220 … P2223. The selected PID fixed setpoint is available using connector output r2224 where it can be further processed (e.g. as PID main setpoint → P2253 = 2224).

Two modes are available to select the PID fixed setpoints, similar to the fixed frequencies. They are set via parameter P2216:

- Direct selection (P2216 = 1)
- Binary-coded selection (P2216 = 2)

The fixed frequency status bit r2225 (binector output) allows to combine the two selection modes for fixed frequencies with an ON command. For this, P0840 should be set to 2225. Please note that the meaning of P0840 may change with using the 2/3 wire functionality.

All logical connections are like the connections with fixed frequencies and for each selection mode there are the two connection methods:

- Standard method
- BICO method

**Note**

The standard method has priority over the BICO method.

## Direct selection (P2216 = 1)

Table 8-14 Example of direct selection using digital inputs

| FF number | Frequency | P2223 | P2222 | P2221 | P2220 |
|---|---|---|---|---|---|
| PID-FF0 | 0 Hz | 0 | 0 | 0 | 0 |
| PID-FF1 | P2201 | 0 | 0 | 0 | 1 |
| PID-FF2 | P2202 | 0 | 0 | 1 | 0 |
| PID-FF3 | P2203 | 0 | 1 | 0 | 0 |
| PID-FF4 | P2204 | 1 | 0 | 0 | 0 |
| PID-(FF1+FF2) | | 0 | 0 | 1 | 1 |
| PID-(FF1+FF2+FF3) | | 0 | 1 | 1 | 1 |
| PID-(FF1+FF2+FF3+FF4) | | 1 | 1 | 1 | 1 |

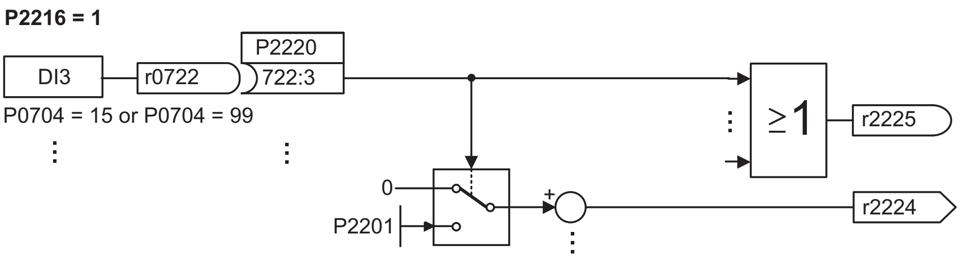



Figure 8-26 Directly selected PID fixed setpoint using DI3

## Binary-coded selection (P2216 = 2)

Table 8-15 Example of binary-coding using digital inputs

| FF number | Frequency | P2223 | P2222 | P2221 | P2220 |
|---|---|---|---|---|---|
| PID-FF0 | 0 Hz | 0 | 0 | 0 | 0 |
| PID-FF1 | P2201 | 0 | 0 | 0 | 1 |
| PID-FF2 | P2202 | 0 | 0 | 1 | 0 |
| … | … | … | … | … | … |
| PID-FF14 | P2214 | 1 | 1 | 1 | 0 |
| PID-FF15 | P2215 | 1 | 1 | 1 | 1 |

# 8.11.3 PID dancer roll control

## Description

For various continuous production processes, for example, in the paper and pulp industry or in the manufacture of cables, it is necessary to control (closed-loop) the velocity of stations along the production process so that the continuous material web is not subject to any unwanted tension levels. It is important that no folds or creases are formed. For applications such as these, it is practical to provide a type of material buffer in the form of a loop with a defined tension. This provides a de-coupling between the individual inverter locations. This loop represents the difference between the material fed-in and that fed-out and therefore indicates the process quality.

Using the PID dancer roll control, with SINAMICS G120 it is possible to ensure that continuous material webs have a constant tension.

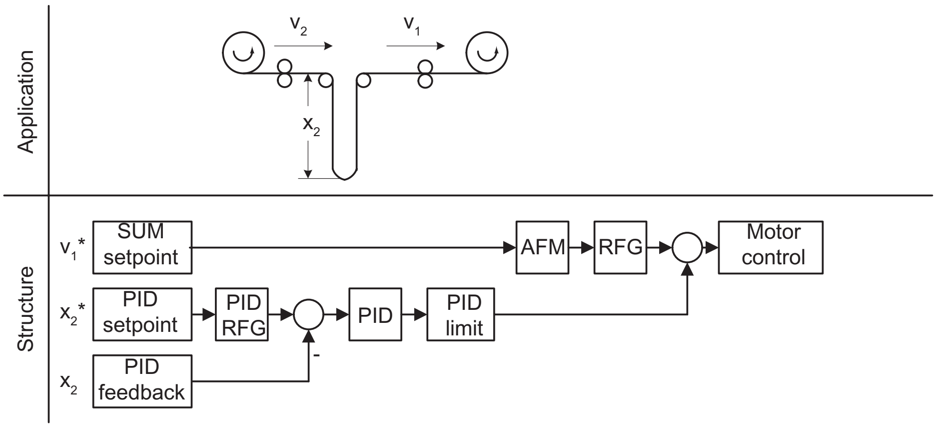



Figure 8-27 PID dancer roll control

The velocity $v_1$ is assumed to be an independent disturbance; the input velocity $v_2$ should be controlled using motor rolls $A_2$ so that the length $x_2$ of the loop corresponds, as far as possible, to the setpoint.

**Note**

When selecting the closed-loop dancer roll control it should be noted that neither PID-MOP nor PID-FF should be used - but instead the MOP (motorized potentiometer) or the FF (fixed frequencies).

The structure and important parameters for the PID dancer roll control are shown below.

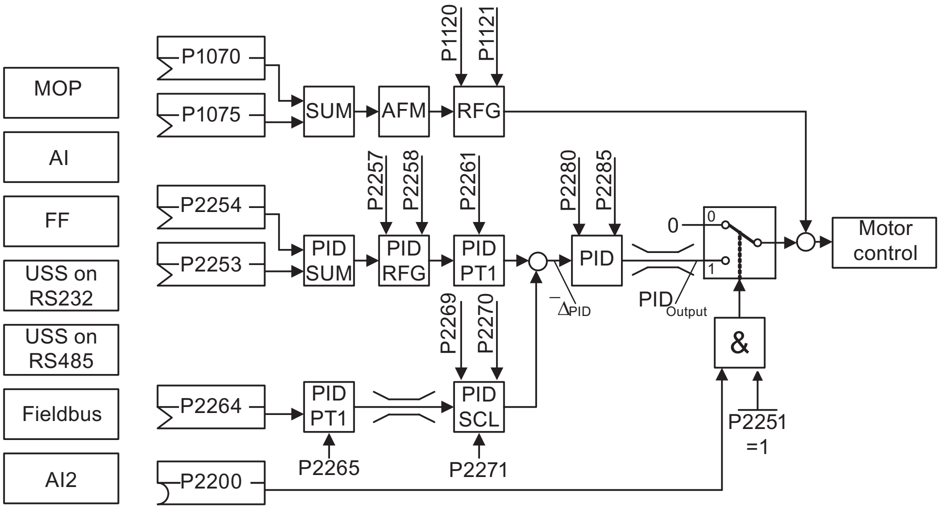



Figure 8-28 Structure of the closed-loop PID-dancer roll control

Table 8-16 Important parameters for PID dancer roll control

| Parameter | Parameter text | Setting | Meaning |
|---|---|---|---|
| P1070 | CI: Main setpoint | 1024 | Fixed setpoint (FF) |
| | | 1050 | MOP |
| | | 755.0 | Analog input 0 |
| | | 2015.1 | USS on RS232 |
| | | 2018.1 | USS on RS485 |
| | | 2050.1 | Fieldbus |
| P2200 | BI: Enable PID controller | 1.0 | PID controller always active |
| | | 722.x | Digital input x |
| P2251 | PID mode | 1 | PID as trim |
| P2253 | CI: PID setpoint | 1024 | Fixed setpoint (FF) |
| | | 1050 | MOP |
| | | 755.0 | Analog input 0 |
| | | 2015.1 | USS on RS232 |
| | | 2018.1 | USS on RS485 |
| | | 2050.1 | Fieldbus |
| P2264 | CI: PID feedback | 755.0 | Analog input 0 |
| | | 755.1 | Analog input 1 |

# 8.12 Setpoint channel

## Description

The setpoint channel (see figure below) forms the coupling element between the setpoint source and the closed-loop motor control. The SINAMICS G120 inverter has a special characteristic which allows the setpoint to be entered simultaneously from two setpoint sources. The generation and subsequent modification (influencing the direction, suppression frequency, up/down ramp) of the complete setpoint is carried-out in the setpoint channel.

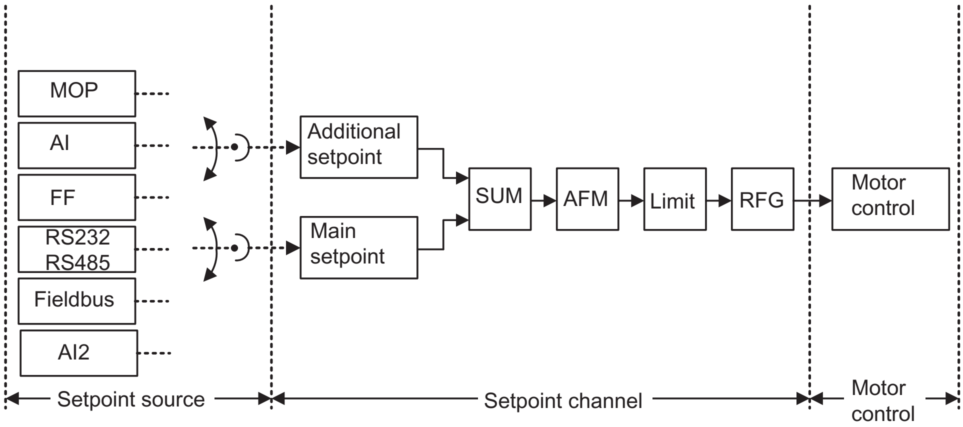



Figure 8-29 Setpoint channel

## 8.12.1 Summation and modification of frequency setpoint

## Description

| | |
|---|---|
| Parameter range: | P1070 … r1114 |
| Warnings: | - |
| Fault: | - |
| Function chart number: | FP5000, FP5200 |

For applications where the control quantities are generated from central control systems, fine tuning is often required locally on-site (correction quantity). For SINAMICS G120, this can be elegantly realized using the summation point where the main and supplementary (additional) setpoints are added in the setpoint channel. In this case, both quantities are simultaneously read-in through two separate or one setpoint source and summed in the setpoint channel. Depending on external circumstances, the supplementary setpoint can be dynamically disconnected or switched-in to the summation point (see figure below). This functionality can be used to advantage, especially for discontinuous processes.

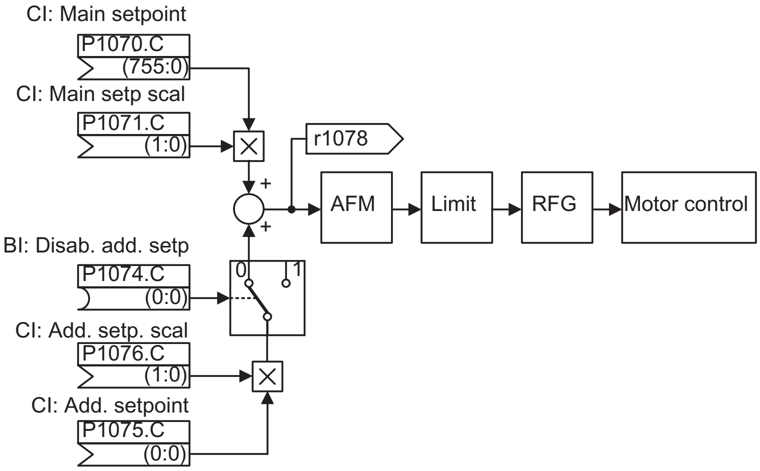



Figure 8-30 Summation

SINAMICS G120 has the following possibilities to select the setpoint source:

1. P1000 – selecting the frequency setpoint source
2. BICO parameterization
   - P1070 CI: Main setpoint
   - P1075 CI: Additional setpoint

Further, the main setpoint as well as the supplementary (additional) setpoint can be scaled independently of one another. In this case, for example, a user can simply implement an override function using the appropriate parameterization.

A scan sequence is generally associated with a forwards and a backwards motion. When selecting the reversing functionality, after reaching the end position, a direction of rotation reversal can be initiated in the setpoint channel (see figure below).

On the other hand, if a direction of rotation reversal or a negative frequency setpoint is to be prevented from being entered using the setpoint channel, then this can be inhibited using BICO parameter P1110.

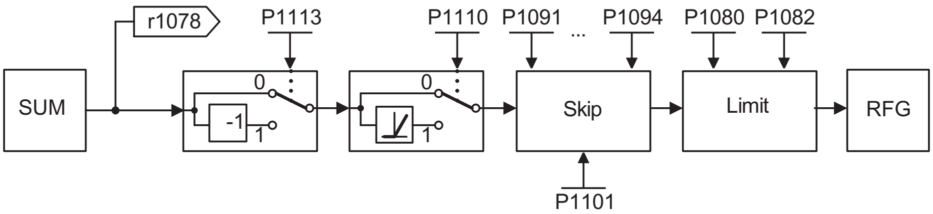



Figure 8-31 Modifying the frequency setpoint

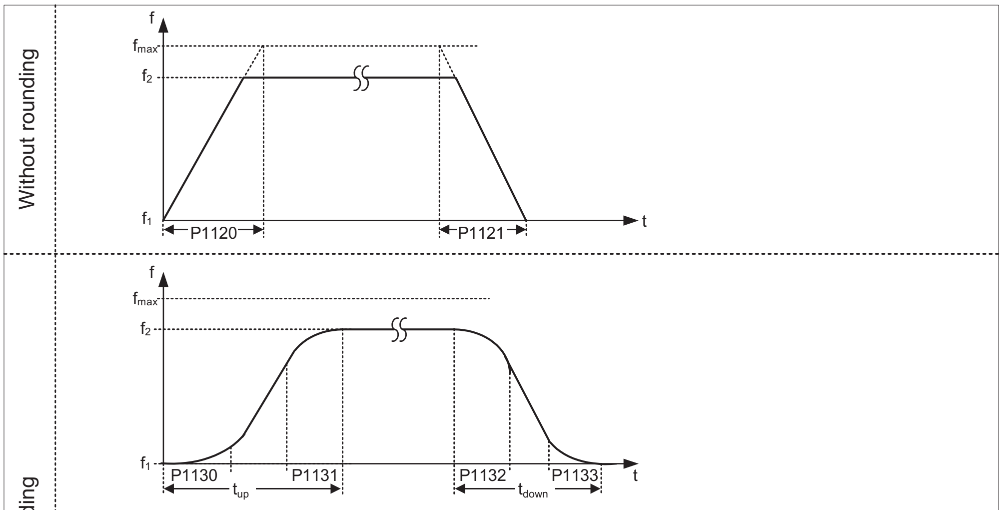
Motors can have one or several resonance points in the range from 0 Hz up to the reference frequency. These resonance points result in oscillations which, under worst case conditions, can damage the motor load. Using skip frequencies, SINAMICS G120 allows these resonant frequencies to be passed through as quickly as possible. This means that the skip frequencies increase the availability of the motor load over the long term.

## 8.12.2 Ramp-function generator

### Description

| | |
|---|---|
| Parameter range: | P1120, P1121 |
| | r1119, r1170 |
| | P1130 … P1142 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP5000, FP5300 |

The ramp-function generator (RFG) is used to limit the acceleration when the setpoint changes according to a step function. This therefore helps to reduce the stressing on the mechanical system of the machine. An acceleration ramp and a braking ramp can be set independently of one another using the ramp-up time P1120 and the ramp-down time P1121. This allows a controlled transition when the setpoint is changed (see figure below).




| Dependency | Ramp-up time | Ramp-down time |
|---|---|---|
| always for $\lvert f_2 - f_1 \rvert = P1082$ | $t_{up} = \frac{P1130 + P1131}{2} + P1120$ | $t_{down} = \frac{P1132 + P1133}{2} + P1121$ |
| for $\frac{P1130 + P1131}{2} > P1120$ and $\frac{p1132 + P1133}{2} > P1121$ | $t_{up} = (\frac{P1130 + P1131}{2} + P1120) \cdot \sqrt{\frac{\lvert f_2 - f_1 \rvert}{P1082}}$ | $t_{down} = (\frac{P1132 + P1133}{2} + P1121) \cdot \sqrt{\frac{\lvert f_2 - f_1 \rvert}{P1082}}$ |
| for $\frac{P1130 + P1131}{2} \leq P1120$ and $\frac{P1132 + P1133}{2} \leq P1121$ | $t_{up} = \frac{P1130 + P1131}{2} + P1120 \cdot \frac{\lvert f_2 - f_1 \rvert}{P1082}$ | $t_{down} = \frac{P1132 + P1133}{2} + P1121 \cdot \frac{\lvert f_2 - f_1 \rvert}{P1082}$ |

Figure 8-32 Ramp-function generator

In order to avoid torque surges at the transitions (constant velocity phase ←→ accelerating/braking phase), additional rounding-off times P1130 … P1133 can be programmed. This is especially important for applications (e.g. transporting or pumping liquids or for cranes) which require an especially "soft", jerk-free acceleration and braking.

If the OFF1 command is initiated while the motor is accelerating, then rounding-off can be activated or deactivated using parameter P1134 (see figure below). These rounding-off times are defined using parameters P1132 and P1133.

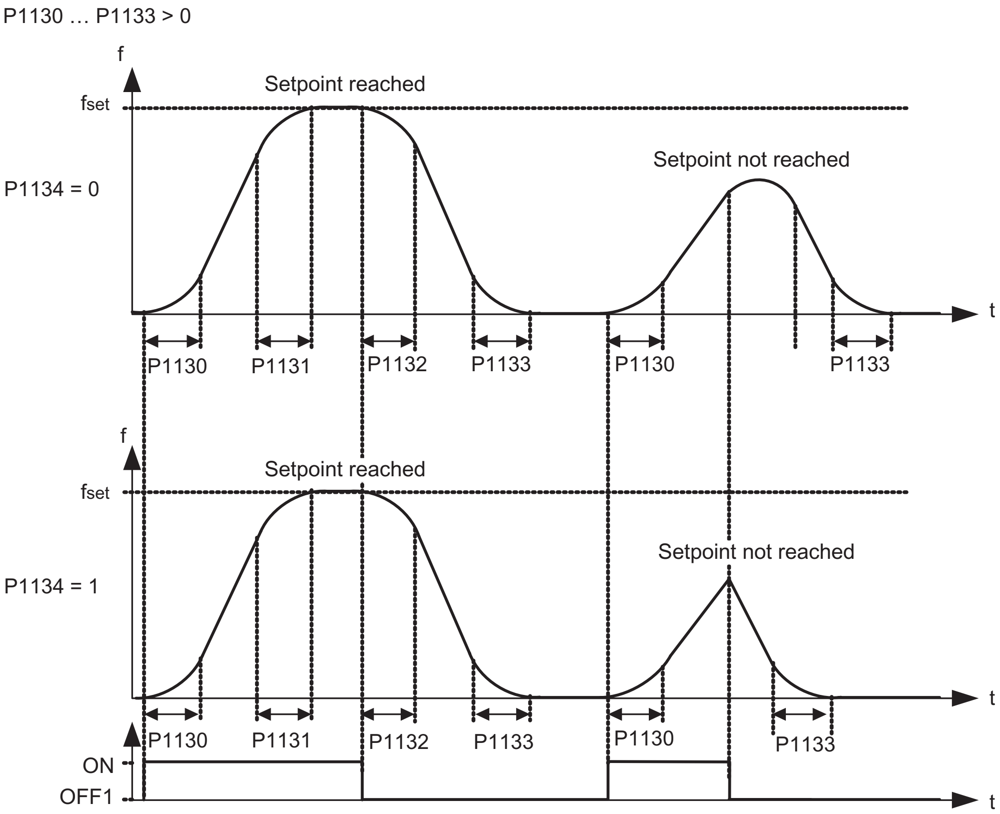



Figure 8-33 Rounding-off after an OFF1 command

In addition to the rounding-off times, the ramp-function generator can be influenced using external signals. The ramp-function generator provides the following functionality using BICO parameters P1140, P1141 and P1142 (see table below).

The ramp-function generator itself is enabled after the pulses have been enabled (inverter enable) and after the excitation time has expired (P0346). After limiting to the maximum speeds for the positive and negative directions of rotation (±P1082 or 0 Hz for the direction of rotation inhibit) the setpoint speed for the control is obtained (r1170).

While the V/f characteristic operates up to 650 Hz, the control (vector mode) is limited to a maximum frequency of 200 Hz (r1084).

Table 8-17 BICO parameters for ramp-function generator

| Parameter | | Description |
|---|---|---|
| P1140 | BI: RFG enable | The ramp-function generator **output** is set to 0 if the binary signal = 0. |
| P1141 | BI: RFG start | The ramp-function generator **output** keeps its actual value if the binary signal = 0. |
| P1142 | BI: RFG enable setpoint | If the binary signal = 0, then the ramp-function generator **input** is set to 0 and the output is reduced to 0 through the ramp-function generator ramp. |

**Note**

The maximum frequency of the setpoint channel is set using parameter P1080.

In V/f mode the maximum frequency is 650 Hz.

In vector mode the maximum frequency is 200 Hz (r1084).

## 8.12.3 OFF/braking functions

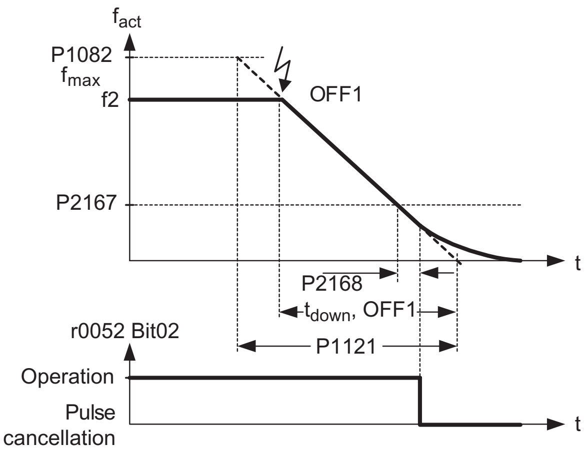
### Description

| | |
|---|---|
| Parameter range: | P1121, P1135, P2167, P2168<br>P0840 … P0849<br>r0052 bit 02 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

The inverter and the user must respond to an extremely wide range of situations and stop the inverter. In this case, both requirements relating to operations as well as the inverter protective functions (for example, electrical and thermal overload) and man-machine protective functions have to be taken into account. As a result of the different OFF/braking functions (OFF1, OFF2, OFF3) the SINAMICS G120 can flexibly respond to the requirements mentioned above.

## OFF1

The OFF1 command is closely coupled to the ON command. When the ON command is withdrawn, then OFF1 is directly activated. The motor is braked by OFF1 with the ramp-down time P1121. If the output frequency falls below the parameter value P2167 and if the time in P2168 has expired, then the inverter pulses are cancelled.




$$t_{down}, \text{OFF1} = \text{P1121} \cdot \frac{|f2|}{\text{P1082}}$$

Figure 8-34 OFF1 brake function

---

**Note**

OFF1 can be entered using a wide range of command sources via BICO parameter P0840 (BI: ON/OFF1) and P0842 (BI: ON/OFF1 with reversing).

BICO parameter P0840 is pre-assigned by defining the command source using P0700.

The ON and the following OFF1 command must have the same source.

If the ON/OFF1 command is set for more than one digital input, then only the digital input that was last set, is valid, e.g. DI3 is active.

OFF1 is low active.

When simultaneously selecting the various OFF commands, the following priority applies:

- OFF2 (highest priority)
- OFF3
- OFF1.

OFF1 can be combined with DC current braking or compound braking.

When the motor holding brake MHB (P1215) is activated, for an OFF1, P2167 and P2168 are not taken into account.

---

## OFF2

The inverter pulses are immediately cancelled by the OFF2 command. This means that the motor coasts down and it is not possible to brake in a controlled fashion.

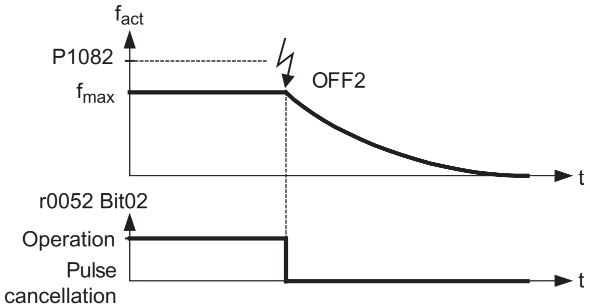



Figure 8-35 OFF2 brake function

---

**Note**

The OFF2 command can have one or several sources. The command sources are defined using BICO parameters P0844 (BI: 1. OFF2) and P0845 (BI: 2. OFF2).

As a result of the pre-assignment (default setting), the OFF2 command is set to the OP. This source is still available even if another command source is defined (e.g. terminal as command source → P0700 = 2 and OFF2 is selected using DI2 → P0702 = 3).

OFF2 is low-active.

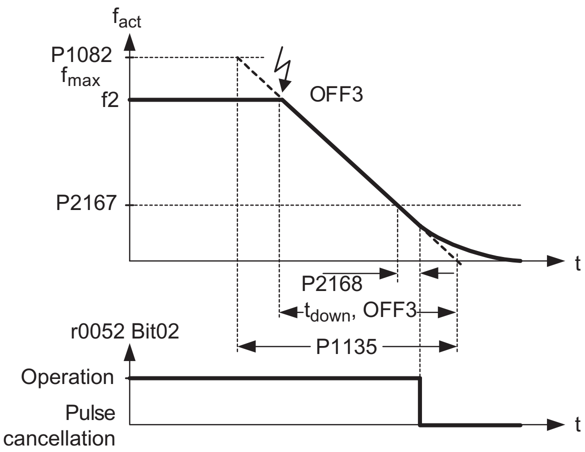
When simultaneously selecting the various OFF commands, the following priority applies:

- OFF2 (highest priority)
- OFF3
- OFF1.

---

## OFF3

The braking characteristics of OFF3 are identical with those of OFF1 with the exception of the autonomous OFF3 ramp-down time P1135. If the output frequency falls below parameter value P2167 and if the time in P2168 has expired, then the inverter pulses are cancelled as for the OFF1 command.




$$t_{down,\ OFF3} = P1135 \cdot \frac{|f2|}{P1082}$$

Figure 8-36 OFF3 brake function

---

**Note**

OFF3 can be entered using a wide range of command sources via BICO parameters P0848 (BI: 1. OFF3) and P0849 (BI: 2. OFF3).

OFF3 is low active.

When simultaneously selecting the various OFF commands, the following priority applies:

- OFF2 (highest priority)
- OFF3
- OFF1.

---

## 8.12.4 Manual and automatic operation

### Description

| | |
|---|---|
| Parameter range: | P0700, P1000 |
| | P0810, P0811 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

It is necessary to change-over from the automatic mode into the manual mode to load and unload production machines and to feed new materials (e.g. batch processing). The machine operator carries-out the preparatory activities for subsequent automatic operation in the manual mode. In the manual mode, the machine operator locally controls the machine (enters the ON/OFF command as well as also the setpoint). A changeover is only made into the automatic mode after the set-up has been completed. In the automatic mode, the control (open-loop) of the machines and production processes are handled by a higher-level control system (e.g. PLC). This operation is maintained until it is necessary to again load and unload the machine or feed new material into the machine or production process.

In the SINAMICS G120, indexed parameters P0700 or P1000 and BICO parameters P0810 and P0811 are used to changeover (toggle between) the manual/automatic modes. The command source is defined using P0700 and the setpoint source is defined using P1000, whereby index 0 (P0700[0] and P1000[0]) defines the automatic mode and index 1 (P0700[1] and P1000[1]) the manual mode. BICO parameters P0810 and P0811 are used to changeover (toggle between) the automatic and manual modes. These BICO parameters can be controlled from any control source. In so doing, in addition to P0700 and P1000, also all of the other CDS parameters are changed over (manual/automatic changeover is generalized as a CDS changeover).

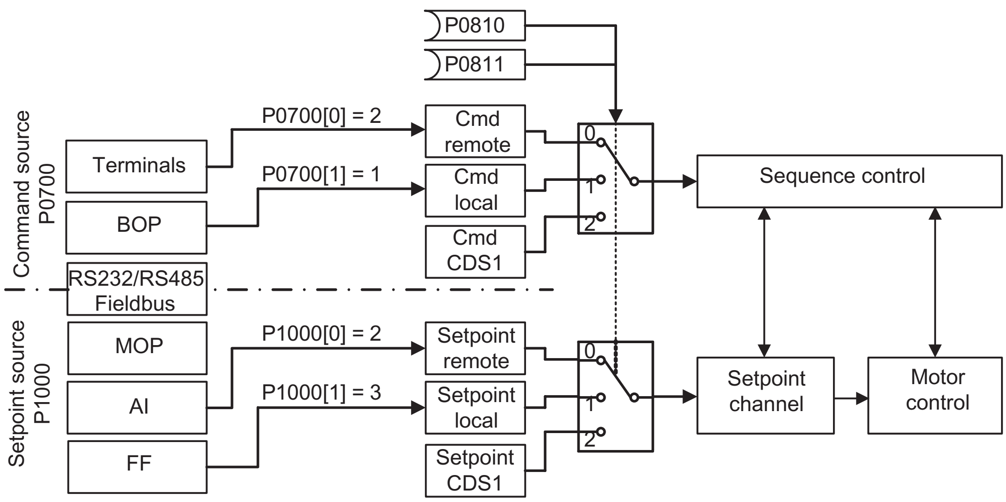



Figure 8-37 Changing-over using the BICO parameters P0810 and P0811

Table 8-18 Examples of settings of parameter P0810

| Parameter setting | Command source |
|---|---|
| P0810 = 722.2 requires P0703 = 99 | Digital input 3 |
| P0810 = 2032.15 | USS on RS232 |
| P0810 = 2036.15 | USS on RS485 |
| P0810 = 2090.15 | Fieldbus |

Table 8-19 Possible settings for parameters P0700 and P1000

| Value | Command source (P0700) | | Value | Setpoint source (P1000) |
|---|---|---|---|---|
| 1 | OP (keyboard) | | 1 | MOP setpoint |
| 2 | Terminal strip | | 2 | Analog setpoint |
| 4 | USS on RS232 | | 3 | Fixed frequency |
| 5 | USS on RS485 | | 4 | USS on RS232 |
| 6 | Fieldbus | | 5 | USS on RS485 |
| | | | 6 | Fieldbus |
| | | | 7 | Analog setpoint 2 |
| | | | 10 | No main setpoint + MOP setpoint |
| | | | … | |
| | | | 77 | Analog setpoint 2 + analog setpoint 2 |

# 8.13 Free function blocks

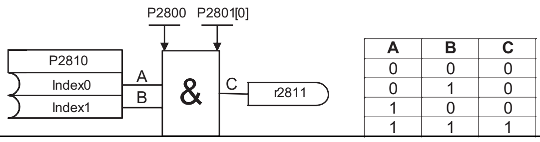
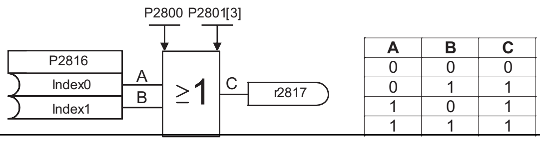
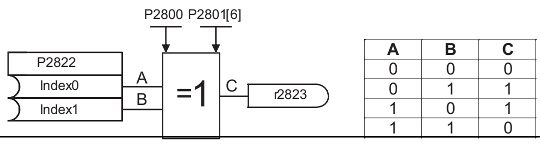
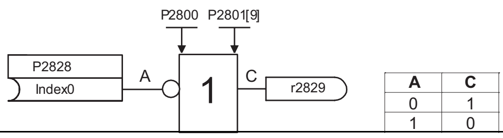
## Description

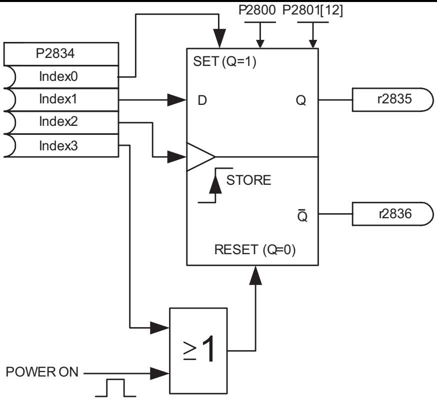
| | |
|---|---|
| Parameter range: | P2800 … P2890 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP4800 … FP4830 |
| Cycle time: | 128 ms |

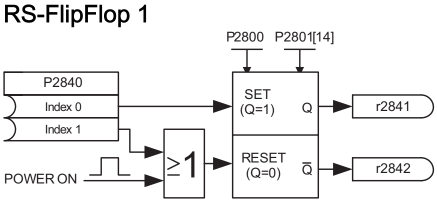
For many applications, interlocking logic is required in order to control (open-loop) the inverter. This interlocking logic couples several states (e.g. access control, plant/system state) to form a control signal (e.g. ON command). Previously this was implemented using either a PLC or relays. This represented additional costs for the plant or system. In addition to logic operations, increasingly, arithmetic operations and storage elements are required in inverters which generate a new unit from several physical quantities. This simplified PLC functionality is integrated in the SINAMICS G120 using the freely programmable function blocks (FFB).

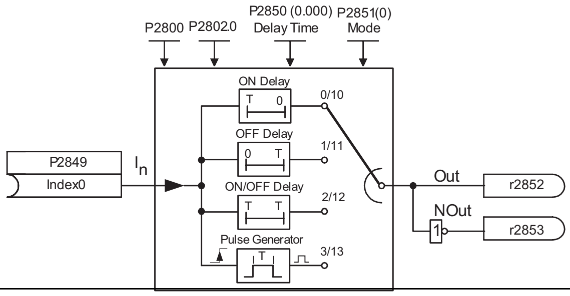
The table below shows the function blocks that are integrated in the SINAMICS G120 inverter:

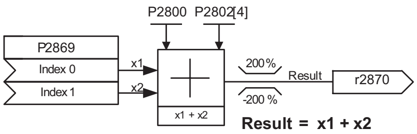
Table 8-20 Free function blocks

| No. | Type | Example |
|---|---|---|
| 3 | AND | AND 1   |
| 3 | OR | OR 1   |
| 3 | XOR | XOR 1   |
| 3 | NOT | NOT 1   |
| 2 | D-FlipFlops | D-FlipFlop 1 |

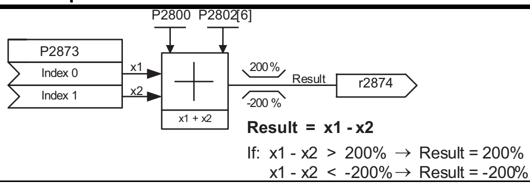
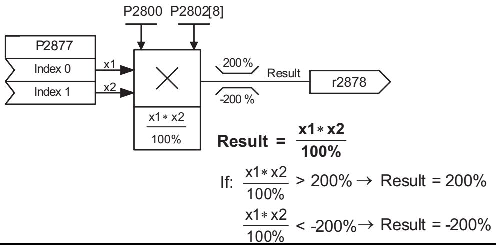
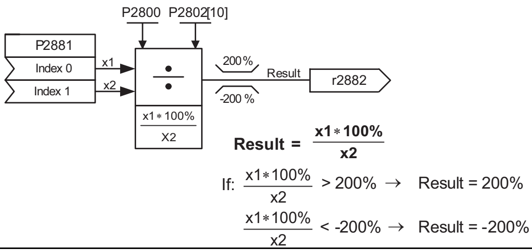
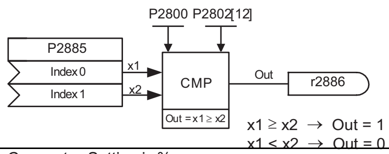
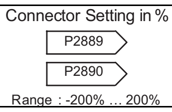
<table>
<tr><th>No.</th><th>Type</th><th>Example</th></tr>
<tr><td></td><td></td><td>


<table>
<tr><th>SET</th><th>RESET</th><th>D</th><th>STORE</th><th>Q</th><th>Q̄</th></tr>
<tr><td>1</td><td>0</td><td>x</td><td>x</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>x</td><td>x</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>x</td><td>x</td><td>$Q_{n-1}$</td><td>$\overline{Q}_{n-1}$</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>↑</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>↑</td><td>0</td><td>1</td></tr>
<tr><td colspan="4">POWER-ON</td><td>0</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>3</td><td>RS-FlipFlops</td><td>
RS-FlipFlop 1


<table>
<tr><th>SET</th><th>RESET</th><th>Q</th><th>Q̄</th></tr>
<tr><td>0</td><td>0</td><td>$Q_{n-1}$</td><td>$\overline{Q}_{n-1}$</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>$Q_{n-1}$</td><td>$\overline{Q}_{n-1}$</td></tr>
<tr><td colspan="2">POWER-ON</td><td>0</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>4</td><td>Timer</td><td>
Timer 1


</td></tr>
<tr><td>2</td><td>ADD</td><td>
ADD 1


Result = x1 + x2<br>
If: x1 + x2 > 200% → Result = 200%<br>
x1 + x2 < -200% → Result = -200%
</td></tr>
<tr><td>2</td><td>SUB</td><td>SUB 1</td></tr>
</table>

<table>
<tr><th>No.</th><th>Type</th><th>Example</th></tr>
<tr><td></td><td></td><td>
</td></tr>
<tr><td>2</td><td>MUL</td><td>MUL 1<br>
</td></tr>
<tr><td>2</td><td>DIV</td><td>DIV 1<br>
</td></tr>
<tr><td>2</td><td>CMP</td><td>CMP 1<br>
</td></tr>
<tr><td>2</td><td>FFB setpoints (connector settings)</td><td>
</td></tr>
</table>

The free function blocks (FFB) are enabled in two steps:

1. General enable P2800:
   The function "Free function blocks (FFB)" is enabled using parameter P2800 (P2800 =1).
2. Specific enable P2801, P2802:
   Using parameter P2801 or P2802, the particular function block is enabled (P2801[x] > 0 or P2802[x] > 0) and the sequence in which they are executed is also defined.

All free function blocks are called within the 128 ms time slice (cycle time). Additionally, to adapt to the application, the chronological sequence in which the FFBs are executed, can also be controlled. This is especially important so that the FFBs are executed in the sequence which is technologically correct. Parameter P2801 and P2802 are used for the individual enable function as well as to define the priority in which the blocks are executed. The following priority levels can be assigned:

- 0 = Inactive
- 1 = Level 1
- 2 = Level 2
- 3 = Level 3

The figure below indicates that the priority decreases from the top towards the bottom (priority 1 → level) or from the right to left (priority 2 → line).

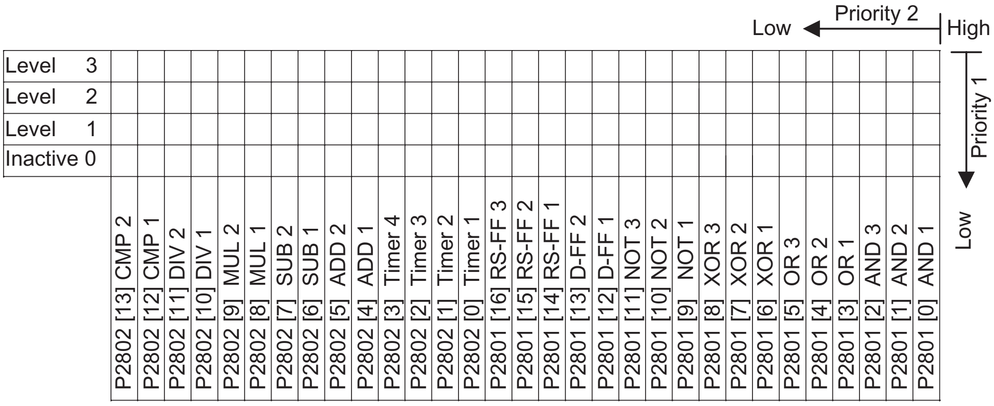



Figure 8-38 Free function block priorities

## Example 1

| | |
|---|---|
| Enabling the FFBs: | P2800 = 1 |
| Enabling individual FFB including assigning a priority: | |
| P2801[0] = 1 | AND 1 |
| P2801[1] = 2 | AND 2 |
| P2801[2] = 3 | AND 3 |
| P2802[12] = 2 | CMP 1 |
| P2802[13] = 3 | CMP 2 |
| The FFBs are calculated in the following sequence: | AND 3 → CMP 2 → AND 2 → CMP 1 → AND 1 |

## Example 2

| | |
|---|---|
| Enabling the FFBs: | P2800 = 1 |
| Enabling individual FFB including assigning a priority: | |
| P2801[3] = 2 | OR 1 |
| P2801[4] = 2 | OR 2 |
| P2802[3] = 3 | Timer 4 |
| P2801[0] = 1 | AND 1 |
| The FFBs are calculated in the following sequence: | Timer 4 → OR 1 → OR 2 → AND 1 |

The function blocks are interconnected using BICO technology. In so doing, the function blocks can be connected with one another as well as to other signals and quantities as long as these signals or quantities have the appropriate attribute (BO, BI, CO and CI).

# 8.14 Brake functions

## 8.14.1 Electro-mechanical brakes

### Functions of the electro-mechanical brake

Warning

**Dimensioning the electro-mechanical motor brake**

The electro-mechanical brake must be dimensioned that, in case of a fault, the complete motor can be braked to zero from any possible operational speed. If no electro-mechanical brake is present, the machine manufacturer must adopt other suitable measures to protect against motion after the energy supply to the motor has been cut (for example, to protect against sagging loads).

The electro-mechanical brake can be used as motor holding brake or as an instant brake.

- As motor holding brake it is used to prevent the motor from unintented rotation (e.g. lifting or lowering the load in lifting applications) by applying torque in order to compensate brake release times. The motor holding brake functionality is triggered by an OFF1 or OFF3 command. For details see section motor holding brake.
- As an instant brake it has to brake down the motor from any speed down to zero speed. The related brake release times are not considered in this case. The brake as instant brake is triggered by an OFF2 command or in fail-safe applications via a Safe Torque Off (STO) or a LSTO fault condition (refer to Chapter "Functions", Section "Safe Brake Control").

The electro-mechanical brake is normally energized, which keeps the mechanical brake in an opened position, that is, it does not interfere with the movement of the motor. When power is lost, or removed from the mechanical brake, or the system, the brake is closed and the motor shaft is held in position.

Note

If an electro-mechanical brake is attached, parameter P1215 needs to be enabled, otherwise it will not be possible to run the motor!

### 8.14.1.1 Brake Control Relays

#### Overview

There are two types of brake control relays:

- Relay Brake Module
- Safe Brake Module

The Safe Brake Module and the Relay Brake Module are different variants of the same device (for details see option description "Brake Module Instructions".

Connections of Relay Brake Module and Safe Brake Module:

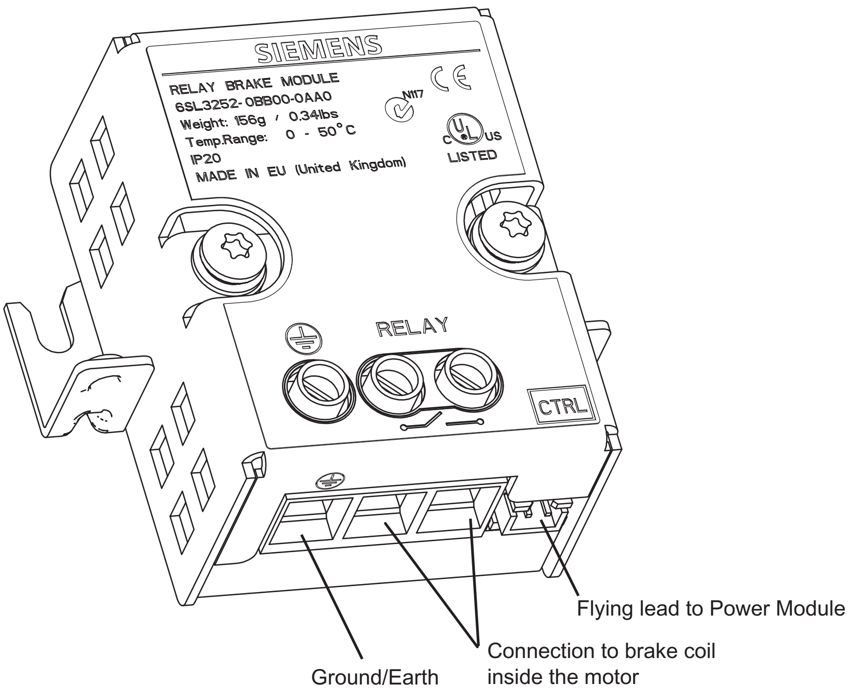



Figure 8-39 Relay Brake Module

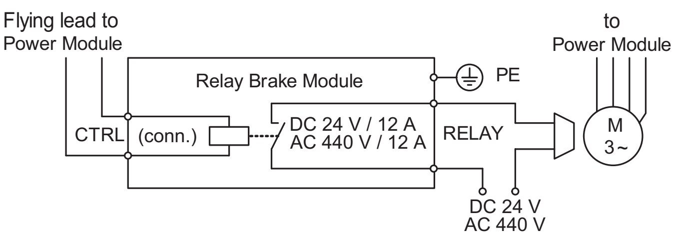



Figure 8-40 Wiring of Relay Brake Module

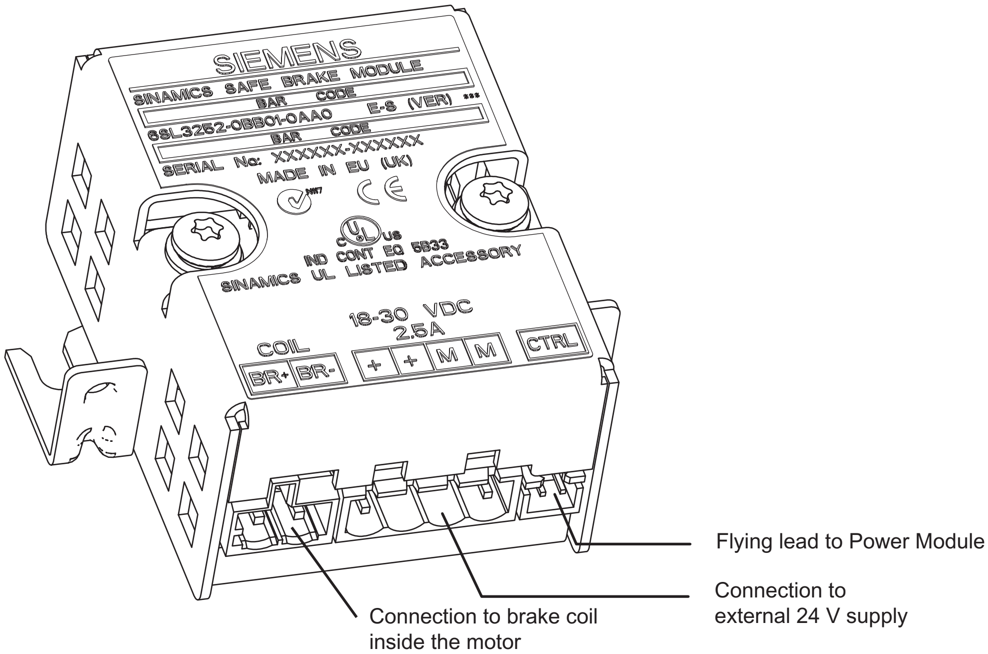



Figure 8-41 Safe Brake Module

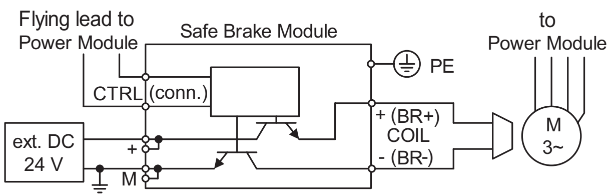



Figure 8-42 Wiring of Safe Brake Module

24 V motor brakes up to a current consumption of 2 A can be operated with the Safe Brake Module. Necessary is an external controlled power supply for 2.5 A and an output voltage which can be adjusted at a voltage of 26 V, e.g. SITOP modular. The higher voltage is required to compensate the voltage drop across the cables to the coil of the brake.

---

**Note**

On fail-safe reasons it is not allowed to take the 24 V supply of the Control Unit.
The power supply for the Safe Brake Module must be a separate additional power supply.

During power ON for the drive it is necessary to supply the Safe Brake Module first, so that the Control Unit is able to check its function, otherwise the fault F1601 will occur.

---

The Safe Brake Module is designed to reaction to a stepped voltage input, which allows the braking mechanism to be tested. The Relay Brake Module does not have this functionality.

**Note**

During forced dynamisation all connections of the Safe Brake Module are checked but in operation the connection between Safe Brake Module and brake coil is not monitored.

### Triggering the Brake Control with non-safety Control Units

The motor brake function can be activated or deactivated via P1215. It controls a brake relay, connected to the power module. This brake relay controls an electro-mechanical brake, which is always closed when powered down.

P1215 = 0
(motor brake not active - factory setting), that means, if a brake is available, it will be closed to prevent the motor against unintended moves, e.g. after a parameter download.

P1215 = 1
(motor brake active) the brake will be controlled via terminals A and B on the power module.

### Triggering the Brake Control with Faill-safe Contol Units

Prerequisite: P1215 = 1

**Warning**

The brake can be triggered via both, a Relay Brake Module and a Safe Brake Module. Triggering via a Relay Brake Module is not fail-safe!

For a fail-safe triggering of a Safe Brake Module the following parameters must be set: P9602 = P9802 = 1 (factory setting is 0). If P9602 ≠ P9802 a fault will be generated.

In case of P9602 = P9802 = 1 a test signal regarding the signal to the Safe Brake Control is generated and monitored.

This test signal does not interfere with the normal function of the mechanical brake. If the mechanical brake is fitted and the test fails, a fault condition will be indicated by the inverter.

If the Safe Brake Control is deactivated by setting P9602 = P9802 = 0 the Safe Brake Module will still work as intendet but will not be monitored in a safe way.

### 8.14.1.2 Motor Holding Brake

## Description

| | |
|---|---|
| Parameter range: | P1215<br>P0346, P1216, P1217, P1080<br>r0052 bit 12 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

For motors which must be secured when powered-down to prevent undesirable movement, the SINAMICS G120 brake sequence control (enabled through P1215) can be used to control the motor holding brake.

Before opening the brake, the pulse inhibit must be removed and a current impressed which keeps the motor in that particular position. In this case, the impressed current is defined by the min. frequency P1080. A typical value in this case is the rated motor slip r0330. In order to protect the motor holding brake from continuous damage, the motor may only continue to move after the brake has been released (brake release times are between 35 ms and 500 ms). This delay must be taken into account in parameter P1216 "Holding brake release delay" (see figure below).

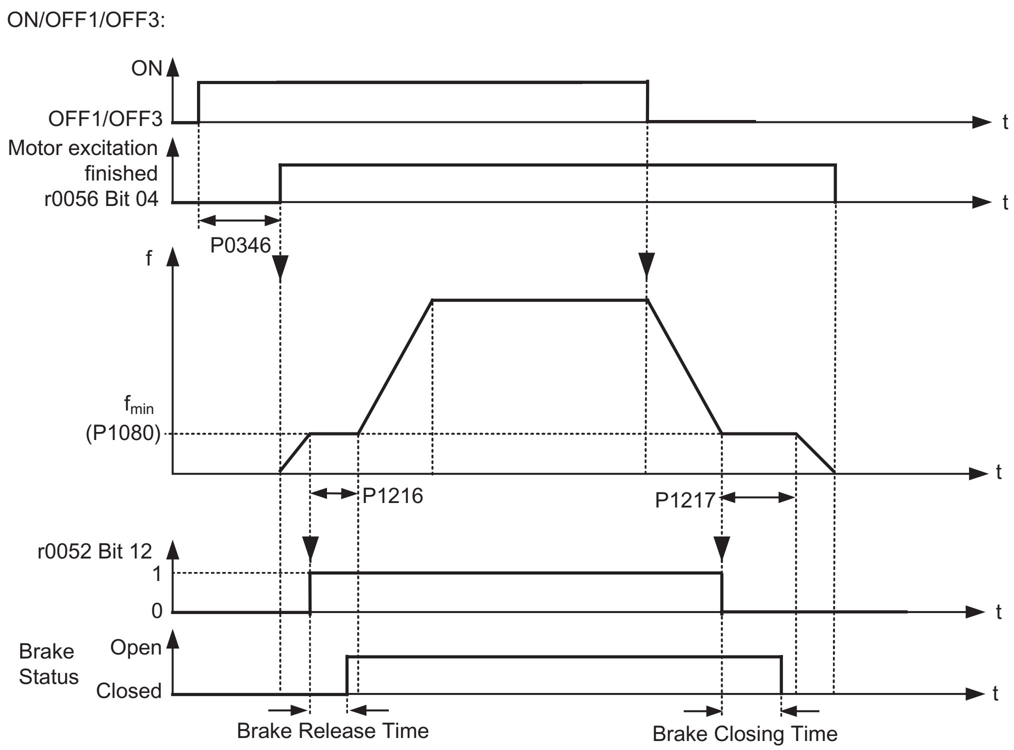



Figure 8-43 Motor holding brake after ON/OFF1 resp. ON/OFF3

The motor holding brake is either closed using OFF1 or OFF3. When the minimum frequency P1080 is reached, the motor is operated at this frequency until the brake has been applied (closing times of brakes are between 15 ms and 300 ms). The actual time is specified using parameter P1217 "Holding time after ramp down" (see figure above). If, on the other hand, an OFF2 command has been output, then independent of the motor state, the status signal r0052 bit 12 "Brake active" is reset. This means that the brake immediately closes after OFF2 (instant brake).

The mechanical brake is controlled using the status signal r0052 bit 12 "Brake active" of the brake control. This signal is connected to terminal A and B of the power module.

---

**Warning**

It is not sufficient to select the status signal r0052 bit 12 "Brake active" in P0731 … P0733. In order to activate the motor holding brake, in addition, parameter P1215 must also be set to 1.

If SINAMICS G120 controls the motor holding brake, then a series commissioning may not be carried-out for potentially hazardous loads (e.g. suspended loads for crane applications) unless the load has been secured. Potentially hazardous loads can be secured as follows before series commissioning is started:

- Lower the load to the floor, or
- Clamp the load using the motor holding brake
  (**Caution**: During the series commissioning, SINAMICS G120 must be prevented from controlling the motor holding brake).

---

**Note**

Motors have optional holding brakes which are not designed to be used as brakes for normal operation. The holding brakes are only designed for a limited number of emergency braking operations / motor revolutions with the brake closed (refer to the Catalog data).

When commissioning a motor with integrated holding brake it is therefore absolutely imperative that it is ensured that the holding brake functions perfectly. A "clicking noise" in the motor indicates that the brake has been correctly released.

---

Before the motor holding brake is applied, a torque must be established that maintains the motor at the required position. The pulses, from the inverter, must be enabled to allow the necessary torque to be generated. The torque is defined by the minimum frequency in parameter P1080. A typical value for this is the rated motor slip r0330. Additionally, this torque can be modified using the following parameters:

- V/f control – boost parameter P1310
- SLVC – boost parameters P1610 and P1611
- VC – supplementary torque setpoint P1511

The motor holding brake can be permanently damaged, if the motor shaft is moved when the motor holding brake is applied. It is imperative that the release of the motor holding brake is timed correctly.

### 8.14.1.3 Instant brake

#### Description

An instant brake is an electro-mechanical brake which has to brake down the motor from any speed down to zero speed. The instant brake function is activated after an OFF2 command (refer to Chapter "Functions", Section "OFF/braking functions") and additional in the case of a fail-safe application after a Safe Torque Off (STO) or a LSTO fault condition (refer to Chapter "Functions", Section "Safe Brake Control").

The behavior of the instant brake function is described below.

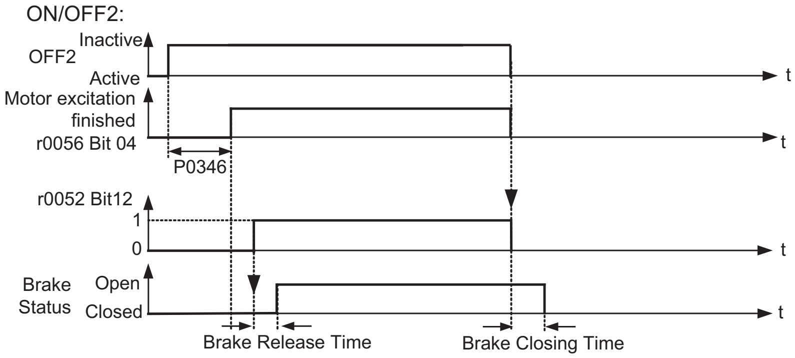



Figure 8-44 Instant Brake

**Warning**

**Dimensioning the electro-mechanical motor brake**

The electro-mechanical brake must be dimensioned that, in case of a fault, the complete motor can be braked to zero from any possible operational speed.

## 8.14.2 Electronic brakes

### Overview

The SINAMICS G120 inverter has three electronic braking technologies:

- DC braking
- Compound braking
- Dynamic braking

These brakes can actively brake the motor and avoid a possible DC link overvoltage condition. The figure below shows the inter-dependency of the electronic braking functions.

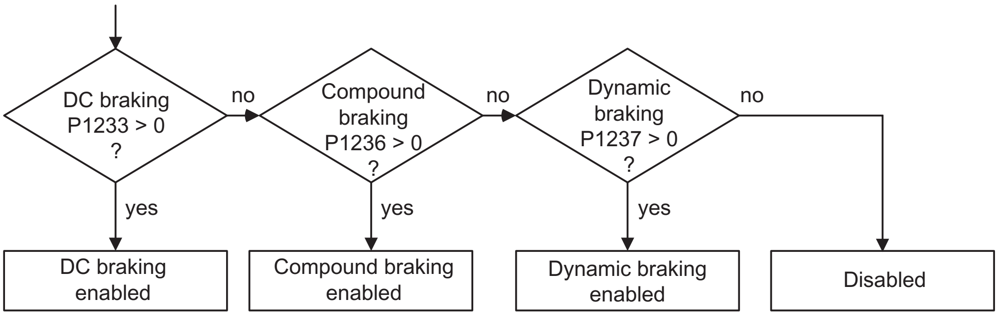



Figure 8-45 Inter-dependency of electronic brakes

### 8.14.2.1 DC braking

### Description

| | |
|---|---|
| Parameter range: | P1230, P1233 |
| | P1232, P1234 |
| | r0053 Bit00 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

The motor decelerates along a parameterized braking ramp if an OFF1 or OFF3 command is output. A "flat" ramp must be selected so that the inverter is not tripped (shutdown) due to the high regenerative energy which would cause a DC link overvoltage condition. The DC brake should be activated while the OFF1 or OFF3 command is present if the motor is to be braked faster. For DC braking, instead of continually reducing the output frequency/voltage during the OFF1 or OFF3 phase, from a selectable frequency, a DC voltage/current is input (refer to sequence 1).

The motor can be brought to a standstill in the shortest time using DC current braking (DC brake). DC braking is selected as follows:

- After OFF1 or OFF3 (the DC brake is released via P1233) – Sequence 1
- Directly selected using BICO parameter P1230 – Sequence 2

For DC braking, a DC current is impressed in the stator winding which results in a significant braking torque for an induction motor. The magnitude, duration and frequency at which braking starts can be set for the braking current and therefore braking torque by setting the appropriate parameters.

DC braking is especially used for:

- Centrifuges
- Saws
- Grinding machines
- Conveyor belts

## Sequence 1

1. Enabled using P1233
2. DC braking is activated with the OFF1 or OFF3 command (see figure below)
3. The inverter frequency is ramped down along the parameterized OFF1 or OFF3 ramp down to the frequency at which DC braking is to start - P1234. This means that the kinetic energy of the motor can be reduced without endangering the inverter. However, if the ramp-down time is too short, there is a danger that a fault will be output as a result of an overvoltage condition in DC link - F0002.
4. The inverter pulses are inhibited for the duration of the de-magnetizing time P0347.
5. The required braking current P1232 is then impressed for the selected braking time P1233. The status is displayed using signal r0053 bit 00.

The inverter pulses are inhibited after the braking time has expired.

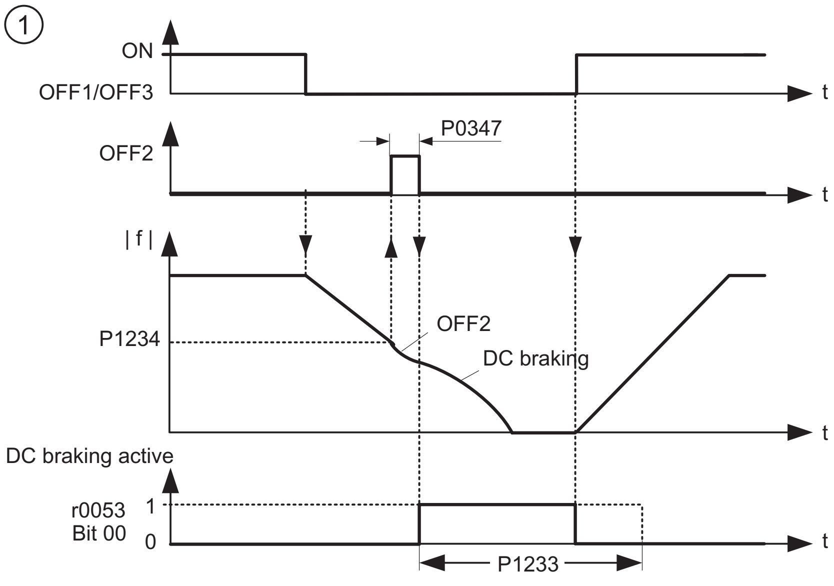



Figure 8-46 DC braking after OFF1/OFF3

## Sequence 2

1. Enabled and selected using BICO parameter P1230 (see figure below).
2. The inverter pulses are inhibited for the duration of the de-magnetizing time P0347.
3. The requested braking current P1232 is impressed as long as DC braking is enabled (P1230 = 1) and the motor is braked. This state is displayed using signal r0053 bit 00.
4. After DC braking has been cancelled, the motor accelerates back to the setpoint frequency until the motor speed matches the inverter output frequency. If there is no match, then there is danger that a fault will be output as a result of overcurrent - F0001. This can be avoided by activating the flying restart function.
5. If any fault occurs during P1230 = 1 the DC current is set to zero. The motor doesn't ramp up even the fault is acknowledged. A new ON command is necessary.
6. If the DC brake is enabled again, the braking current P1232 is impressed as long as P1230 = 1.

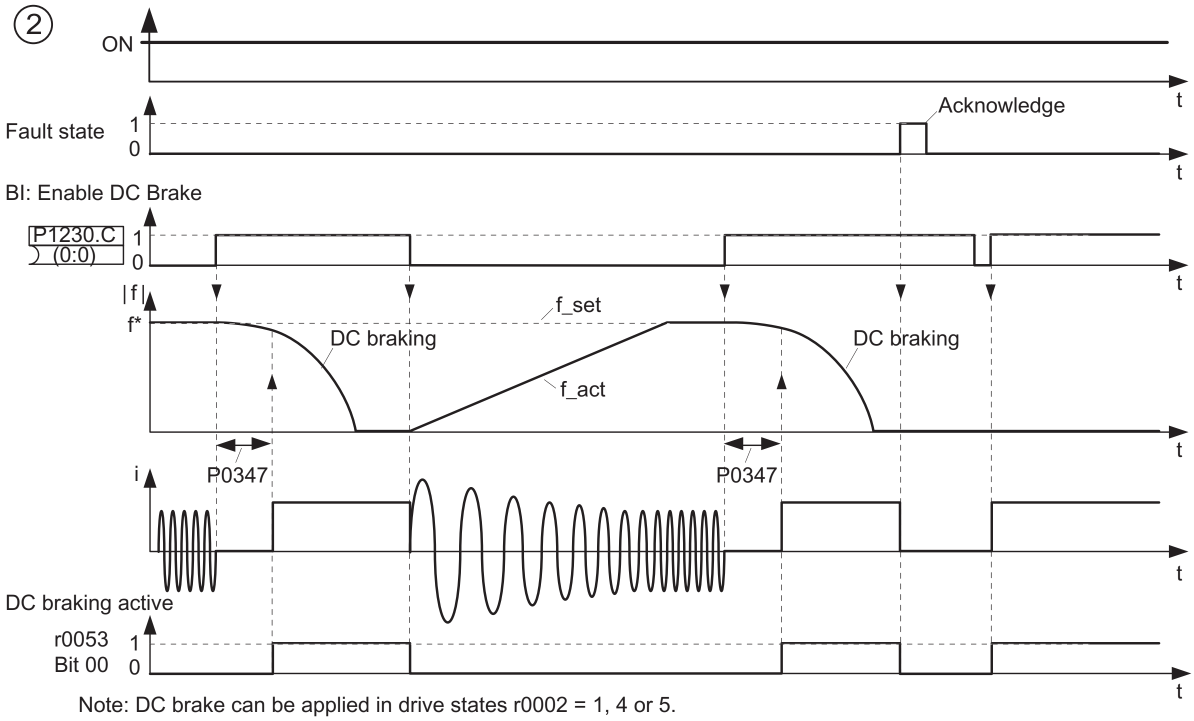



Figure 8-47 DC braking after external selection

**Note**

1. The "DC braking" function is only practical for induction motors!
2. DC braking is not suitable to hold suspended loads!
3. For DC current braking, the motor kinetic energy is converted into thermal energy in the motor. If braking lasts too long, then the motor can overheat!
4. While DC braking, there is no other way of influencing the motor speed using an external control. When parameterizing and setting the motor system, then as far as possible, it should be tested using real loads!

### 8.14.2.2 Compound braking

#### Description

| | |
|---|---|
| Parameter range: | P1236 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

For compound braking (this is enabled using P1236) DC braking is superimposed with regenerative braking (where the motor regenerates into the line supply as it brakes along a ramp). If the DC link voltage exceeds the compound switch-in threshold VDC-Comp (see figure below), then a DC current is impressed as a function of P1236. In this case, braking is possible with a controlled (closed-loop) motor frequency and minimum regenerative feedback. Effective braking is obtained without having to use additional components by optimizing the ramp-down time (P1121 for OFF1 or when braking from f1 to f2, P1135 for OFF3) and using compound braking P1236.

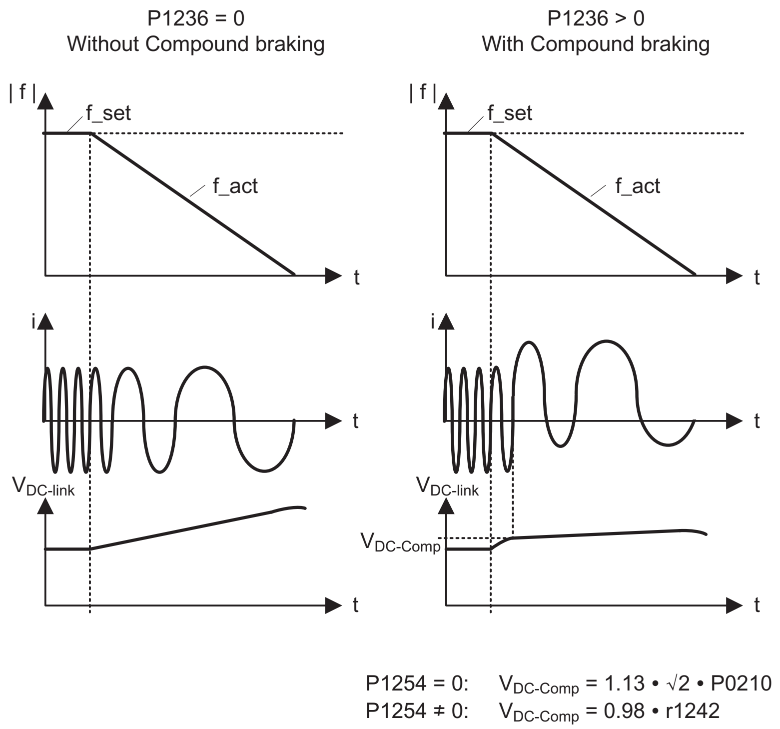



Figure 8-48 Compound braking

The compound braking switch-in threshold VDC-Comp is calculated as a function of parameter P1254 (Auto detect VDC switch-on levels) either directly using the line supply voltage P0210 or indirectly using the DC link voltage and r1242 (refer to the formula in the figure above).

**Warning**

For compound braking, regenerative braking is superimposed on the DC braking (braking along a ramp). This means that components of the kinetic energy of the motor and motor load are converted into thermal energy in the motor. If this power loss is too high or if the braking operation takes too long, then this can cause the motor to overheat!

**Note**

Only active in conjunction with V/f control.

Compound braking is deactivated, if:

- flying restart is active,
- DC braking is active, and
- Vector control (SLVC, VC) is selected.

The compound switch-in threshold VDC-Comp is dependent on P1254:

$V_{DC\text{-}Comp}(P1254 = 0) \neq V_{DC\text{-}Comp}(P1254 \neq 0)$

### 8.14.2.3 Dynamic braking

## Dynamic braking

| | |
|---|---|
| Parameter range: | P1237 |
| Warnings: | A0535 |
| Faults: | F0022 |
| Function chart number: | - |

For several motor applications, in certain operating states, the motor can regenerate. Examples of these applications include:

- Cranes
- Traction motors
- Conveyor belts which transport loads downwards.

When the motor is in the regenerative mode, the energy from the motor is fed back into the DC link of the motor through the inverter. This means that the DC link voltage increases and when the maximum threshold is reached, the inverter is shutdown (tripped) with fault F0002. This shutdown (trip) can be avoided by using dynamic braking. Contrary to DC and compound braking, this technique requires that an external braking resistor is installed.

The advantages of dynamic resistor braking include:

- The regenerative energy is not converted into heat in the motor.
- It is significantly more dynamic and can be used in all operating states (not only when an OFF command is output).

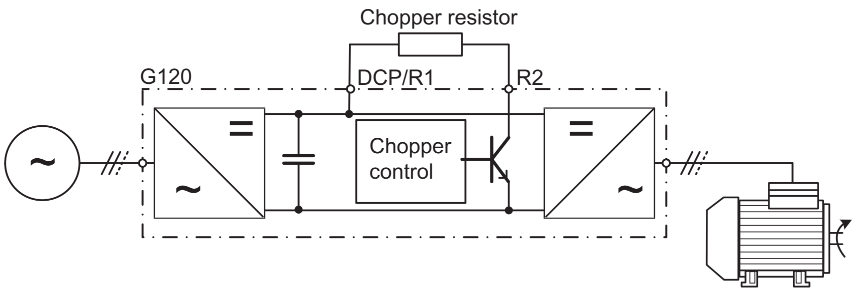



Figure 8-49 Connecting the chopper (braking) resistor

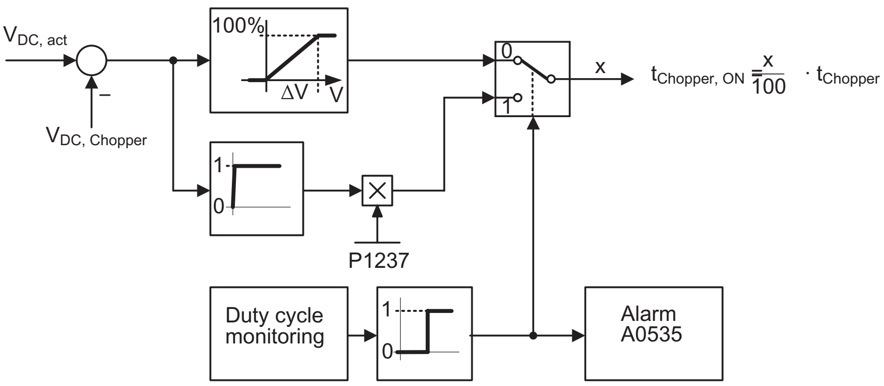
The braking energy in the DC link is converted into heat when dynamic braking is activated (enabled using P1237). The energy is converted into heat using the voltage-controlled chopper resistor (ballast resistor). When regenerative energy is fed back to the DC link and in consequence the DC link threshold $V_{DC,\ Chopper}$ is exceeded, then the chopper resistor is switched in using an electronic semiconductor switch.

Switch-in threshold of the chopper resistor:

If P1254 = 0: $V_{DC,\,Chopper} = 1.13 \cdot \sqrt{2} \cdot V_{line\ supply} = 1.13 \cdot \sqrt{2} \cdot P0210$

Otherwise: $V_{DC,\,Chopper} = 0.98 \cdot r1242$

The chopper switch-in threshold $V_{DC\ chopper}$ is calculated as a function of parameter P1254 (Auto detect $V_{DC}$ switch-on levels), either directly using the line supply voltage P0210 or indirectly using the DC link voltage and r1242.

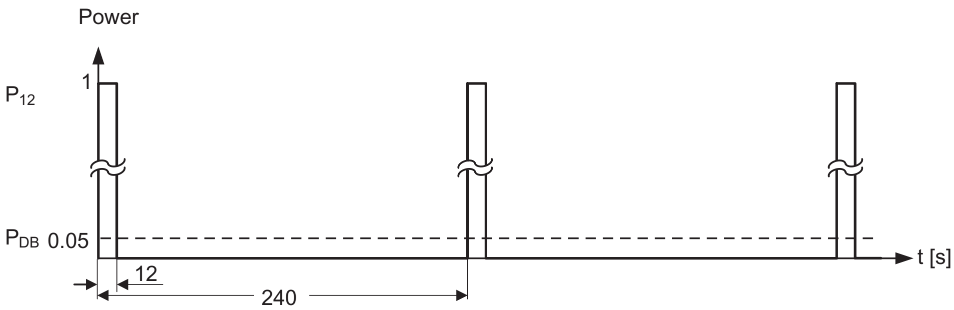



| | Mains | | |
|---|---|---|---|
| | 200 - 240 V | 380 - 480 V | 500 - 600 V |
| ΔV | 9.8 V | 17.0 V | 21.3 V |

Figure 8-50 Mode of operation of the dynamic braking

The regenerative (braking) energy is converted into thermal energy using the chopper resistor. A braking module (chopper control) is integrated in the DC link for this purpose. The chopper of the braking module switches the resistor with a mark-space ratio corresponding to the regenerative power to be dissipated. The braking module is only active if, as a result of the regenerative operation, the DC link voltage lies above the chopper switch-in threshold $V_{DC\ chopper}$. This means that the braking module is not active in normal operation when motoring.

The chopper resistor is only designed for a specific power and a certain load duty cycle and can only absorb a limited amount of braking energy within a specific time period. The chopper resistors, specified in SINAMICS G120 Catalog, have the following load duty cycle as shown in the figure below.




$P_{DB}$ = continuous power

$P_{12}$ = $20 \cdot P_{DB}$ = permissable power for 12 s every 240 s

Figure 8-51 Load duty cycle - chopper resistors

This load duty cycle is saved in the SINAMICS G120 inverter for P1237 = 1 (→ 5 %). If the values are exceeded due to the load required, then when the maximum acceptable braking energy is reached, the load duty cycle monitoring controls the chopper so that the value is reduced to the value entered in parameter P1237. This means that the energy to be dissipated in the chopper resistor is reduced, which means that the DC link voltage quickly increases due to the regenerative energy available and the inverter is shutdown (tripped) due to a DC link overvoltage condition.

If the continuous power or the load duty cycle for a resistor is too high, then the continuous rating can be quadrupled using four resistors in a bridge circuit configuration (see figure below). In this case, in addition, the load duty cycle must be increased using parameter P1237 from P1237 = 1 (→ 5 %) to P1237 = 3 (→ 20 %). When using the bridge circuit, the overtemperature switch of the resistors should be connected in series and incorporated in the fault circuit. This guarantees, that when a resistor overheats, the complete system/inverter is shut down.

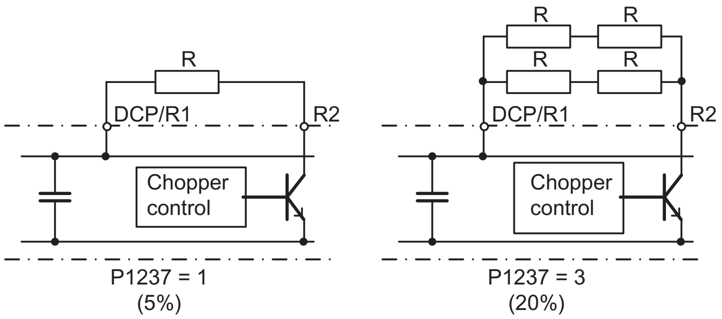
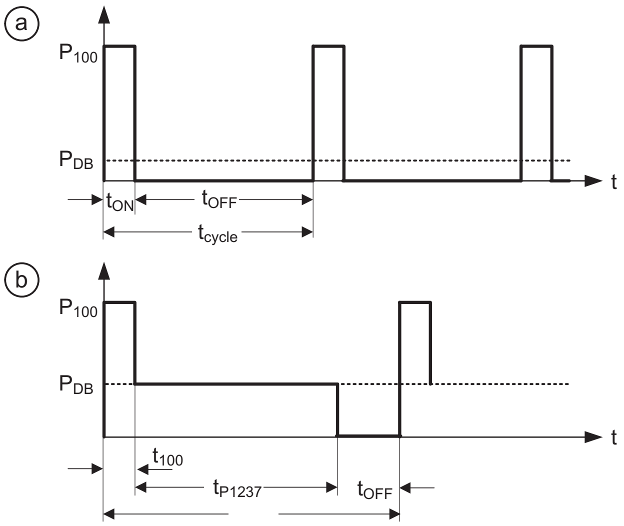



Figure 8-52 Increasing the level of braking energy which can be absorbed

The continuous power and the load duty cycle are modified using parameter P1237. If the load duty cycle monitoring switches from the peak power (100 %) to the continuous power, then this is dissipated for an unlimited length of time in the braking resistor. Contrary to the braking resistor, as listed in the Catalog, the chopper control can be permanently operated with 100 % power.




| P1237 | $t_{ON}$ | $t_{OFF}$ | $t_{cycle}$ | $P_{DB}$ |
|---|---|---|---|---|
| 5% | 12.0 | 228.0 | 240.0 | 0.05 |
| 10% | 12.6 | 114.0 | 126.6 | 0.10 |
| 20% | 14.2 | 57.0 | 71.2 | 0.20 |
| 50% | 22.8 | 22.8 | 45.6 | 0.50 |
| 100% | Infinite | 0 | Infinite | 1.00 |

Figure 8-53 Chopper load duty cycle

For SINAMICS G120, the braking module is integrated in the inverter and the braking resistor can be connected using the external terminals DCP/R1 and R2 (for more details refer to Operating Instructions of the corresponding Power Module). Where the DCP/R1 is the positive terminal for the braking resistor and R2 is the negative terminal for the braking resistor.

**Warning**

Braking resistors, which are to be mounted on SINAMICS G120, must be designed so that they can tolerate the power dissipated.

If an unsuitable braking resistor is used there is a danger of fire and that the associated inverter will be significantly damaged.

The chopper control, integrated in the inverter is designed for the braking resistor value assigned in Catalog; e.g.:

- SINAMICS G120 XXXXXXX-2UD23-0BA1
- brake resistor XXXXXX-4BD12-0BA0
- brake resistor value 160 Ω

A brake resistor with a lower resistance value will destroy the inverter. In this case, an external braking unit must be used.

When operational, the temperature of braking resistors increases – do not touch! Ensure that there is sufficient clearance around the unit and there is adequate ventilation.

A temperature protection switch must be used to protect the units against overheating.

**Note**

The switch-on threshold $V_{DC}$ chopper of the dynamic resistor braking is dependent on P1254

$V_{DC\ chopper}$(P1254 = 0) ≠ $V_{DC\ chopper}$(P1254 ≠ 0).

External braking modules (chopper units) including braking resistor can be used with all of the sizes of inverters. When engineering the system, the particular braking module/resistor must be taken into consideration.

# 8.15 Automatic restart

## Description

| | |
|---|---|
| Parameter range: | P1210 |
| | P1211 |
| Warnings: | A0571 |
| Faults: | F0035 |
| Function chart number: | - |

After a power failure (F0003 "Undervoltage"), the "Automatic restart" function (enabled using P1210) automatically powers-up the inverter again. Any faults are automatically acknowledged by the inverter.

The automatic restart function will only take place if a RUN command was present prior to the power failure. If no RUN command was present prior to the power failure an automatic restart will not be performed.

When it comes to power failures (line supply failure), then a differentiation is made between the following conditions:

## Line undervoltage (brownout)

"Line undervoltage" is a situation where the line supply is interrupted and returns before (if installed) the OP display has gone dark (this is an extremely short line supply interruption where the DC link hasn't completely collapsed).

## Line failure (blackout)

"Line failure" is a situation where the display has gone dark (this represents a longer line supply interruption where the DC link has completely collapsed) before the line supply returns.

The automatic restart function P1210 is shown in the figure below as a function of external states/events.

Table 8-21 Automatic restart

| P1210 | ON always active | | | | Inverter ON and no RUN command |
|---|---|---|---|---|---|
| | Fault F0003 for | | All other faults for | | All faults + F0003 |
| | Blackout | Brownout | Blackout | Brownout | |
| 0 | - | - | - | - | - |
| 1 | Fault acknowledge | - | - | - | Fault acknowledge |
| 2 | Fault acknowledge + restart | See Caution 1. | - | - | Fault acknowledge + restart |
| 3 | Fault acknowledge + restart | Fault acknowledge + restart | Fault acknowledge + restart | Fault acknowledge + restart | - |

| | ON always active | | | | Inverter ON and no RUN command |
|---|---|---|---|---|---|
| 4 | Fault acknowledge + restart | Fault acknowledge + restart | - | - | - |
| 5 | Fault acknowledge + restart | See Caution 1. | - | Fault acknowledge + restart | Fault acknowledge + restart |
| 6 | Fault acknowledge + restart | Fault acknowledge + restart | Fault acknowledge + restart | Fault acknowledge + restart | Fault acknowledge + restart |

The number of start attempts is specified using parameter P1211. The number is internally decremented after each unsuccessful attempt. After all attempts have been made (as specified in parameter P1211), automatic restart is cancelled with the message F0035. After a successful start attempt, the counter is again reset to the initial value.

**Danger**

For longer line supply failures (blackouts) and when the automatic restart function is activated, over a longer period of time it may be assumed that SINAMICS G120 is powered-down. However, when the line supply returns, inverters can automatically start to run again without any operator intervention.

If the operating range of the motor is entered in this status, this can result in death, severe injury or material damage.

**Caution**

The Control Unit can be powered using and external 24 V supply. If the Control Unit is powered by an external 24 V supply and the mains line supply fails, the Power Module will lose power, but the Control Unit will remain active. If this situation occurs then the Control Unit will not perform an automatic restart. This situation could result in the inverter being in an undetermined state and may not react as predicted.

The automatic restart function has been designed to ignore command source time-outs. That is, if the command sources is, for example, a PLC or through USS communications and the PLC or USS times-out an automatic restart will not be initiated.

**Note**

In addition the "Flying restart" function must be activated if, for an automatic restart, the inverter is to be connected to a motor which may already be spinning.

# 8.16 Flying restart

## Description

| | |
|---|---|
| Parameter range: | P1200<br>P1202, P1203<br>r1204, r1205 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

The "Flying restart" function (this is enabled using P1200) allows the inverter to be switched to a motor which is still spinning. If the inverter was to be powered-up without using the flying restart function, there would be a high possibility that a fault with overcurrent F0001 would occur. The reason for this is that the flux must first be established in the motor and the V/f control or closed-loop Vector control must be set corresponding to the actual motor speed. The inverter frequency is synchronized with the motor frequency using the flying restart function.

When the inverter is normally powered-up it is assumed that the motor is stationary and the inverter accelerates the motor from a standstill and the speed is ramped-up to the setpoint which has been entered. However, in many cases this condition is not fulfilled. A fan motor is a typical example. When the inverter is powered-down the air flowing through the fan can cause it to rotate in any direction.

Table 8-22 Settings for parameter P1200

| P1200 | Flying restart active | Search direction |
|---|---|---|
| 0 | Disabled | - |
| 1 | Always | Start in the direction of the setpoint |
| 2 | For line supply on and fault | Start in the direction of the setpoint |
| 3 | For fault and OFF2 | Start in the direction of the setpoint |
| 4 | Always | Only in the direction of the setpoint |
| 5 | For line supply on, fault and OFF2 | Only in the direction of the setpoint |
| 6 | For fault and OFF2 | Only in the direction of the setpoint |

## Flying restart without speed encoder

Depending on parameter P1200, after the demagnetization time has expired P0347, flying restart is started with the maximum search frequency $f_{search,max}$ (see figure below).

$$f_{search,max} = f_{max} + 2 \cdot f_{slip,standard} = P1802 + 2 \cdot \frac{r0330}{100} \cdot P0310$$

This is realized either after the line supply returns when the automatic restart function has been activated or after the last shutdown with the OFF2 command (pulse inhibit).

- V/f characteristic (P1300 < 20):
  The search frequency is reduced, as a function of the DC link current with the search rate which is calculated from parameter P1203. In so doing, the parameterizable search current P1202 is impressed. If the search frequency is close to the rotor frequency, the DC link current suddenly changes because the flux in the motor establishes itself. Once this state has been reached, the search frequency is kept constant and the output voltage is changed to the voltage value of the V/f characteristic with the magnetization time P0346 (see figure below).
- Closed-loop Vector control without encoder (SLVC):
  Starting from the initial value, the search frequency approaches the motor frequency with the impressed current P1202. The motor frequency has been found if both frequencies coincide. The search frequency is then kept constant and the flux setpoint is changed to the rated flux with the magnetization time constant (dependent on P0346).

After the magnetization time P0346 has expired, the ramp-function generator is set to the speed actual value and the motor is operated with the actual reference frequency.

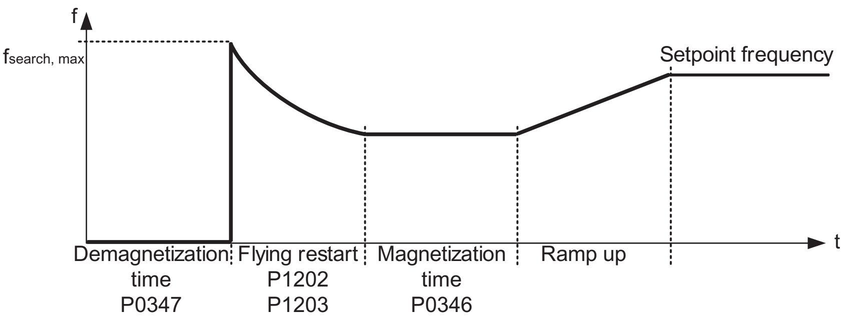



Figure 8-54 Flying restart

### Flying restart with speed encoder

Depending on parameter P1200, after the demagnetization time P0347 expires

1. After the line supply returns with the automatic restart active, or
2. After the last shutdown using the OFF2 command (pulse inhibit)
   flying restart is started with the maximum search frequency $f_{search,max.}$

- V/f characteristic (P1300 < 20):
  For V/f control, the output voltage of the inverter is linearly increased from 0 to the V/f characteristic value within the magnetization time P0346.
- Closed-loop Vector control with speed encoder (VC):
  For the closed-loop Vector control, the necessary magnetization current is established within the magnetization time P0346.

After the magnetization time P0346 has expired, the ramp-function generator is set to the speed actual value and the motor is operated at the actual setpoint frequency.

**Warning**

When "Flying restart" is activated (P1200 > 0), although the motor is at a standstill and the setpoint is 0, it is possible that the motor can be accelerated as a result of the search current!

If the operating range of the motor is entered when the motor is in this state, this can result in death, severe injury or material damage.

**Note**

If a higher value is entered for the search velocity P1203 this results in a flatter search curve and therefore to an extended search time. A lower value has the opposite effect.

For "Flying restart", a braking torque is generated which can cause motors, with low moments of inertia, to brake.

For group motors, "Flying restart" should not be activated due to the different characteristics of the individual motors when coasting down.

# 8.17 Fail-safe functions

## 8.17.1 Overview of the fail-safe functions

### Overview

Warning

Installation of Control Units

All installation areas for Fail-safe Control Units as well as outside installed components specific fail-safe system, if correctly installed, must comply with the minimum protection class of IP54 [see EN 60529 (IEC 60529)].

Change of Fail-Safe Control Units

When carrying out a swap of Control Units, it is not allowed to replace a Fail-safe Control Unit with a standard Control Unit. Replacing a Fail-safe Control Unit with a standard Control Unit disables all fail-safe functions that have been implemented and therefore can lead to personal injury and damage to the machine. A replacement of fail-safe components with standard components has to be considered as a completely new application and re-commissioned as such.

Dimensioning of the Motor

If driving loads occur in the application, the motor must be dimensioned so that its slip in super-synchronous operation always remains within the rated slip.

Dimensioning of the Motor holding brake

The holding brake must be dimensioned that in case of a fault the complete drive can be braked to zero from any possible operational speed. If no holding brake is present, the machine manufacturer must adopt other suitable measures to protect against motion after the energy supply to the motor has been cut (e.g. to protect against sagging loads).

Protection level for fail-safe systems

All installation spaces for safety related control units as well as outside installed components of the according safety system must match a minimum protection level of IP54 [see EN 60529 (IEC 60529)].

Regenerative load with SLS

In the safety state "safely limited speed" (SLS) operation with permanent regenerative loads is not permitted.

Note

In order to verify the parameters for the fail-safe functions, an acceptance test must always be carried-out after commissioning, reset and also when changing a completely backed-up data set of the parameters for the fail-safe functions. This acceptance test must be appropriately logged and documented. For more details refer to Section "Acceptance Test and Acceptance Log" In Chapter "Commissioning".

The Fail-safe Control Unit (CU) has specific fail-safe functions integrated into its system. These are:

- Safe Torque Off (STO)
- Safe Stop 1 (SS1)
- Safely-Limited Speed (SLS)
- Safe Brake Control (SBC)

These functions are controlled using either the fail-safe digital inputs on the front of the CU, PROFIsafe via PROFIBUS-DP interface located at the bottom of the CU. See figure below.

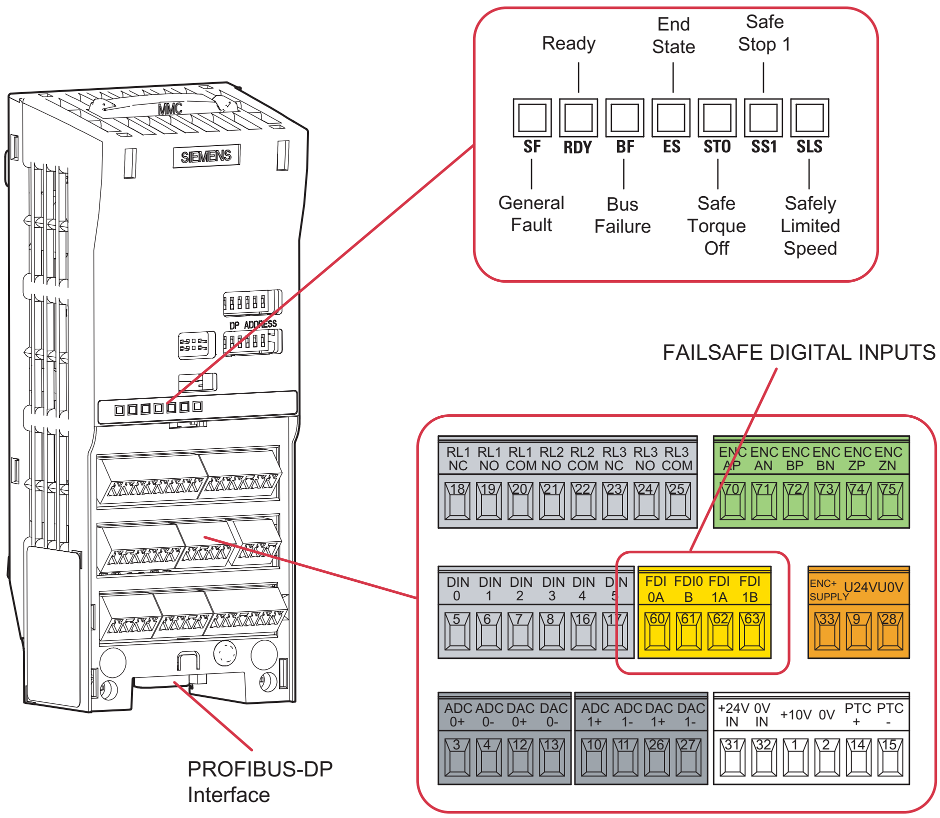



Figure 8-55 Fail-safe Control Unit (CU)

Fail-safe functions are only available on the Fail-safe Control Units. On the standard CUs, the fail-safe features are not available.

The parameters for the fail-safe functions are held on two separate processors within the control unit. Each processor holds a unique copy of the parameterized fail-safe function. These unique copies of the parameterized fail-safe function are accomplished by double-parameters. Double-parameters have their own unique number, but have identical functionality. Each processor controls two separate and isolated shutdown control mechanisms which are continually monitored by the system to ensure they are operating correctly. Should a discrepancy occur, then the Latched Safe Torque Off is activated.

## 8.17.2 Monitoring the fail-safe functions

### Overview

There are three types of monitoring functionalities:

- Time controlled request for forced dynamisation
- Forced dynamisation
- Process dynamisation

The dynamisation process is designed to detect software and hardware faults of the two shutdown paths. The forced dynamisation consists of a processor self-test of both processors within the Control Unit and a hardware test. The hardware test include a test to ensure, that if fitted, the Safe Brake Control is functioning correctly.

---

Note

In fail-safe applications it is necesarry that the forced dynamisation process takes place during regular intervals.

---

### Time controlled request for forced dynamisation

When the time, set in P9659 (hours or fractions of hours), has expired, a warning A1699 is issued by the system. This warning can only be cleared by performing a forced dynamisation. If the forced dynamisation is successful, the timer will be reset to the value in P9659 and the inverter will be ready to run. If the forced dynamisation fails, the timer will remain at 0 and the inverter will be disabled from running.

The time remaining until the next forced dynamisation becomes necesarry is displayed in r9660.

With each forced dynamisation r9660 is reset to the value of P9659.

### Forced dynamisation

The forced dynamisation process delays the switch-on process after a Safe Torque Off (STO), but it ensures that all the fail-safe features of the inverter are functioning correctly. However, should this delay after a STO be unacceptable for the user application, it can be disabled by setting parameters P9601 = P9801 = 0.

The forced dynamisation process is automatically initiated by the following events:

- On power-up of the inverter.
- When the Latched Safe Torque Off (LSTO) function is deactivated.
- When the Safe Torque Off (STO) or Safe Stop 1 (SS1) is left (if P9601 = P9801 = 2).
- When commissioning of fail-safe functions is left.

## Process dynamisation

The process dynamisation is initiated when the STO or SS1 function has been initiated or ended.
The testing includes both shutdown paths, but does not perform a processor self-test or a test of the Safe Brake Control.

Warning

**Dynamisation of the shutdown paths**

For safety reasons, it is necessary to initiate a safe torque off as a test at intervals of maximal 8760 hours (one year) in order to check its operability. Thus, 8760 hours after the last activation of the safe torque off the converter sets a status bit that specifies this requirement.

The process control must then initiate the safe torque off at the next opportunity, for example, when the drive has in any case a short phase with zero speed. If the converter returns the "safe torque off initiated" status signal, the torque off can be released again. The setting and clearing of the status bit and the dynamisation must be logged as process data by the higher-level control.

## 8.17.3 Limiting values for SS1 and SLS

### Description

When parameterising the limiting envelope for SLS and SS1 with P9680/P9880 and P9691/P9891 the following minimum tolerances should be considered to provide maximum performance of the drive:

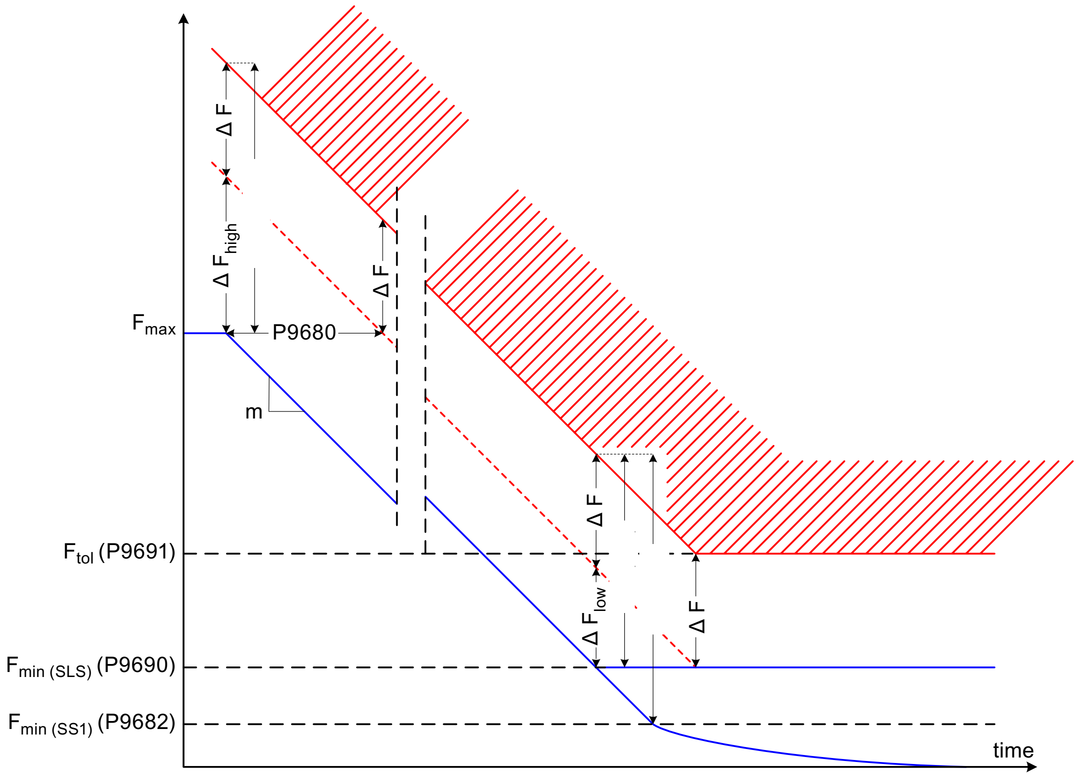



Figure 8-56 Safety limits for SLS and SS1

1. The minimum monitoring speed tolerance p9691 should be set to
   P9691 ≥ 1.15 • P9690
   thus defining the minimum frequency tolerance as
   ΔF = P9691 - P9690.
   This prevents sporadic trips caused by measurement inaccuracies. Note that according to the above formula, P9691 must be set, even if SLS is not parameterised.
2. The resulting frequency tolerance ΔFhigh due to the minimum frequency tolerance at high frequencies is then given as
   ΔFhigh ≥ 0.15 •Fmax - ΔF
   where Fmax defines the maximum process frequency at initiation of SLS or SS1.

3. The resulting frequency tolerance Δ Flow due to the minimum frequency tolerance at low frequencies is then given as
   $\Delta F_{low} \geq \frac{m}{D} - \Delta F$
   where the gradient m is defined as
   $m = \frac{200}{P9681}$
   The denominator D in the above formula is calculated as follows:
   SLS parameterised: D = 2 · P9690
   SS1 parameterised: D = 2 · P9682
   SLS and SS1 parameterised: D = 2 · min [P9682, P9690]
4. The valid delay ΔFdelay is then given as maximum of
   ΔFdelay = max [ΔFlow, ΔFhigh]
5. Finally the minimum braking ramp delay can be calculated as
   $P9680 \geq \frac{\Delta F_{delay}}{m}$

The safe frequency envelope results from a time delay (p9680) in t-direction and an additional frequency tolerance ΔF in F-direction.

## Fault reaction time

**Caution**

During an SS1 and an SLS the internal failure detection time is related to the actual frequency of the converter. A failure is always detected when the actual speed exceeds the safe frequency envelope. The first frequency measurement value which lies outside the safe area triggers an LSTO. The maximum reaction time for an LSTO during SS1 and SLS is 8 ms, whereas the converter can reach a maximum speed of 650 Hz before shutting down. However, this speed can only be reached for one half frequency cycle.

E.g. the maximum reaction time at 650 Hz is:

$$8.7\ \text{ms} = 8\ \text{ms} + 0{,}5 \cdot \frac{1}{650\ \text{Hz}},$$

at 10 Hz is:

$$58\ \text{ms} = 8\ \text{ms} + 0{,}5 \cdot \frac{1}{10\ \text{Hz}}$$

The formula for calculating the fault reaction time is given below:

$$\text{Reaction time} = 8\ \text{ms} + 0{,}5 \cdot \frac{1}{F_{act}}$$

## 8.17.4 Safe Torque Off

### Description

| | |
|---|---|
| Parameter range: | P0003, P0010 |
| | P09761 |
| | P9603/P9803, Bit 04, Bit 05 or Bit 07 (PROFIsafe) |
| | P9690/P9890 |
| | P9691/P9891 |
| | P9692/P9892 |
| | P9799/P9899/P3900 |
| Warnings | A1691, A1692, A1696, A1699 |
| Faults | F1600, F1616 |

Safe Torque Off (STO) is the simplest fail-safe function and its purpose is to shutdown the motor safely. Once the motor is at a standstill, STO then enables a switch-on lock which prevents the inverter from starting the motor, unless the STO signal is removed. Shutting down of the triggering pulses from the Power Module effectively stops the motor and should a mechanical brake be connected, it will be closed immediately.

**Caution**

**Fault reaction time**

An internal failure during an STO will be detected within 20 ms and lead immediately to an LSTO.

**When the STO function is initiated the inverter performs the following actions:**

1. The triggering pulses from the Power Module are disabled.
2. The mechanical brake (if connected) is closed immediately.
3. The status LED STO starts flashing.
4. The status LED ES is switched on, indicating the end-of-state has been reached.

**When the STO signal is removed the inverter performs the following actions:**

1. The process dynamisation is carried out (always).
2. The forced dynamisation procedure is carried out (if parameterised by p9601 and p9801).
3. The forced dynamisation timer (p9660) is reset to the value in p9659 (if the forced dynamisation procedure was carried out successfully).
4. The mechanical brake is opened (if connected).
5. The status LED STO is switched on and ES is switched off.
6. The pulse-lock must be released by applying a rising edge signal (OFF1/ON).

These actions are shown in the figure below.

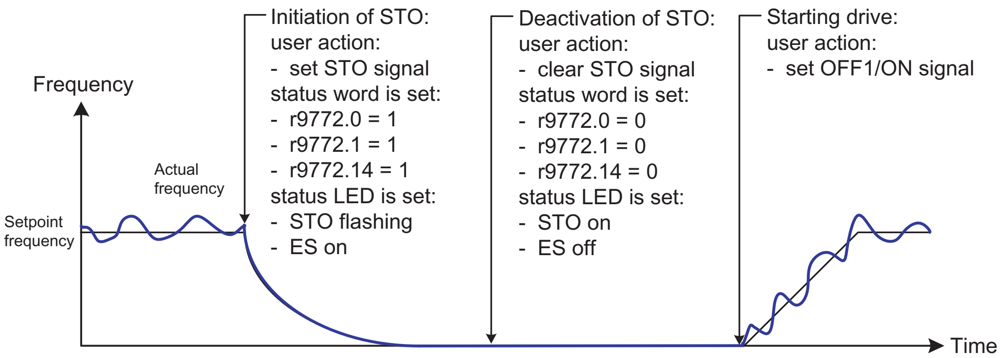



Figure 8-57 Safe Torque Off function

The STO function has the highest priority and cannot be intercepted by any other function.

---

**Note**

The inveter safety state is announced by r9772.

---

## Latched Safe Torque Off (LSTO)

The latched safe torque off (LSTO) is always initiated when a detected fault requires, that the drive must be brought to a standstill. The drive can be returned to operation only when the fault has been explicitly acknowledged and a forced dynamisation procedure has been carried out.

The latched safe torque off state is left by the following procedure:

1. Turning the drive off by sending an OFF1-signal.
2. Acknowledging all active faults.
3. Sending an ON-signal after the dynamisation procedure was carried out successfully.

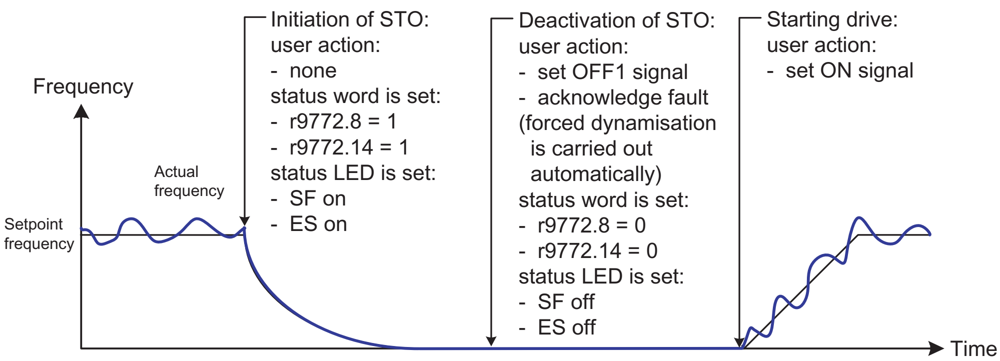



Figure 8-58 Latched safe torque off function

**Caution**

After an STO or LSTO it is possible (but almost unlikely) that the field generating components become faulty in a way that they will generate one single rising edge of a rotating field causing the motor to jerk for a defined maximum electrical angle of 60 °.

The resulting rotating angle at the motor shaft is smaller than the maximum electrical angle due to inertia and the number of pole pairs.

**Note**

A latched safe torque off is always initiated by a fault condition within the drive. Therefore, the drive must perform always a forced dynamisation procedure before it is allowed to restart.

## 8.17.5 Safe Stop 1

### Description

| | |
|---|---|
| Parameter range: | P0003, P0010 |
| | P09761 |
| | P9603/P9803, Bit 02, Bit 03 or Bit 07 (PROFIsafe) |
| | P9680/P9880 |
| | P9681/P9881 |
| | P9682/P9882 |
| | P9799/P9899/P3900 |
| Warnings | A1691, A1692, A1696, A1699 |
| Faults | F1600, F1616 |

In contrast to STO, the actual speed of the motor has an influence on the behavior of the SS1 (Safe Stop 1) function. When SS1 is initiated the speed of the motor is detected, if the speed of the motor is lower than the speed threshold for standstill set in P9682 and P9882, the STO function is initiated immediately to bring the motor to a standstill. If the motor speed is higher than the speed threshold for standstill, then the motor is slowed down using the braking-ramp time set in P9681 and P9881. See figure below.

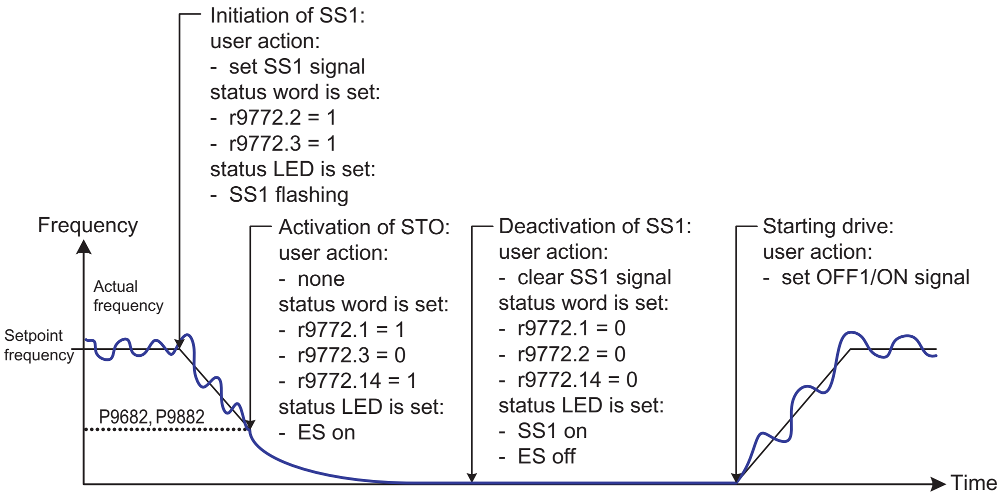



Figure 8-59 Safe Stop 1 (SS1) function

When SS1 is activated, the following actions are performed by the inverter:

1. Both shutdown paths initiate a controlled safe ramp function, including detecting the speed of the motor.
2. The motor is slowed down by the safe ramp function.
3. The status LED SS1 starts flashing.
4. When the "minimum speed for standstill detection" is reached, the STO function is activated.
5. The mechanical brake (if fitted) is closed.

6. The status LED ES is switched on.

The SS1 function can be interrupted by either an OFF2 command or the STO function.

When SS1 is deactivated before the "minimum speed for standstill detection" (P9682/P9882) is reached, the following actions are performed by the inverter:

1. The monitoring of the actual speed is deactivated.
2. The mechanical brake (if fitted) is opened.
3. The drive accelerates to the set speed
4. The status LED SS1 changes from flashing to on state.

When SS1 is deactivated after the "minimum speed for standstill detection" (P9682/P9882) is reached, the following actions are performed by the inverter:

1. STO is deactivated.
2. The forced dynamisation procedure is carried out (if parameterised by p9601 and p9801).
3. The forced dynamisation timer (p9660) is reset to the value in p9659 (if the forced dynamisation procedure was carried out successfully).
4. The mechanical brake (if fitted) is opened.
5. The status LED SS1 changes from flashing to on state.
6. The status LED ES is switched off.

---

**Note**

The inveter safety state is announced by r9772.

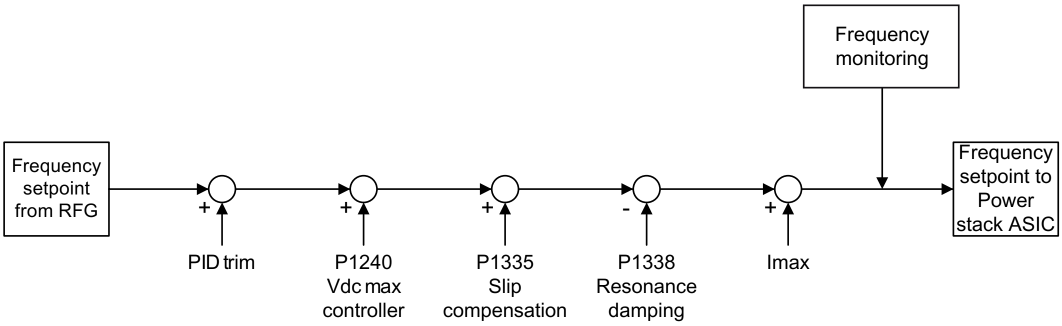
---

**Caution**

The frequency setpoint can increase related to the following functions

- PID Trim
- Vdc max controller
- Slip compensation
- Resonance damping
- Imax

As the frequency is monitored after adding these values, this increasement should be taken into account by the user when parameterising the safe frequency envelope.



## 8.17.6 Safely-Limited Speed

### Description

| | |
|---|---|
| Parameter range: | P0003, P0010 |
| | P09761 |
| | P9603/P9803, Bit 00, Bit 01 or Bit 07 (PROFIsafe) |
| | P9799/P9899/P3900 |
| | P9690/P9890 |
| | P9691/P9891 |
| | P9692/P9892 |
| Warnings | A1691, A1692, A1696, A1699 |
| Faults | F1600, F1616 |

The purpose of the Safely-Limited Speed (SLS) function is to monitor the speed of the motor to ensure that it does not exceed the tolerance for reduced speed set by parameters P9691 and P9891.

Should the tolerance for reduced speed be exceeded SLS will initiate a braking process which is monitored using the safe ramp function. If a stationary state is detected, the Safe Torque Off (STO) will be initiated to bring the motor to a safe standstill. If the braking functions fails, which is detected as a fault, then the Latched Safe Torque Off (LSTO) function is initiated and cannot be cleared without explicitly acknowledgment of the fault.

The SLS function can be intercepted by the following commands:

- Safe Torque Off (STO)
- OFF1 (only SLS Mode 2)
- OFF2
- OFF3 (only SLS Mode 2)

However, the reaction of the system to the standard OFF commands may produce unpredictable results. If the standard OFF commands are to be used with the fail-safe functions, the interaction of the commands on the system are automatically monitored in the background by the fail-safe system (i.e. the commands, which are not fail-safe, cannot cause the inverter to accelerate in an unsafe way as the LSTO function will be triggered automatically).

### Modes of behaviour

The SLS function has three modes of behaviour giving the user a choice of functionality to suit their specific application. These modes of behaviour of the SLS function are controlled by setting the required values in parameters P9692 and P9892.

---

**Caution**

Due to monitoring reasons, the so called "accuracy limit for SLS" with a value of 1 Hz is set. If - in SLS mode - the actual frequency under-runs this value, an STO is triggered.

---

## SLS Mode 0

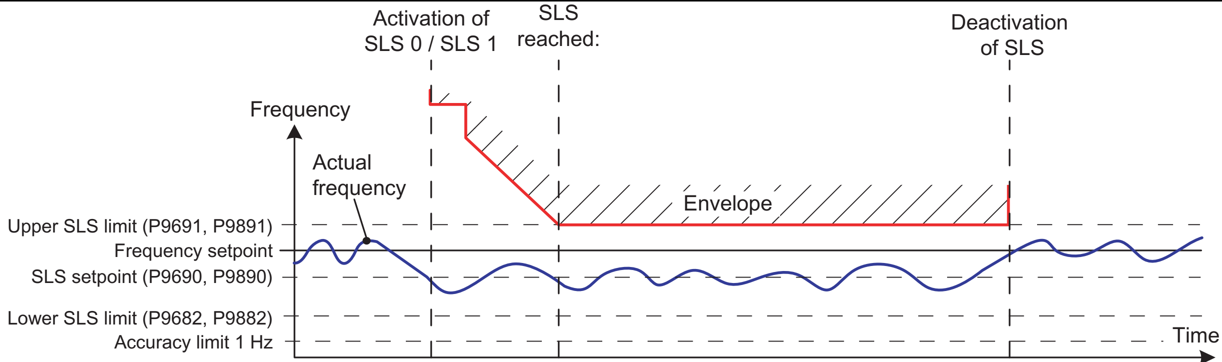
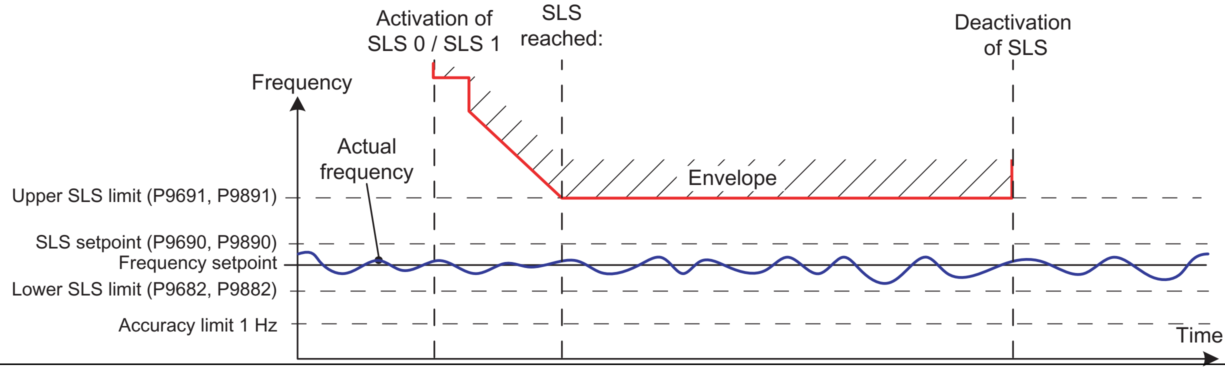
P9692 = P9892 = 0

If, after initiation of SLS, the motor exceeds the set tolerance for safely-limited speed of P9691 and P9891, then the latched STO (LSTO) function is initiated to bring the motor to a standstill.

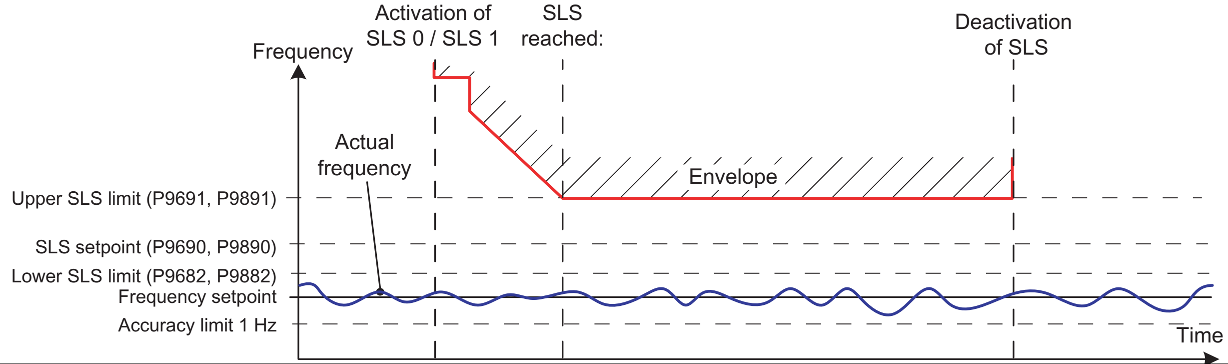
If the motor speed is below the tolerance for safely-limited speed, all control signals that can affect the speed of the motor are blocked. No external control of the motor speed is possible.

Once the motor is locked at its present speed, if the motor again falls below this speed (for example additional load on the motor), it is not interpreted as a fault condition and no action is taken. See the following table.

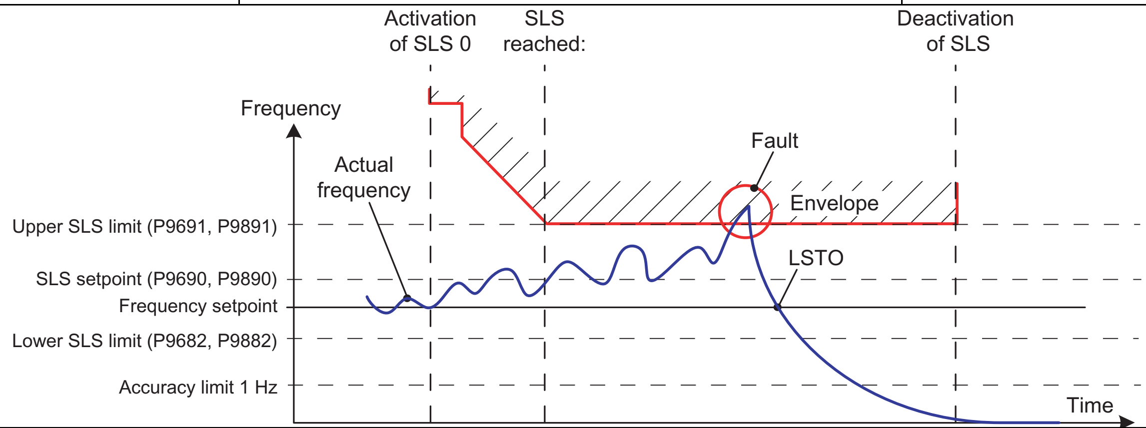
Table 8-23 Fault reactiones according the selected SLS mode 0

| **Conditiones** | **SLS mode 0** | | |
|---|---|---|---|
| | **Activated:**<br>- ramp monitoring on<br>- SLS-LED flashing<br>- r9772.4 = 1 | **Reached**<br>- SLS monitoring on<br>- ES-LED on<br>- r9772.5 = 1 | **deactivated**<br>- ramp monitoring off<br>- SLS monitorinf off<br>- SLS and ES LED off<br>- r9772.4 = r9772.4 = 0 |
| Freq. setpoint<br>• inside SLS tolerance<br>• > SLS setpoint | • deactivate Freq. setpoint<br>• ↓ (SS1) to SLS setpoint | • Freq. setpoint inactive | • activate freq. setpoint and ramp to freq. setpoint |
|  | | | |
| Freq. setpoint<br>• inside SLS tolerance<br>• < SLS setpoint | • deactivate Freq. setpoint | • Freq. setpoint inactive | • activate freq. setpoint and ramp to freq. setpoint |
|  | | | |

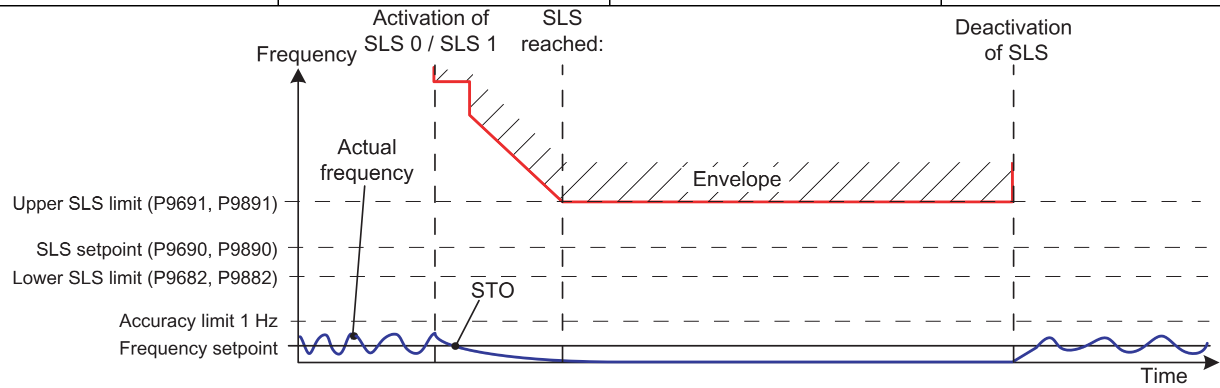
| Conditiones | SLS mode 0 | | |
|---|---|---|---|
| | **Activated:**<br>- ramp monitoring on<br>- SLS-LED flashing<br>- r9772.4 = 1 | **Reached**<br>- SLS monitoring on<br>- ES-LED on<br>- r9772.5 = 1 | **deactivated**<br>- ramp monitoring off<br>- SLS monitorinf off<br>- SLS and ES LED off<br>- r9772.4 = r9772.4 = 0 |
| Freq. setpoint<br>• < SLS tolerance<br>• > 1Hz (accuracy limit) | • deactivate Freq. setpoint | • Freq. setpoint inactive | • activate freq. setpoint and ramp to freq. setpoint |



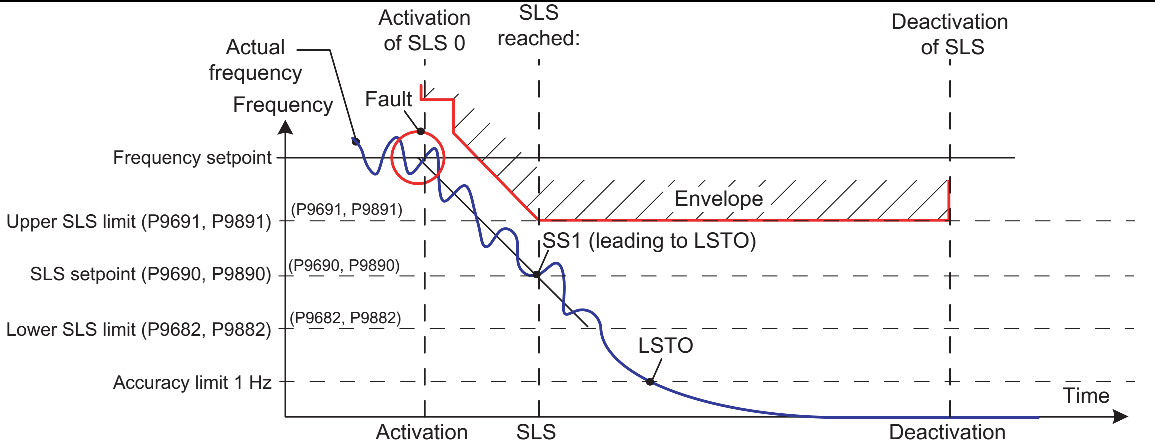

| | | |
|---|---|---|
| For all above cases | • If speed increases SLS tolerance (e.g. due to trim or slip compensation), LSTO becomes active | • ramp to freq. setpoint after LSTO ackowledge + ON command |

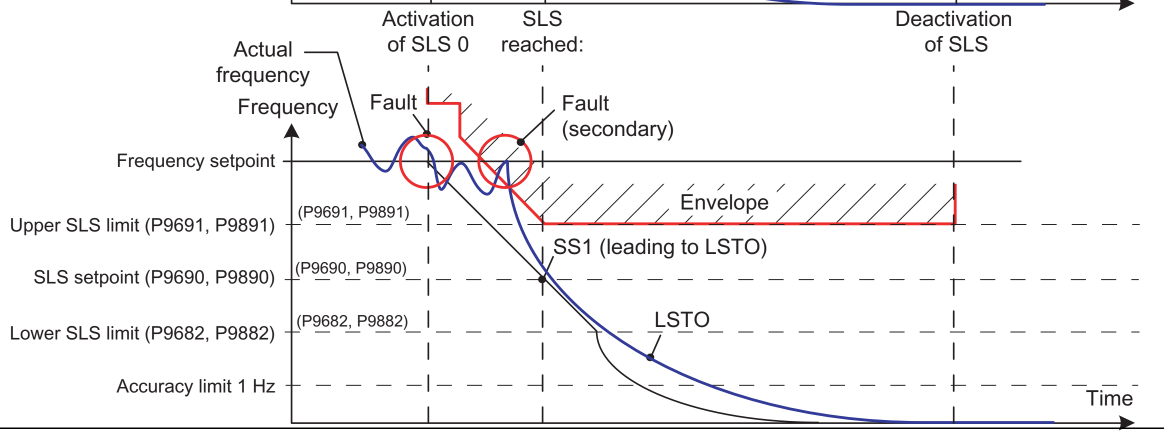



| | | | |
|---|---|---|---|
| Freq. setpoint<br>• < 1 Hz (accuracy limit) | • deactivate Freq. setpoint<br>• activate STO | • STO active | • activate freq. setpoint<br>• ramp to freq. setpoint after ON command |



| Conditiones | SLS mode 0 | | |
|---|---|---|---|
| | **Activated:**<br>- ramp monitoring on<br>- SLS-LED flashing<br>- r9772.4 = 1 | **Reached**<br>- SLS monitoring on<br>- ES-LED on<br>- r9772.5 = 1 | **deactivated**<br>- ramp monitoring off<br>- SLS monitorinf off<br>- SLS and ES LED off<br>- r9772.4 = r9772.4 = 0 |
| Freq. setpoint<br>• > SLS tolerance | • deactivate Freq. setpoint<br>• ↓ (SS1) to minimum speed for standstill,<br>• LSTO activated, when<br>– mimimum speed for standstill is reached<br>– speed increases SLS tolerance | | • activate freq. setpoint<br>• ramp to freq. setpoint after LSTO ackowledge + ON command |




## SLS Mode 1

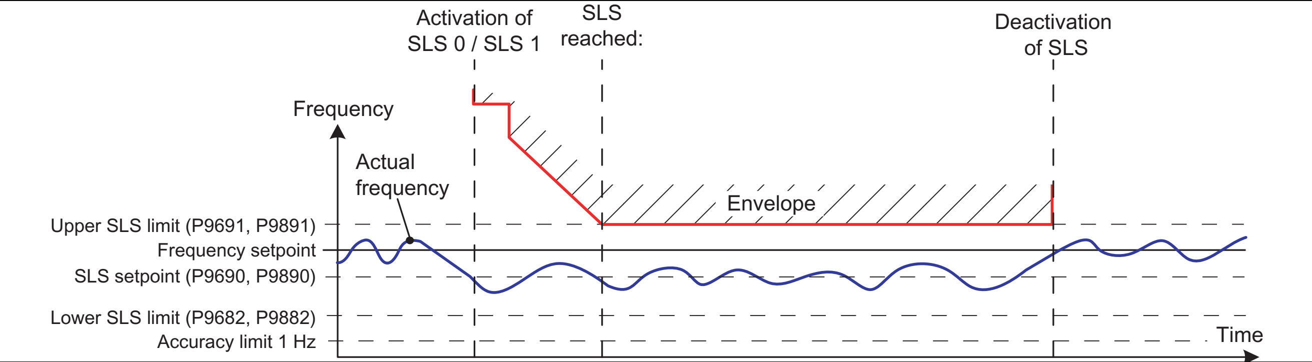
P9692 = P9892 = 1

In addition to the speed limits set in parameters P9691 and P9891, a further speed limit can be set in parameters P9690 and P9890. This additional speed limit is used to set the speed of the motor to a specific frequency, instead of bringing the motor to a standstill.

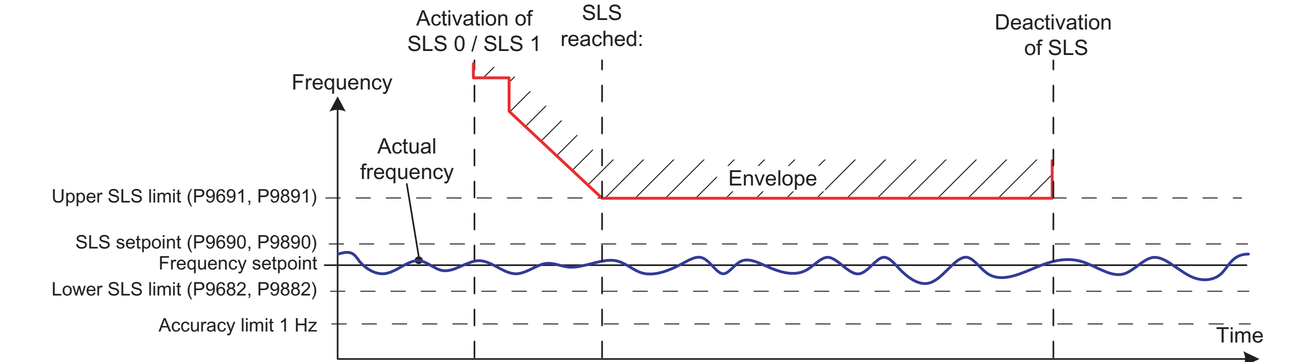
If the actual speed of the motor falls below the thresholds set in P9690 and P9890, the motor is allowed to run at that speed. See the following table.

Table 8-24 Fault reactiones according the selected SLS mode 1

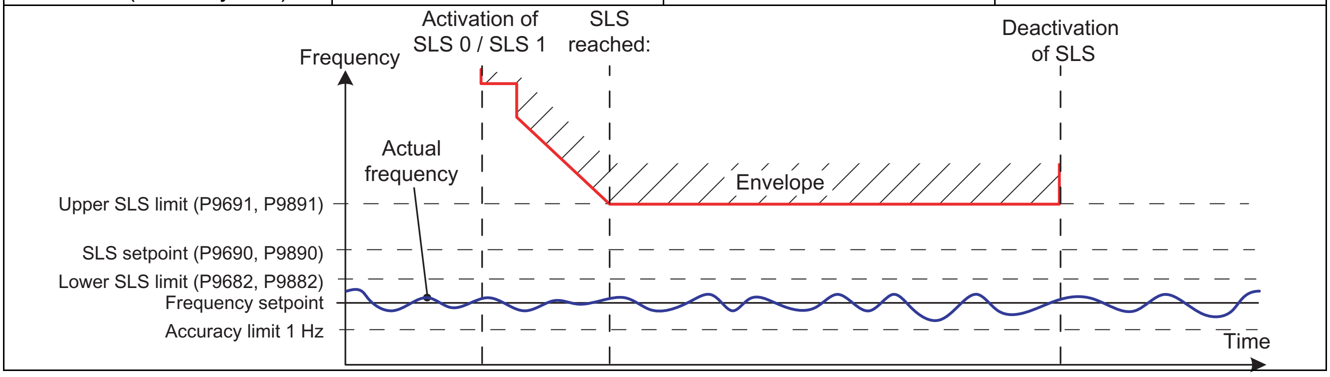
| Conditiones | SLS mode 1 | | |
|---|---|---|---|
| | **Activated:**<br>- ramp monitoring on<br>- SLS-LED flashing<br>- r9772.4 = 1 | **Reached**<br>- SLS monitoring on<br>- ES-LED on<br>- r9772.5 = 1 | **Deactivated**<br>- ramp monitoring off<br>- SLS monitorinf off<br>- SLS and ES LED off<br>- r9772.4 = r9772.4 = 0 |
| Freq. setpoint<br>• inside SLS tolerance<br>• > SLS setpoint | • deactivate Freq. setpoint<br>• ↓ (SS1) to SLS setpoint | • Freq. setpoint inactive | • activate freq. setpoint and ramp to freq. setpoint |



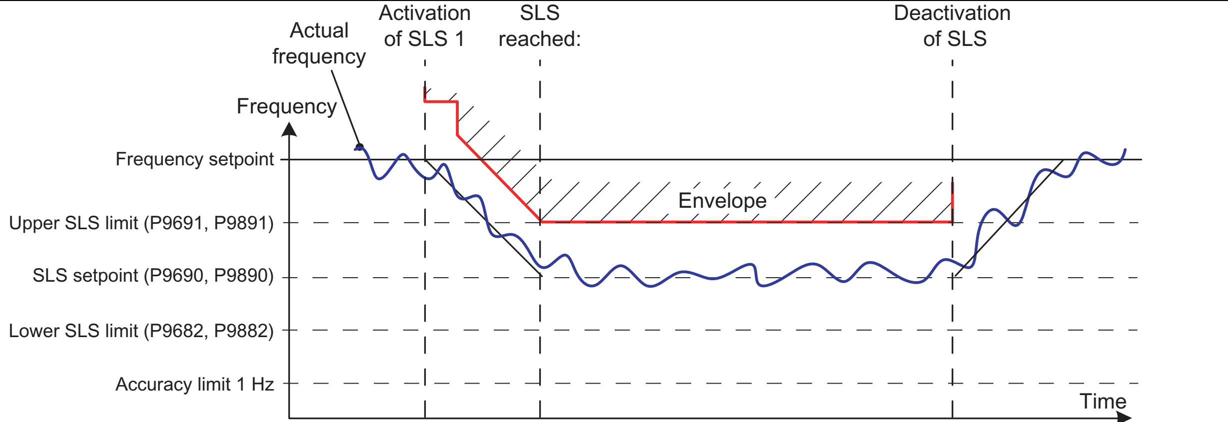

| Conditiones | Activated | Reached | Deactivated |
|---|---|---|---|
| Freq. setpoint<br>• inside SLS tolerance<br>• < SLS setpoint | • deactivate Freq. setpoint | • Freq. setpoint inactive | • activate freq. setpoint and ramp to freq. setpoint |



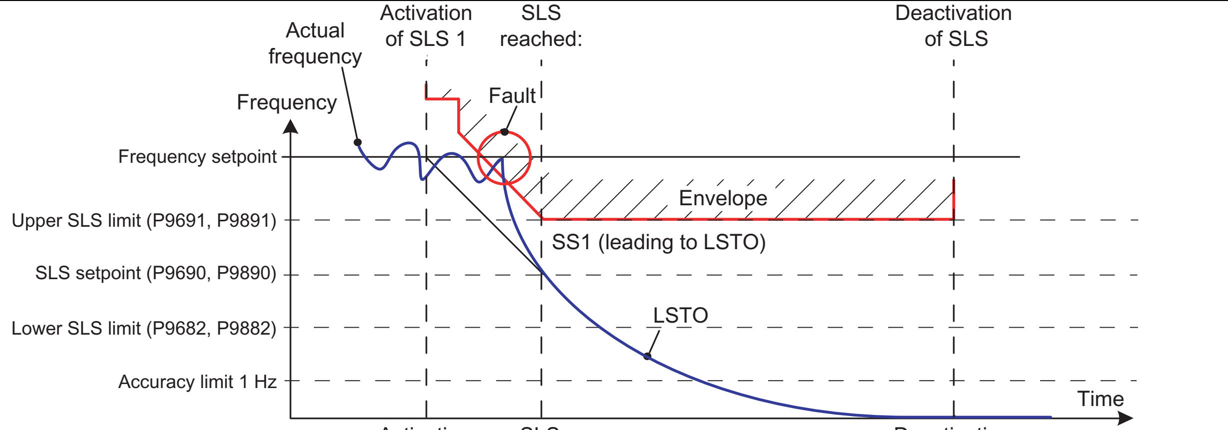

| Conditiones | Activated | Reached | Deactivated |
|---|---|---|---|
| Freq. setpoint<br>• < SLS tolerance<br>• > 1 Hz (accuracy limit) | • deactivate Freq. setpoint | • Freq. setpoint inactive | • activate freq. setpoint and ramp to freq. setpoint |

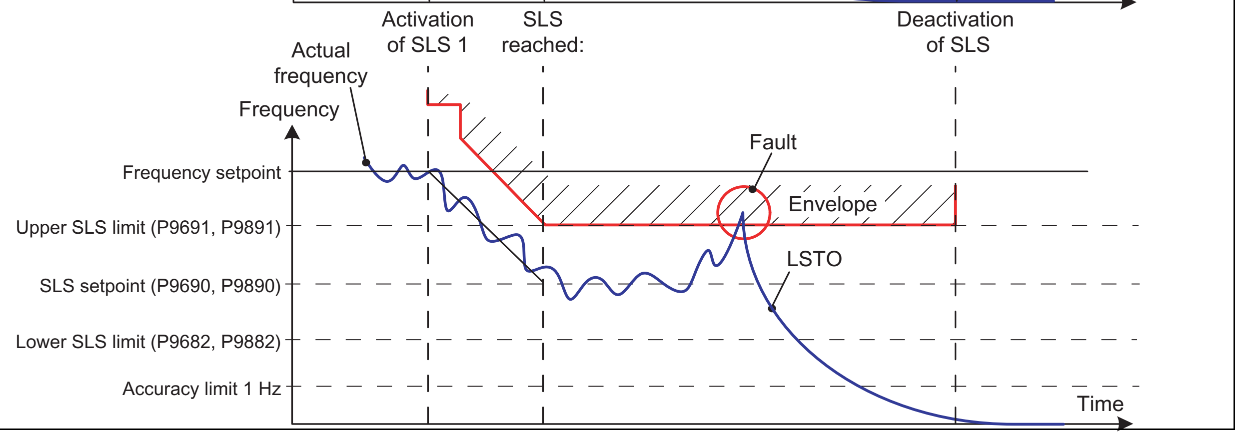


| Conditiones | SLS mode 1 | | |
|---|---|---|---|
| | **Activated:**<br>- ramp monitoring on<br>- SLS-LED flashing<br>- r9772.4 = 1 | **Reached**<br>- SLS monitoring on<br>- ES-LED on<br>- r9772.5 = 1 | **Deactivated**<br>- ramp monitoring off<br>- SLS monitorinf off<br>- SLS and ES LED off<br>- r9772.4 = r9772.4 = 0 |
| Freq. setpoint<br>• > SLS tolerance | • deactivate Freq. setpoint<br>• ↓ (SS1) to SLS setpoint | • Freq. setpoint inactive | • activate freq. setpoint and ramp to freq. setpoint |

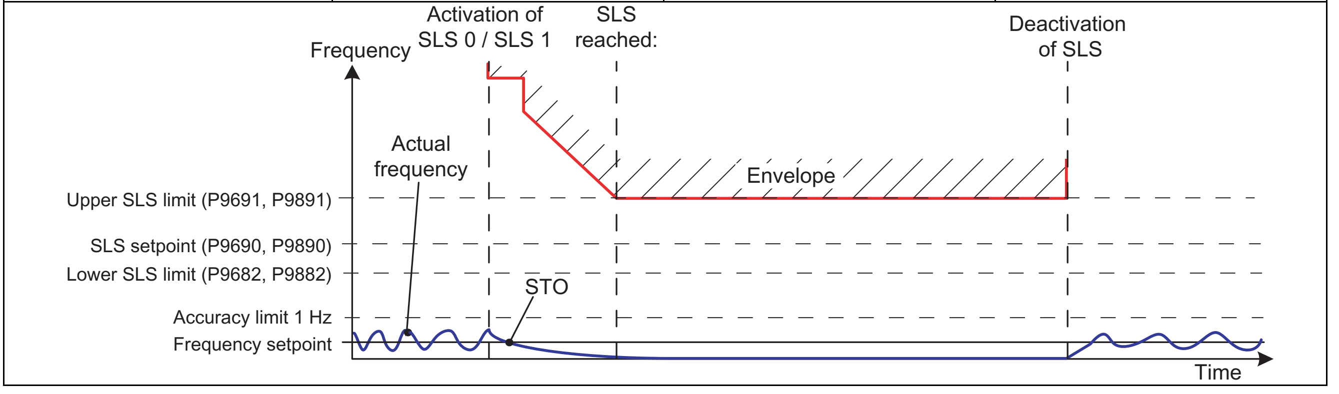



| | | |
|---|---|---|
| For all above cases | • LSTO activated, when<br>– speed increases SLS tolerance (e.g. due to trim or slip compensation)<br>– speed increases monitoring ramp | • ramp to freq. setpoint after LSTO ackowledge + ON command |



| Conditiones | SLS mode 1 | | |
|---|---|---|---|
| | **Activated:**<br>- ramp monitoring on<br>- SLS-LED flashing<br>- r9772.4 = 1 | **Reached**<br>- SLS monitoring on<br>- ES-LED on<br>- r9772.5 = 1 | **Deactivated**<br>- ramp monitoring off<br>- SLS monitorinf off<br>- SLS and ES LED off<br>- r9772.4 = r9772.4 = 0 |
| Freq. setpoint<br>• < 1Hz (accuracy limit) | • deactivate Freq. setpoint<br>• activate STO | STO active | • activate freq. setpoint<br>• ramp to freq. setpoint after ON command |




## SLS Mode 2

P9692 = P9892 = 2

**Warning**

**Safe ramping not actived**

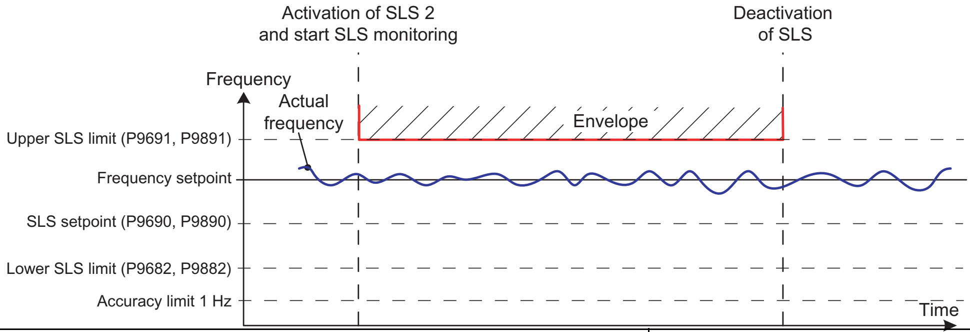
Mode 2 means that the safe ramping is not activated, therefore it is the users responsibility to ensure that the motor is ramped down to or below the SLS set point.

In Mode 2, only the monitoring ramp is activated, the safe ramp will is not active.

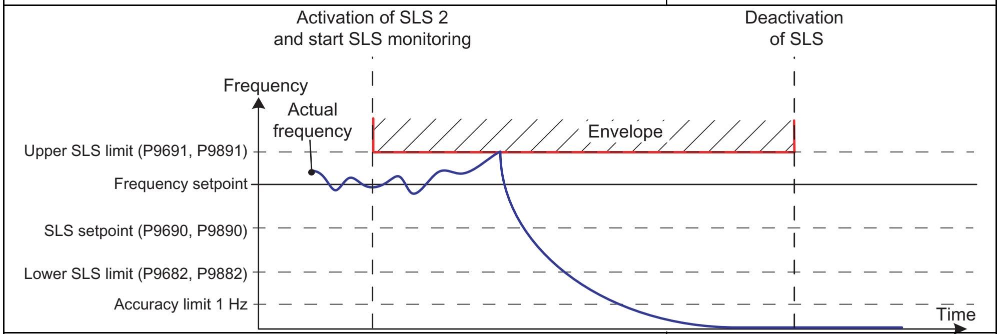
If the motor speed exceeds the thresholds set in P9691 and P9891, the motor must be ramped down using an external control channel (for example, a PLC, potentiometer or USS etc.). If the control channel tries to set the speed of the motor to exceed the SLS threshold, this will be interpreted as a fault condition and the motor will be stopped and locked. To start the motor again, the fault condition needs to be explicitly acknowledged. See the following table.

Table 8-25 Fault reactiones according the selected SLS mode 2

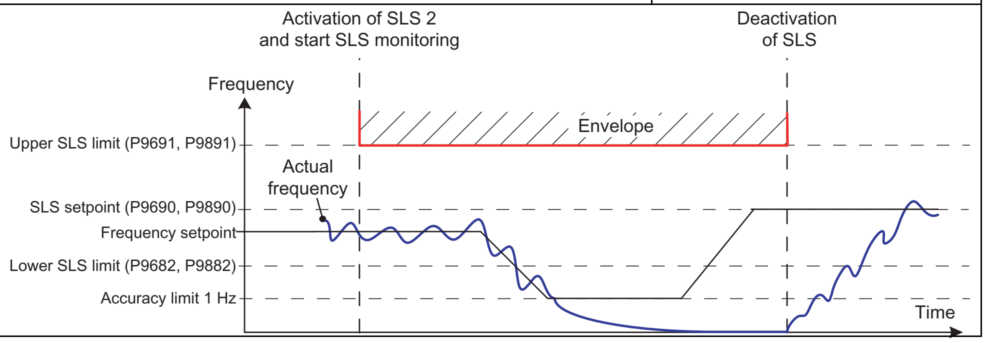
| Conditiones | SLS mode 2 | | |
|---|---|---|---|
| | **Activated:**<br>- ramp monitoring off<br>- SLS-LED flashing<br>- r9772.4 = 1 | **Reached**<br>- SLS monitoring on<br>- ES-LED on<br>- r9772.5 = 1 | **Deactivated**<br>- ramp monitoring off<br>- SLS monitorinf off<br>- SLS and ES LED off<br>- r9772.4 = r9772.4 = 0 |
| Freq. setpoint<br>• inside SLS tolerance | • Freq. setpoint active, drive runs according freq. setpoint<br>• No action, unless speed<br>– increases SLS tolerance<br>– under-runs 1 Hz (accuracy limit) | | • Run with freq. setpoint |

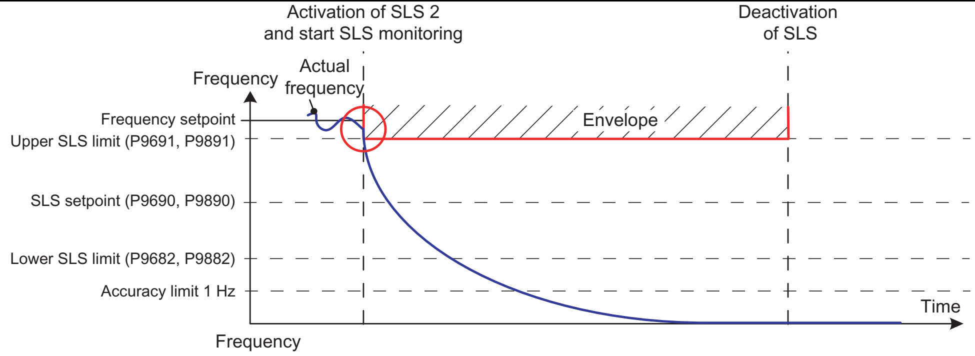



| | | |
|---|---|---|
| | • if speed increases SLS tolerance, LSTO becomes active | • activate freq. setpoint<br>• ramp to freq. setpoint after LSTO ackowledge + ON command |




| | | |
|---|---|---|
| | • if under-runs 1 Hz, STO becomes active | • ramp to freq. setpoint after ON command |



| Conditiones | SLS mode 2 | | |
|---|---|---|---|
| | **Activated:**<br>- ramp monitoring off<br>- SLS-LED flashing<br>- r9772.4 = 1 | **Reached**<br>- SLS monitoring on<br>- ES-LED on<br>- r9772.5 = 1 | **Deactivated**<br>- ramp monitoring off<br>- SLS monitorinf off<br>- SLS and ES LED off<br>- r9772.4 = r9772.4 = 0 |
| Freq. setpoint<br>• > SLS tolerance | • LSTO becomes active | | • ramp to freq. setpoint after LSTO ackowledge + ON command |
| |  | | |

---

**Note**

Following expressions are used as synonyms

- "Mimimum speed for standstill" and "lower limit for SLS"
- "SLS tolerance" and "upper limit for SLS"

Inside SLS tolerance means a value between higher and lower limit for SLS.

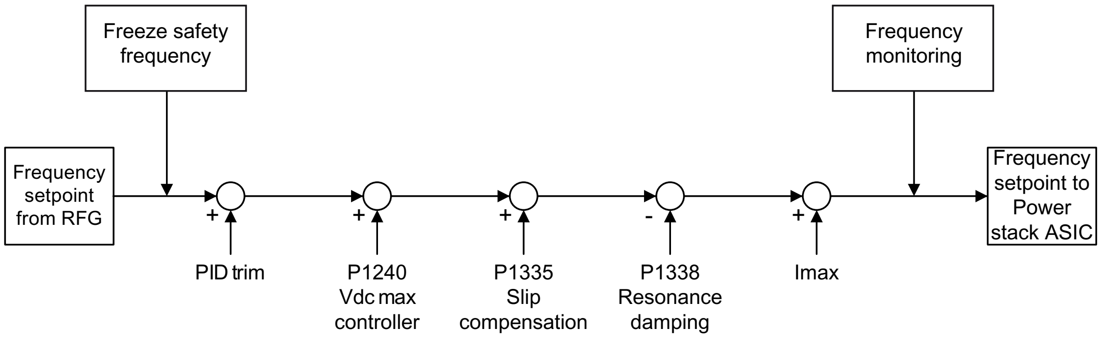
---

**Caution**

In SLS modes 0 and 1, the frequency setpoint can increase related to the following functions

- PID Trim
- Vdc max controller
- Slip compensation
- Resonance damping
- Imax

As the frequency is monitored after adding these values, this increasement should be taken into account by the user when parameterising the safe frequency envelope.




## 8.17.7 Safe Brake Control

### Description

| | |
|---|---|
| Parameter range: | P0003, P0010 |
| | P09761 |
| | P9601/P9801, P1215, P3046 |
| | P9602/P9802 |
| | P9799/P9899/P3900 |
| Warnings | A1691, A1692, A1696, A1699 |
| Faults | F1600, F1616 |

The Safe Brake Control function (SBC) is to create a fail-safe signal to control an electromechanical motor brake.

**Prerequisite**: P1215 = 1 and the optional Safe Brake Control Relay

To activate the Safe Brake Control function, the following parameters must be set: P9602 = P9802 = 1 (factory setting is 0).

In case of P9602 = P9802 = 1 a test signal regarding the signal to the Safe Brake Control is created.

This test signal does not interfere with the normal function of the mechanical brake. If the mechanical brake is fitted and the test fails, a fault condition will be indicated by the inverter.

The SBC signal will be created in the following cases:

- STO/LSTO
- SS1

The brake triggered by an SBC signal reacts as follows:

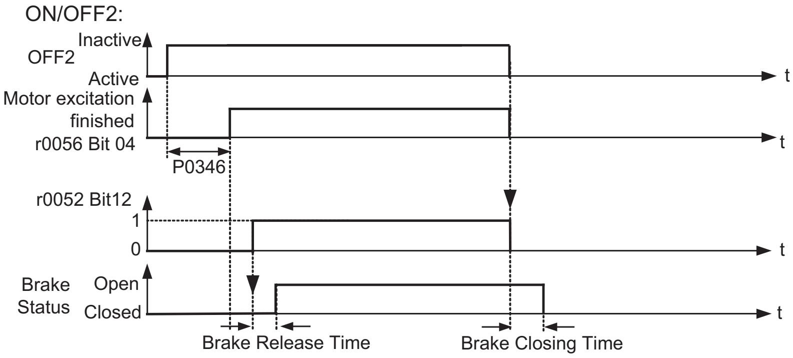



Figure 8-60 Brake reaction in case of SBC

The SBC state is indicated in P9772.14. If SBC is disabled by P9602 = P9802 = 0 then P9772.14 is set to 0 (brake open) even if the brake is closed from a non-safe brake control (e.g. MHB).

# 8.18 Closed-loop Vdc control

## Description

In addition to DC, compound and dynamic braking, for the SINAMICS G120 it is possible to prevent a DC link overvoltage condition using the closed-loop Vdc controller. With this technique, the output frequency is automatically modified during operation using the closed-loop Vdc controller so that the motor doesn't go too far into the regenerative mode.

## DC link overvoltage

- Cause:

  The motor regenerates and feeds too much energy back into the DC link.
- Remedy:

  The DC link voltage is further reduced using the Vdc_max controller by reducing the regenerative torque down to zero.

Using the Vdc controller, it is also possible to prevent the inverter from being shut down (tripped) during brief line supply dips – which cause a DC link undervoltage condition. Also in this case, the output frequency is automatically modified by the Vdc controller during operation. Contrary to an overvoltage condition, in this case the motor is operated with increased regenerative operation in order to support and buffer the DC link voltage.

## DC link undervoltage

- Cause:

  Line supply voltage failure or dip (blackout or brownout)
- Remedy:

  A regenerative torque is entered for the operational motor which compensates the existing losses and therefore stabilizes the voltage in the DC link. This technique is carried-out using the Vdc_min controller and is known as kinetic buffering.

### 8.18.1 Vdc_max controller

#### Description

| | |
|---|---|
| Parameter range: | P1240, r0056 bit 14 |
| | r1242, P1243 |
| | P1250 – P1254 |
| Warnings: | A0502, A0503, A0910, A0911 |
| Faults: | F0002 |
| Function chart number: | FP4600 |

A brief regenerative load can be handled using this function (enabled using P1240) without the inverter being shut down (tripped) with fault message F0002 ("DC link overvoltage"). In this case, the frequency is controlled (closed-loop) so that the motor doesn't go too far into regenerative operation.

If the inverter regenerates too much when braking the machine due to a fast ramp-down time P1121, then the braking ramp/ramp time is automatically extended and the inverter is operated at the DC link voltage limit r1242 (see figure below). If the DC link again falls below the threshold r1242, then the Vdc_max controller withdraws the extension of the braking ramp.

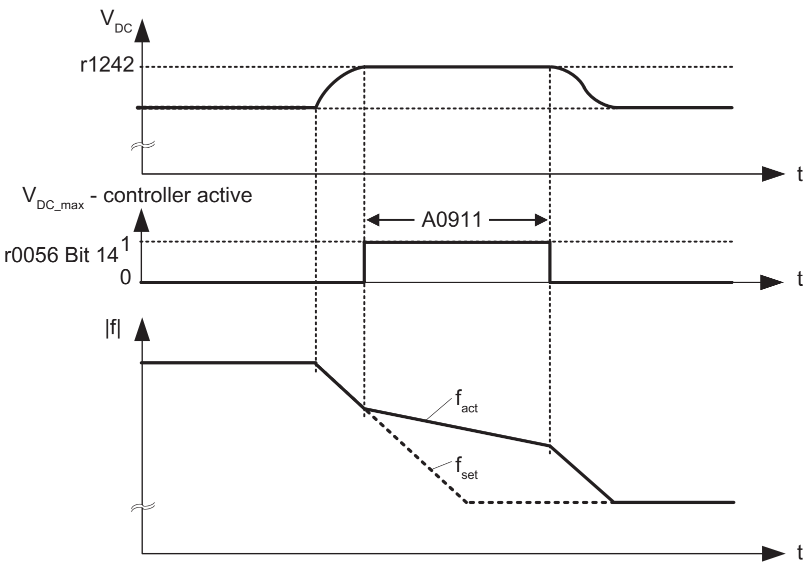



Figure 8-61 Vdc_max controller

On the other hand, if the Vdc_max controller increases the output frequency (e.g. for a steady-state regenerative load), then the Vdc_max controller is disabled by an internal inverter monitoring function and the warning A0910 is output. If the regenerative load continues, the inverter is protected using fault F0002.

In addition to controlling the DC link (closed-loop), the Vdc_max controller supports the stabilizing processes of the speed at the end of an acceleration phase. This is especially the case if there is an overshoot and the motor therefore briefly goes into regenerative operation (damping effect).

---

**Note**

If the DC link voltage exceeds the power-on threshold r1242 (switch-on level of Vdc_max.) of the Vdc_max controller in the "Ready" state, then the Vdc_max controller is de-activated and warning A0910 is output.
*Cause:* The line supply voltage does not match the application situation
*Remedy:* Refer to parameters P1254 and P0210.

If, in the "Run" state, the DC link voltage exceeds the power-on threshold r1242 and if the Vdc_max controller output is limited by parameter P1253 for approx. 200 ms, then the Vdc_max controller is de-activated and the warning A0910 and, where relevant, fault F0002 are output.
*Cause:* Line supply voltage P0210 or ramp-down time P1121 too low
The moment of inertia of the motor load is too high
*Remedy:* Refer to parameters P1254, P0210, P1121
Use a braking resistor

---

## 8.18.2 Kinetic buffering

### Description

| | |
|---|---|
| Parameter range: | P1240 |
| | r0056 bit 15 |
| | P1245, r1246, P1247 |
| | P1250 |
| | P1256, P1257 |
| Warnings: | A0503 |
| Faults: | F0003 |
| Function chart number: | FP4600 |

Brief line supply failures can be buffered using the kinetic buffering function (enabled using P1240). Line supply failures are buffered using the kinetic energy (i.e. moments of inertia) of the motor load. In this case the prerequisite is that the motor load has a sufficiently high moment of inertia - i.e. has sufficient kinetic energy.

Using this technique, the frequency is controlled (closed-loop), so that energy is fed to the inverter from the regenerating motor thus covering the system losses. The losses during the line supply failure still remain which means that the motor speed decreases. When using kinetic buffering it has to be taken into consideration that the motor speed is reduced.

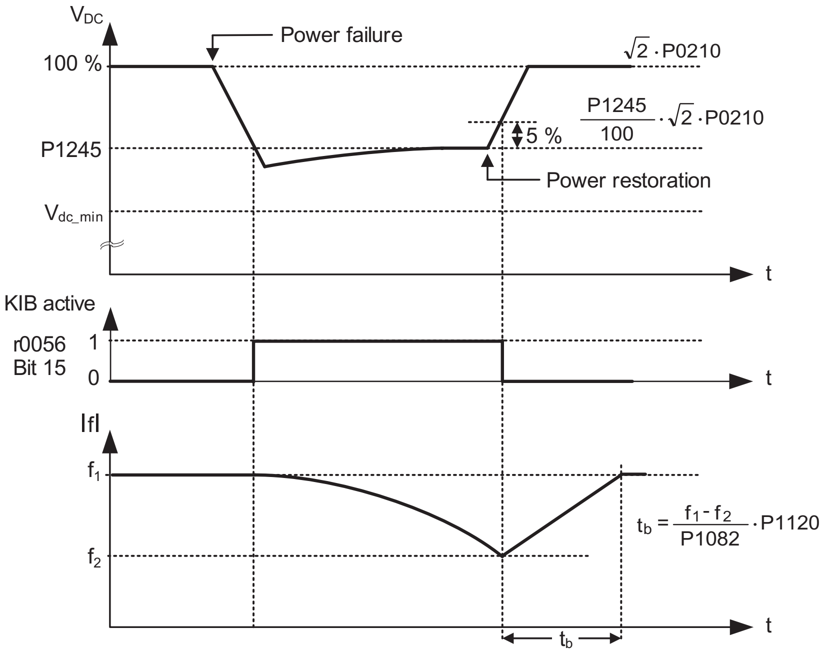



Figure 8-62 Kinetic buffering (Vdc_min controller)

When the line supply returns, the energy feed is again from the line side and the output frequency of the inverter returns to the selected setpoint along the ramp defined by the ramp-function generator.

---

**Note**

When the DC link voltage falls below the minimum $V_{DC\_min}$, fault F0003 "Undervoltage" is output and the inverter is shut down. The shutdown threshold $V_{DC\_min}$ depends on the inverter type and line supply voltage.

For the SINAMICS G120 the DC link undervoltage shutdown threshold is 430 V.

---

# 8.19 Positioning ramp down

## Description

| | |
|---|---|
| Parameter range: | P2480 – r2489 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

The positioning ramp down can be used for applications where it is necessary that a residual distance is moved-through up to the stop dependent on an external event (e.g. BERO switch). In this case, the SINAMICS G120 generates a continuous braking ramp by selecting OFF1 depending on the actual load speed and velocity. The motor is then stopped and positioned along this braking ramp (see figure below).

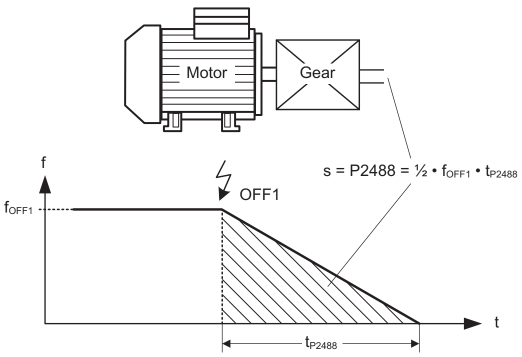



Figure 8-63 Positioning ramp down

In this case, the remaining distance P2488 moved through must be entered, referring to the load. In order to carry-out the residual distance calculation on the load side, the mechanical arrangement of the axis (gearbox ratio, linear or rotary axis) must be appropriately parameterized (see figure below).

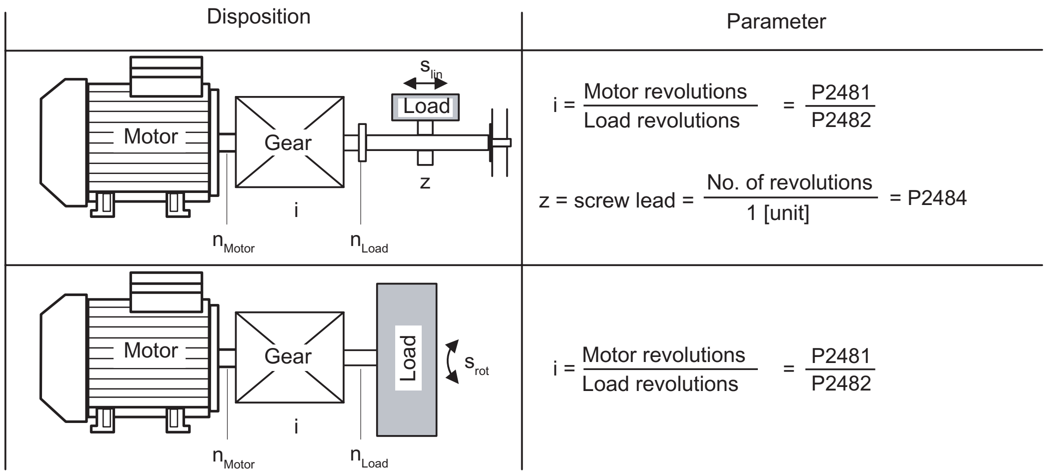



Figure 8-64 Rotary or linear axis

Using this data, SINAMICS G120 calculates the ratio between the distance and the motor revolutions and can therefore consider the movement on the load side.

---

**Note**

The "Switch-off frequency" (P2167) can have an influence on the final positioning result.

---

# 8.20 General monitoring functions and messages

## Description

| | |
|---|---|
| Parameter range: | P2150 … P2180<br>r0052, r0053, r2197, r2198 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP4100, FP4110 |

The SINAMICS G120 has an extensive range of monitoring functions and messages which can be used for open-loop process control. The control can either be implemented in the inverter or using an external control (e.g. PLC). The interlocking functions in the inverter as well as the output of signals for external control are implemented using BICO technology.

The status of the individual monitoring functions and messages are emulated in the following CO/BO parameters:

| | |
|---|---|
| r0019 | CO/BO: OP control word |
| r0050 | CO/BO: Active command data set |
| r0052 | CO/BO: Status word 1 |
| r0053 | CO/BO: Status word 2 |
| r0054 | CO/BO: Control word 1 |
| r0055 | CO/BO: Supplementary (additional) control word |
| r0056 | CO/BO: Status word – closed-loop motor control |
| r0403 | CO/BO: Encoder status word |
| r0722 | CO/BO: Status, digital inputs |
| r0747 | CO/BO: Status, digital outputs |
| r1407 | CO/BO: Status 2 – closed-loop motor control |
| r2197 | CO/BO: Messages 1 |
| r2198 | CO/BO: Messages 2 |

Frequently used monitoring functions/messages including parameter number and bit are shown in the table below.

Table 8-26 Extract of monitoring functions and messages

| Functions/states | Parameter/bit number | Function chart |
|---|---|---|
| Inverter ready | 52.0 | - |
| Inverter ready to run | 52.1 | - |
| Inverter running | 52.2 | - |
| Inverter fault active | 52.3 | - |
| OFF2 active | 52.4 | - |
| OFF3 active | 52.5 | - |
| On inhibit active | 52.6 | - |
| Inverter warning active | 52.7 | - |

| Functions/states | Parameter/bit number | Function chart |
|---|---|---|
| Deviation setpoint – actual value | 52.8 | - |
| PZD control | 52.9 | - |
| Maximum frequency reached | 52.A | - |
| Warning: Motor current limit | 52.B | - |
| Motor holding brake active | 52.C | - |
| Motor overload | 52.D | - |
| Motor runs right | 52.E | - |
| Inverter inverter overload | 52.F | - |
| DC brake active | 53.0 | - |
| Ramping finished | 53.9 | - |
| PID output R2294 == P2292 (PID_min) | 53.A | FP5100 |
| PID output R2294 == P2291 (PID_max) | 53.B | FP5100 |
| \|f_act\| > P1080 (f_min) | 53.2, 2197.0 | FP4100 |
| \|f_act\| <= P2155 (f_1) | 53.5, 2197.1 | FP4110 |
| \|f_act\| > P2155 (f_1) | 53.4, 2197.2 | FP4110 |
| f_act > zero | 2197.3 | FP4110 |
| f_act >= setpoint (f_set) | 53.6, 2197.4 | - |
| \|f_act\| >= P2167 (f_off) | 53.1, 2197.5 | FP4100 |
| \|f_act\| > P1082 (f_max) | 2197.6 | - |
| f_act == setpoint (f_set) | 2197.7 | FP4110 |
| i_act r0068 >= P2170 | 53.3, 2197.8 | FP4100 |
| Approx. Vdc_act < P2172 | 53.7, 2197.9 | FP4110 |
| Approx. Vdc_act > P2172 | 53.8, 2197.A | FP4110 |
| No-load operation | 2197.B | - |
| \|f_act\| <= P2157 (f_2) | 2198.0 | - |
| \|f_act\| > P2157 (f_2) | 2198.1 | - |
| \|f_act\| <= P2159 (f_3) | 2198.2 | - |
| \|f_act\| > P2159 (f_3) | 2198.3 | - |
| \|f_set\| < P2161 (f_min_set) | 2198.4 | - |
| f_set > 0 | 2198.5 | - |
| Motor blocked | 2198.6 | - |
| Motor stalled | 2198.7 | - |
| \|i_act r0068\| < P2170 | 2198.8 | FP4100 |
| \|m_act\| > P2174 & setpoint reached | 2198.9 | - |
| \|m_act\| > P2174 | 2198.A | - |
| Load torque monitoring: Warning | 2198.B | - |
| Load torque monitoring: Fault | 2198.C | - |

## 8.20.1 Load torque monitoring

### Description

| | |
|---|---|
| Parameter range: | P2181 … P2192 |
| | r2198 |
| Warnings: | A0952 |
| Faults: | F0452 |
| Function chart number: | – |

This function allows the mechanical force transmission between the motor and motor load to be monitored. Typical applications include, for example, pulley belts, flat belts or chains, or pulleys for toothed wheels of motor-in and motor-out shafts which then transmit circumferential velocities and circumferential forces (see figure below). The load torque monitoring function can then detect whether the motor load is locked or the force transmission has been interrupted.

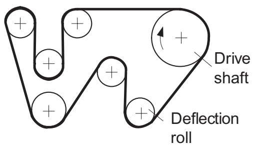



Figure 8-65 Shaft drive with flat belts

For the load torque monitoring function, the actual frequency/torque characteristic is compared with the programmed frequency/torque characteristic (refer to P2182 … P2190). If the actual value lies outside the programmed tolerance bandwidth, then, depending on parameter P2181, either warning A0952 or fault F0452 is generated. Parameter P2192 can be used to delay the output of the warning or fault message. This avoids erroneous alarms which could be caused by brief transient states (see figure below).

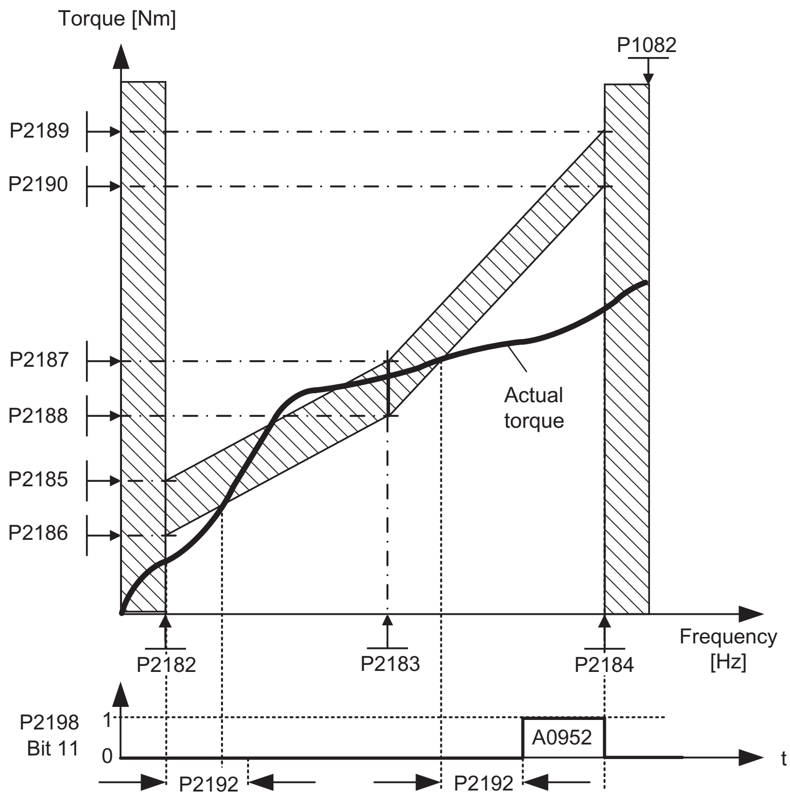



Figure 8-66 Load torque monitoring (P2181 = 1)

The frequency/torque tolerance bandwidth is defined by the gray shaded area in the figure below. The bandwidth is determined by the frequency values P2182 … P2184 including the max. frequency P1082 and the torque limits P2186 … P2189. When defining the tolerance bandwidth it should be ensured that a specific tolerance is taken into account in which the torque values are allows to vary corresponding to the application.

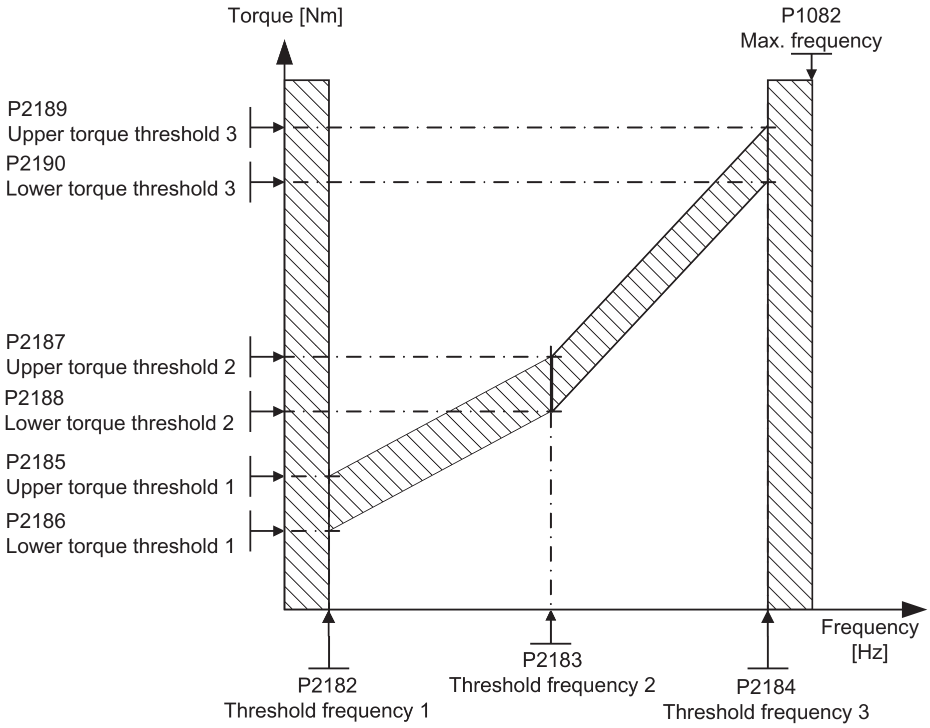



Figure 8-67 Frequency and torque tolerance bandwidth

# 8.21 Thermal motor protection and overload responses

## Description

| | |
|---|---|
| Parameter range: | P0601 … P0640 |
| | P0344 |
| | P0350 … P0360 |
| | r0035 |
| Warnings: | A0511 |
| Faults: | F0011, F0015 |
| Function chart number: | – |

The SINAMICS G120 has a completely new integrated concept for thermal motor protection. There are numerous possibilities of effectively protecting the motor but at the same time ensuring high motor utilization. The basic philosophy of this innovative concept is to detect critical thermal states, output warnings and initiate the appropriate responses. By responding to critical states it is possible to operate the motor at the thermal power limit and to avoid, under all circumstances, an immediate shutdown (where the inverter is tripped).

## Features

The protective concept (see figure below) distinguishes itself as a result of the following individual features:

- Protection is effective without using any temperature sensor (P0601 = 0). The temperatures of various locations in the motor are indirectly determined using a temperature model.
- It is possible to evaluate temperature sensors. This has the advantage that after a line supply failure, precise initial temperatures are immediately available. Both PTC sensors (P0601 = 1) as well as KTY84 sensors (P0601 = 2) can be connected and evaluated.
- When using a KTY84 sensor, the inverter can be parameterized so that a sensor wire breakage or short-circuit F0015 is detected and the system automatically changes-over to the temperature model. This means that the inverter is not shut down (tripped) and operation can continue.
- Selectable temperature warning thresholds P0604 (default: 130 °C) for operation with the temperature model or KTY84 sensor. The inverter is shut down or the current reduced depending on P0610 for a value of P0604 +10 %.
- Selectable responses P0610 which are to be initiated when the warning threshold is exceeded in order to prevent an overload condition.
- The motor protection has been designed to be completely independent of the inverter protection. Warning thresholds and responses for inverter protection must be separately parameterized.
- Various data sets are taken into account in the model. The model is separately calculated for each data set so that when changing-over between various motors the cooling of the presently non-active (fed) motors are taken into account.

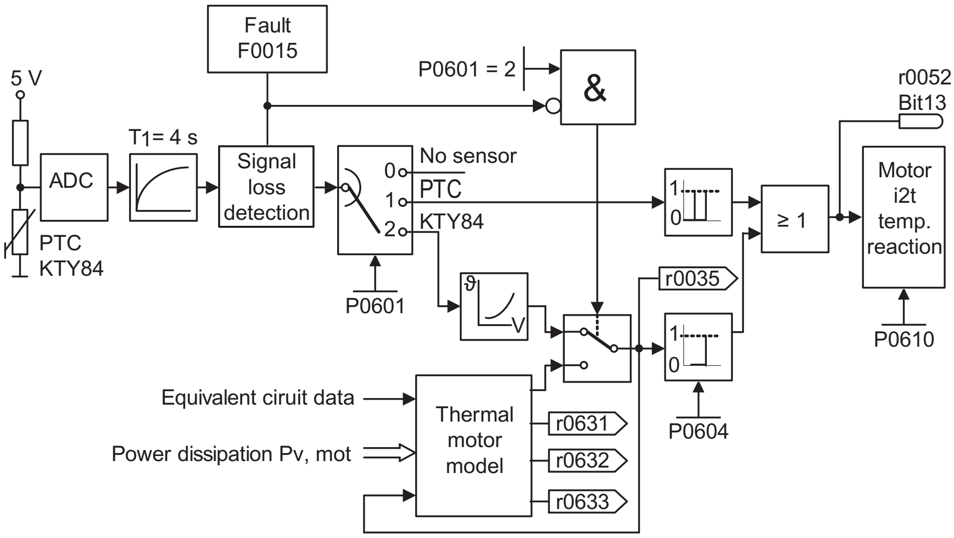



Figure 8-68 Thermal motor protection

## Temperature rise classes

In motor technology, temperature rise issues play a decisive role when dimensioning electrical machinery. Different temperature limits apply for the various materials used in electric motors. Depending on the insulating material being used, a differentiation is made according to thermal classes (refer to the motor rating plate) with defined limit temperatures. An excerpt from IEC85 is provided in the table below

Table 8-27 Extract from IEC85 thermal classes

| Thermal Class | Max. permissible temperature |
|---|---|
| Y | 90 ºC |
| A | 105 ºC |
| E | 120 ºC |
| B | 130 ºC |
| F | 155 ºC |
| H | 180 ºC |

For the temperature model or the KTY84 sensor, the appropriate value $\vartheta_{warn}$ must be calculated and entered into parameter P0604 (temperature warning threshold, default: 130°C). The following applies:

$$P0604 = \vartheta_{warn} = \frac{\vartheta_{trip}}{1.1}$$

## 8.21.1 Thermal motor model

### Description

The data, required for the thermal motor model, is estimated from the rating plate data entered during the quick commissioning. This data permits reliable, stable operation for standard Siemens motors. If required, parameter changes must be made for motors from third-party manufacturers. We always recommend that an automatic motor data identification run is made after quick commissioning so that the electrical equivalent circuit diagram data can be determined. This allows a more precise calculation of the losses which occur in the motor which has an impact on the accuracy of the thermal motor model.

### Example

A stator resistance, which is parameterized to be too high, would result, in the model, higher losses than in a real motor and an excessively high calculated motor temperature would be displayed.

If changes are required in order to optimize the thermal model, then as a first step, the motor weight (P0344) should be checked for plausibility. Generally, the motor weight is taken from the Catalog data of the motor manufacturer. The thermal model can be further optimized by adapting the standard overtemperatures for the stator iron P0626, the stator winding P0627 and the rotor P0628. The standard overtemperatures represent the steady-state temperatures to be expected in rated operation with respect to the environment and are used to estimate the thermal resistances. Generally, these overtemperatures are not listed in the Catalog.

The ambient temperature P0625 is another important parameter which influences the precision of the thermal model.

### 8.21.2 Motor Temperature Identification after Restart

#### Description

| | |
|---|---|
| Parameter range: | P0621 … r0623 |
| Warnings: | – |
| Faults: | – |
| Function chart number: | – |

The thermal motor model can be used to calculate the motor temperature. Not only this it can be also used to optimize the control loops for closed-loop vector control and for temperature monitoring. A KTY84 sensor is then no longer required for temperature sensing.

After the power supply (24 V) has been powered-down, the motor temperature - internally calculated using the thermal motor model - is no longer available. The model then starts with the ambient temperature value (P0625).

If the "Determining the motor temperature after motor start" function is active, the motor temperature is detected by measuring the current after magnetization and the thermal motor model is then pre-assigned this value.

Parameter P0621 is used to select when the function is active:

P0621 = 0: The function is de-activated. The thermal motor model then uses the ambient temperature value (P0625).

P0621 = 1: The motor temperature is determined once when the motor first starts after the power supply has been switched-in. This setting is used for standard motors.

P0621 = 2: For this setting, a new temperature measurement is carried-out each time the motor starts. This technique is practical for motors whose thermal behavior differs from standard motors. In these cases, it is possible that the thermal model is too inaccurate and would supply larger deviations.

---

**Note**

If a KTY84 sensor is being used and is functional, then the temperature of the sensor is used in all settings of parameter P0621. In this case, the temperature is not measured using the stator resistance.

---

#### Procedure when measuring the temperature

After the power supply is switched-in and an ON command is issued, the motor is first magnetized. If the "Determine the motor temperature after motor start" function has still not been activated, the motor immediately starts to rotate after the ON command has been issued. If this function is activated, the system waits until magnetization has been completed and until the motor current is constant. The measuring intervals for this procedure are specified using parameter P0622. The measurement itself is made if the current remains constant over one measuring period within a certain tolerance bandwidth. Generally, several measuring intervals are required. If the current is constant, then the actual current is measured and the actual winding resistance is determined. This is then entered into parameter R0623.

For a cold motor, this must approximately corresponds to the value of parameter P0350 of the motor data identification; it must be appropriately higher for a motor in the warm condition (at 130 °C approximately 150 %).

---

**Note**

In the following cases, the motor temperature is not measured:

- V/f operation
- Fault when measuring the current, e.g. the current isn't sufficiently constant
- For a flying restart the speed is too high

In these cases - when first accelerating after the power supply has been powered-up - an average temperature value is used (approx. 60 °C). When the motor starts without powering-down the power supply, the temperature does not change.

---

## 8.21.3 Temperature sensors

### Description

When the motor is operated below the rated speed the cooling effect of the shaft-mounted fan is reduced. As a result, for most motors when continually operated at lower frequencies, the power has to be reduced. Under these conditions, motor protection against overheating can only be guaranteed if either a temperature sensor (PTC or KTY84 sensor) is integrated in the motor and is connected to the control terminals 14 and 15 (see figure below) of the SINAMICS G120 or the motor temperature model was determined.

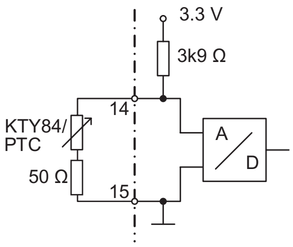



Figure 8-69 Connecting a temperature sensor

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**Note**

In order to avoid EMC noise from being coupled-in to the motor/inverter electronics the associated disturbances is not permissible to use free conductors in the motor cable to connect the temperature sensor to the motor/inverter.

The temperature sensor must be connected to the motor/inverter using a separate cable (if at all possible, this cable should be shielded).

---

### With PTC temperature sensor (P0601 = 1)

The PTC is connected to the control terminals 14 and 15 of the SINAMICS G120. PTC monitoring is activated with the parameter setting P0601 = 1. If the resistance value, connected at the terminals, is less than 1500 Ω, then neither alarm nor fault is generated. If this value is exceeded, the inverter outputs alarm A0511 and fault F0011. The resistance value where the alarm and fault are output is not less than 100 Ω and not more than 2000 Ω.

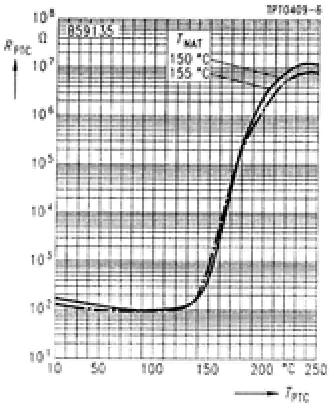


Figure 8-70 PTC characteristics for 1LG/1LA motors

## With KTY84 temperature sensor (P0601 = 2)

The KTY84 must be connected so that the diode is in the conductive direction. This means that the anode is connected to terminal 14 and the cathode to terminal 15. If the temperature monitoring function is activated with the setting P0601 = 2, the temperature of the sensor (i.e. of the motor windings) is written into parameter r0035. The threshold temperature $\vartheta_{trip}$ of the motor can now be set using the warning threshold, motor overtemperature $\vartheta_{warn}$ (parameter P0604) (the factory setting is 130 °C). The following applies:

$$P0604 = \vartheta_{warn} = \frac{\vartheta_{trip}}{1.1}$$

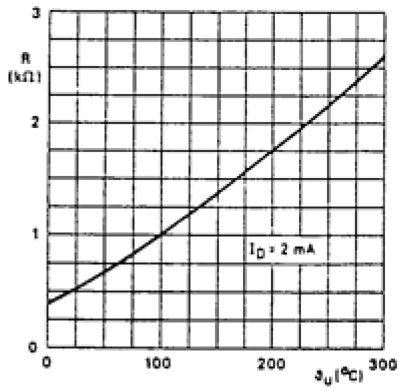


Figure 8-71 KTY84 characteristics for 1LG/1LA motors

## Wire breakage or short-circuit

If the circuit between the inverter and PTC or KTY84 sensor is interrupted or there is a short-circuit, the inverter is shut down (tripped) and fault F0015 is displayed.

# 8.22 Power Module protection

## 8.22.1 General overload monitoring

### Description

| | |
|---|---|
| Parameter range: | P0640, r0067, r1242, P0210 |
| Warnings: | A0501, A0502, A0503 |
| Faults: | F0001, F0002, F0003, F0020 |
| Function chart number: | - |

Just the same as for motor protection, the SINAMICS G120 provides extensive protection for the power components. This protection concept is sub-divided into two levels:

- Warning and response
- Fault and shutdown

Using this concept, a high utilization of the power module components can be achieved without the inverter being immediately shut down.

The monitoring thresholds for the faults and shutdowns are permanently saved in the inverter and cannot be changed by the user. On the other hand, the threshold levels for "Warning and response" can be modified by the user to optimize the system. These values have default settings so that the "Fault and shutdown" thresholds do not respond.

### 8.22.2 Power module thermal monitoring

#### Description

| | |
|---|---|
| Parameter range: | P0290 … P0294 |
| | r0036 … r0037 |
| Warnings: | A0504, A0505 |
| Faults: | F0004, F0005, F0012, F0022 |
| Function chart number: | - |

Similar to motor protection, the main function of the thermal power module monitoring is to detect critical states. Parameterizable responses are provided for the user which allows the motor system to still be operated at the power limit avoiding immediate shutdown. However, the possibilities of assigning parameters only involves interventions below the shutdown threshold which cannot be changed by users.

The SINAMICS G120 has the following thermal monitoring functions:

- $i^2t$ monitoring
  The $i^2t$ monitoring is used to protect components which have a long thermal time constant in comparison to the semiconductors. An overload with reference to $i^2t$ is present if the inverter utilization r0036 indicates a value greater than 100 % (utilization as a % refers to rated operation).
- Heatsink temperature
  The heatsink temperature of the power semiconductor (IGBT) is monitored and displayed in r0037[0].
- Chip temperature
  Significant temperature differences can occur between the junction of the IGBT and the heatsink. These differences are taken into account by the chip temperature monitoring and are displayed in r0037[1].

When an overload occurs regarding one of these three monitoring functions, initially, a warning is output. The warning threshold P0294 ($i^2t$ monitoring) and P0292 (heatsink temperature and chip temperature monitoring) can be parameterized relative to the shutdown values.

## Example

The warning threshold P0292 for the temperature monitoring (chip/heatsink temperature) is set to 15 °C in the factory. This means that warning A0504 is output 15 °C below the shutdown threshold.

At the same time that the warning is output, the parameterized responses are initiated using P0290 **(default: P0290 = 2)**. Possible responses include:

- **Reducing the pulse frequency (P0290 = 2 or 3)**
  This is an extremely effective method to reduce losses in the power module, as the switching losses represent a very high proportion of the overall losses. In many applications, a temporary reduction of the pulse frequency can be tolerated in favor of maintaining the process

**Disadvantage**
The current ripple is increased when the pulse frequency is reduced. This can result in an increase of the torque ripple at the motor shaft (for low moments of inertia) and an increase in the noise level. When the pulse frequency is reduced this has no influence on the dynamic response of the current control loop as the current control sampling time remains constant!

- **Reducing the output frequency (P0290 = 0 or 2)**
  This is advantageous if it is not desirable to reduce the pulse frequency or if the pulse frequency is already set to the lowest level. Further, the load should have a characteristic similar to that of a fan, i.e. a square-law torque characteristic for decreasing speed. When the output frequency is reduced, this significantly reduces the inverter output current and in turn reduces the losses in the power module.
- **No reduction (P0290 = 1)**
  This option should be selected if neither a reduction in the pulse frequency nor a reduction in the output current is being considered. In this case, the inverter does not change its operating point after the warning threshold has been exceeded so that the motor can continue to be operated until the shutdown values are reached. After the shutdown threshold has been reached, the inverter shuts down (trips) with fault F0004. The time which expires up to shutdown is however not defined and depends on the magnitude of the overload. Only the warning threshold can be changed in order to obtain an earlier warning and, if required, externally intervene in the motor process (e.g. by reducing the load, lowering the ambient temperature).

---

**Note**

If the inverter fan fails, this would be indirectly detected by the measurement of the heatsink temperature.

A wire breakage or short circuit of the temperature sensor(s) is also monitored.

---

# 8.23 Open-loop and closed-loop control overview

## Overview

There are several open-loop and closed-loop techniques for closed-loop speed and torque control for inverters with induction and synchronous motors. These techniques can be roughly classified as follows:

- V/f characteristic control (known as: V/f control)
- Field-orientated closed-loop control technique (known as: Vector control)

The field-orientated control technique – Vector control – can be further sub-divided into two groups:

- Vector control without speed feedback (sensorless Vector control (SLVC))
- Vector control with speed feedback (Vector control (VC))

These techniques differ from one another both regarding the control ability and in the complexity of the technique, which in turn are obtained as a result of the requirements associated with a particular application. For basic applications (e.g. pumps and fans), to a large extent, V/f control is used. Vector control is mainly used for sophisticated applications (e.g. winders), where a good control and behavior in noisy conditions are required regarding the speed and torque. If these requirements are also present in the range from 0 Hz to approx. 1 Hz, then the speed/torque accuracy without encoder is not sufficient. In this case, Vector control with speed feedback must be used.

## 8.23.1 V/f control

### Description

| | |
|---|---|
| Parameter range: | P1300 |
| | P1310 … P1350 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP6100 |

The V/f characteristic represents the simplest control technique. In this case the stator voltage of the induction motor or synchronous motor is controlled proportionally to the stator frequency. This technique has proven itself for a wide range of "basic" applications, such as

- Pumps, fans
- Belt motors

and similar processes.

The goal of V/f control is to keep the flux Φ constant in the motor. In this case, this is proportional to the magnetizing current $I_\mu$ and the ratio between voltage V and frequency f.

$\Phi \sim I\mu \sim V/f$

The torque M, developed by induction motors, is proportional to the product (precisely the Vectorial product Φ x I) of flux and current.

$M \sim \Phi * I$

In order to generate the highest possible torque from a given current, the motor must operate with a constant flux which is as high as possible. In order to keep the flux Φ constant, when frequency f changes, the voltage V must be changed in proportion so that a constant magnetizing current Iµ flows. The V/f characteristic control is derived from these basic principles.

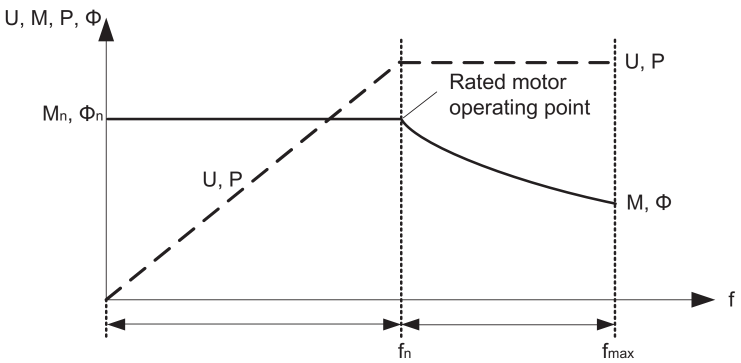
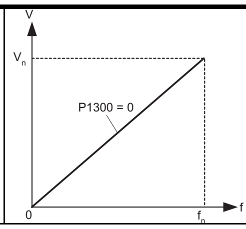
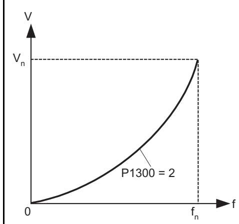
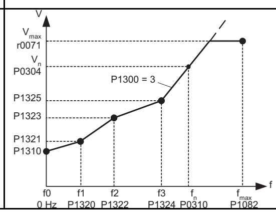



Figure 8-72 Operating ranges and characteristics of an induction motor when fed from an inverter

There are several versions of the V/f characteristic as shown in the table below.

Table 8-28 V/f characteristics (parameter P1300)

| Parameter value | Significance | Use/property |
|---|---|---|
| 0 | Linear characteristic | Standard case   |
| 1 | FCC | Can give a more efficient and better load response than other V/f modes because the FCC characteristic automatically compensates the voltage losses of the stator resistance for static (steady-state) or dynamic loads (flux current control FCC). This is used especially for small motors which have a relatively high stator resistance. |
| 2 | Square-law characteristic | This is a characteristic which takes into consideration the torque characteristic of the motor load (e.g. fan/pump):<br>a) Square-law characteristic ($f^2$ characteristic)<br>b) Energy saving as the lower voltage also results in lower currents and losses.   |
| 3 | Programmable characteristic | Characteristic which takes into consideration the torque characteristic of the motor/driven load (e.g. synchronous motor).   |
| 5 | Application adaptation | This is a characteristic which takes into consideration the special technological issues of an application (e.g. textile applications),<br>a) Where the current limiting (Imax controller) only influences the output voltage and not the output frequency, and<br>b) By inhibiting the slip compensation |
| 6 | Application adaptation with FCC | This is a characteristic which takes into consideration the special technological issues of an application (e.g. textile applications),<br>a) Where the current limiting (Imax controller) only influences the output voltage and not the output frequency, and<br>b) By inhibiting the slip compensation |
| 19 | Independent voltage input | The user can enter the output voltage of the inverter, independently of the frequency, using a BICO parameter P1330 via the interfaces (e.g. analog input → P1330 = 755). |

### 8.23.1.1 Voltage boost

## Description

| | |
|---|---|
| Parameter range: | P1310 … P1312 |
| | r0056 bit 05 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP6100 |

For low output frequencies, the V/f characteristics only output a low output voltage. Even at low frequencies, the ohmic resistances of the stator winding play a role, which are neglected when determining the motor flux in V/f control. This means that the output voltage can be too low in order to:

- implement the magnetization of an induction motor,
- to hold the load
- to equalize losses (ohmic losses in the winding resistances) in the system or
- to provide a breakaway/accelerating/braking torque.

The output voltage can be increased (boosted) in the SINAMICS G120 using the parameters as shown in the table below.

---

**Note**

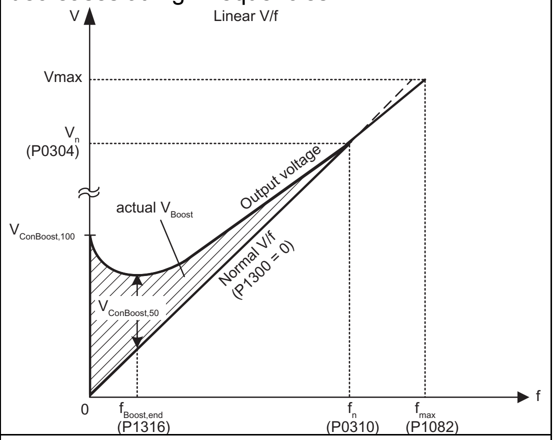
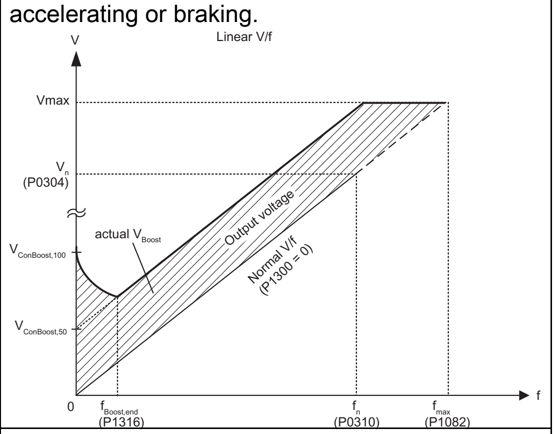
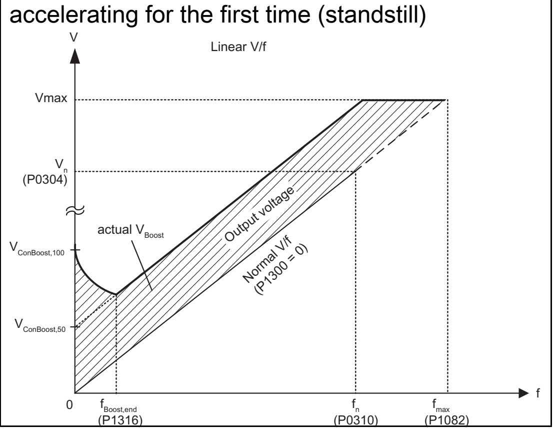
Especially at low frequencies, the motor temperature is additionally increased as a result of the voltage boost (the motor overheats)!

The voltage value at 0 Hz is determined from the product of rated motor current P0305, stator resistance P0350 and the appropriate parameters P1310 .

Using very high boost values may cause the motor to stuck at a low frequency due to the Imax controller (very high boost may cause overcurrent failure).

---

Table 8-29 Voltage boost

| Parameter | Voltage boost | Explanation |
|---|---|---|
| P1310 | Constant voltage boost | The voltage boost is effective over the complete frequency rage whereby the value continually decreases at high frequencies.<br><br> |
| P1311 | Voltage boost when accelerating or braking | The voltage boost is only effective when accelerating or braking.<br><br> |
| P1312 | Voltage boost when starting | The voltage boost is only effective when accelerating for the first time (standstill)<br><br> |

### 8.23.1.2 Slip compensation

## Description

| | |
|---|---|
| Parameter range: | P1335 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP6100 |

In the V/f characteristic operating mode the motor frequency is always lower than the inverter output frequency by the slip frequency $f_s$. If the load (the load is increased from M1 to M2) is increased with a constant output frequency, then the slip increases and the motor frequency decreases (from f1 to f2). This behavior, typical for an induction motor, can be compensated using slip compensation P1335. This therefore eliminates the speed reduction, caused by the load, by boosting (increasing) the inverter output frequency (see figure below).

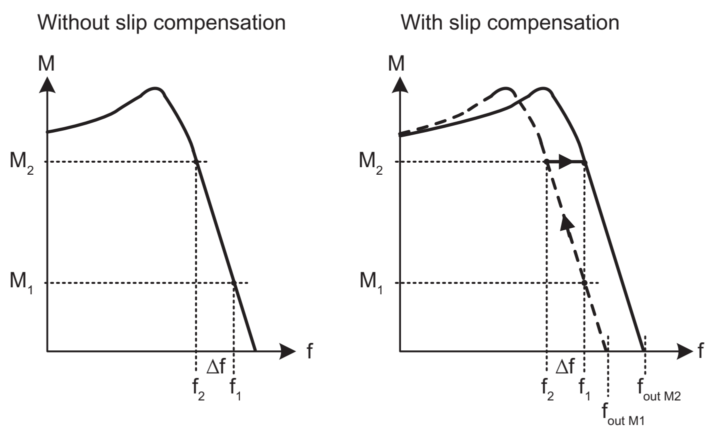



Figure 8-73 Slip compensation

### 8.23.1.3 V/f resonance damping

#### Description

| | |
|---|---|
| Parameter range: | P1338 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

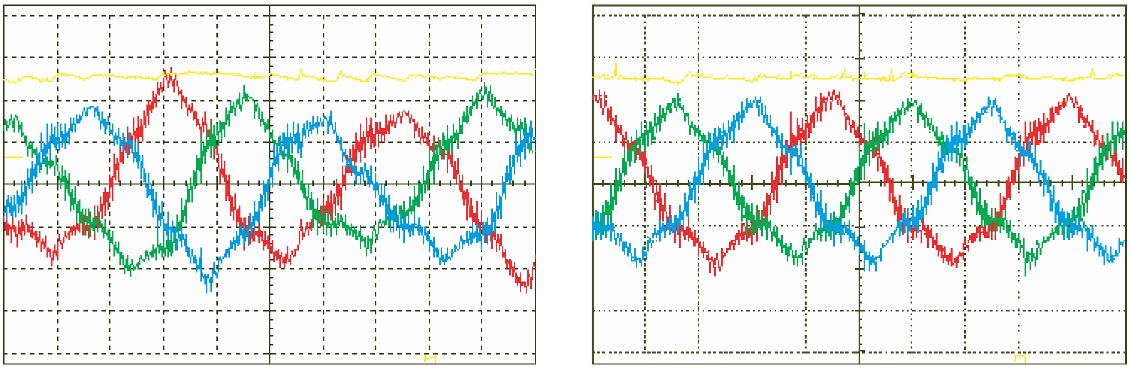
Resonance effects result in an increased noise level and also can damage or destroy the mechanical system. These resonance effects can occur for:

- Geared motors
- Reluctance motors
- Large motors
  (low stator resistance → poor electrical damping)

The V/f resonance damping function is working between 6 % and 80 % of the rated motor frequency when enabled.

Contrary to the "skip frequency" function and parameters P1091 … P1094, where the resonance frequency is passed through as quickly as possible, for the V/f resonance damping (P1338), the resonance effects are dampened from a control-related perspective. The advantage of this function is that by using this active damping, operation is possible in the resonance range.

The V/f resonance damping is activated and adjusted using parameter P1338. This parameter represents a gain factor that is a measure for the damping of the resonance frequency. The following oscillogram indicates the effect of the resonance damping function using as an example a reluctance motor with gearbox. The phase output currents are displayed for an output frequency of 45 Hz.



Without V/f resonance damping (P1338 = 0)          V/f resonance damping active (P1338 = 1)

Figure 8-74 Resonance damping

### 8.23.1.4 V/f control with FCC

#### Description

| | |
|---|---|
| Parameter range: | P1300, P1333 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | - |

An improved current measurement function has been developed for SINAMICS G120 inverters. This permits the output current to be precisely determined referred to the motor voltage. This measurement guarantees that the output current is sub-divided into a load component and a flux component. Using this sub-division, the motor flux can be controlled and can be appropriately adapted and optimized in-line with the prevailing conditions.

FCC operation is only activated after the FCC starting frequency P1333 has been exceeded. The FCC starting frequency P1333 is entered as a percentage to the rated motor frequency P0310. For a rated motor frequency of 50 Hz and a factory setting of P1333 = 10 %, this results in an FCC starting frequency of 5 Hz. The FCC starting frequency may not be selected too low as this has a negative impact on the control characteristics and can result in oscillation and system instability.

The "V/f with FCC" control type (P1300 = 1) has proven itself in many applications. It has the following advantages with respect to the standard V/f control:

- Higher motor efficiency
- Improved stabilizing characteristics
  - higher dynamic response
  - improved behavior to disturbances/control.

---

**Note**

Contrary to closed-loop vector control with/without speed encoder (VC/SLVC), for the V/f open-loop control mode with FCC, it is not possible to specifically influence the motor torque. This is the reason that it isn't always possible to avoid the motor stalling – even when using "V/f with FCC".

An improvement in the stabilizing behavior and in the motor efficiency can be expected when using the closed-loop vector control with/without speed encoder when compared to V/f control with FCC.

---

### 8.23.1.5 Current limiting (Imax controller)

#### Description

| | |
|---|---|
| Parameter range: | P1340 … P1346 |
| | r0056 bit 13 |
| Warnings: | A0501 |
| Faults: | F0001 |
| Function chart number: | FP6100 |

In the V/f characteristic mode, the inverter has a current limiting controller in order to avoid overload conditions (Imax controller, see figure below). This controller protects the inverter and the motor against continuous overload by automatically reducing the inverter output frequency by $f_{Imax}$ (r1343) or the inverter output voltage by $V_{Imax}$ (r1344). By either reducing the frequency or voltage, the stressing on the inverter is reduced and it is protected against continuous overload and damage.

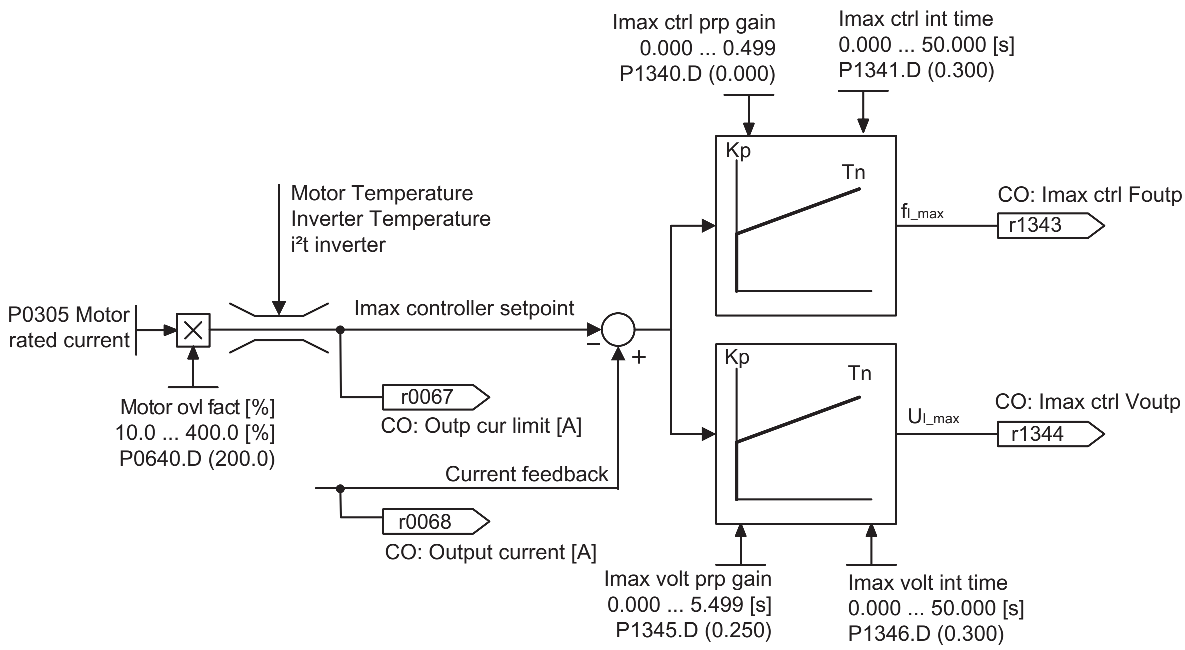



Figure 8-75 Imax controller

**Note**

The inverter load is only reduced when the frequency is reduced if the load decreases at lower speeds (e.g. square-law torque –speed characteristic of the motor load).

### 8.23.2 Vector control

#### Description

Field-orientated Vector control (known as: Vector control) significantly improves torque control when compared to V/f control. The Vector control principle is based on the fact that for a specific load situation or required torque, the required motor current is impressed with respect to the motor flux so that the appropriate torque is obtained. If the stator current is emulated in a circulating coordinate system, linked with the rotor flux Φ, then it can be broken-down into the flux-generating current component $i_d$ in-line with the rotor flux and into a torque-generating current component $i_q$, vertical to the rotor flux. These components are corrected to track their setpoints in the current controller using their own dedicated PI controllers and are equal quantities in steady-state operation.

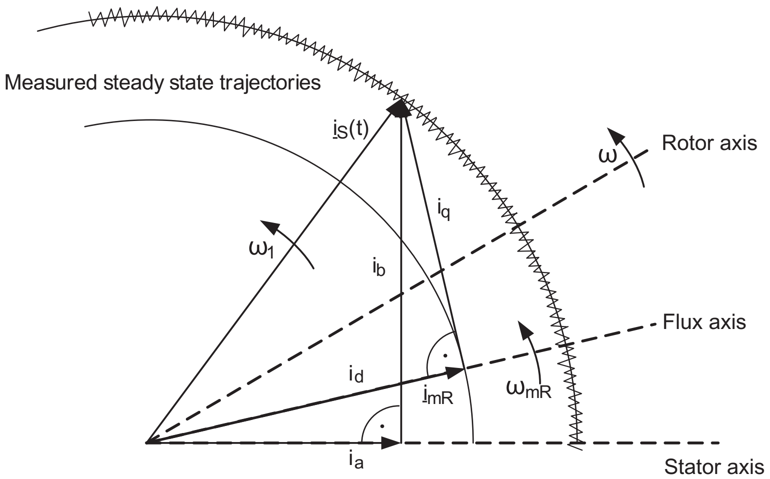



Figure 8-76 Current vector diagram in a steady-state condition

In the steady-state condition, the field-generating current component id is proportional to the flux Φ and the torque is proportional to the product of $i_d$ and $i_q$.

$M \sim \Phi * i_q$

$\Phi \sim i_{d,stat}$

$M \sim i_d * i_q$

When compared to V/f control, Vector control has the following advantages:

- Stable during load and setpoint changes
- Short rise times for setpoint changes (→ better control performance)
- Short rise times for load changes (→ better noise/disturbance characteristics)
- Accelerating and braking are possible with a max. adjustable torque
- The motor and motor machine are protected using the adjustable torque limit, both when motoring and regenerating
- The motor and braking torque are controlled independently of the speed
- Full holding torque is possible at 0 speed.

These advantages are, under certain circumstances, already achieved without using speed feedback.

The Vector control can be used both with and without speed encoder.

The following criteria provide a basis as to when a speed actual value encoder is required:

- High speed accuracy is required
- High requirements are placed on the dynamic response
  - Improved control performance
  - Improved immunity to disturbances.
- The torque is to be controlled over a control range greater than 1:10
- A defined and/or a changing torque has to be maintained for speeds below approx. 10 % of the rated motor frequency P0310.

When it comes to entering a setpoint, the Vector control (see table below) is sub-divided into:

- Closed-loop speed control, and
- Closed-loop torque/current control (known as: Closed-loop torque control).

Table 8-30 Vector control versions

| Vector control (closed-loop) | Without encoder | With encoder |
|---|---|---|
| Closed-loop speed control | P1300 = 20 and P1501 = 0 | P1300 = 21 and P1501 = 0 |
| Closed-loop torque control | P1300 = 22 or | P1300 = 23 or |
| | P1300 = 20 and P1501 = 1 | P1300 = 21 and P1501 = 1 |

When closed-loop speed control is used, the closed-loop torque control is secondary. This type of cascaded closed-loop control has proven itself in practice regarding commissioning and increased transparency.

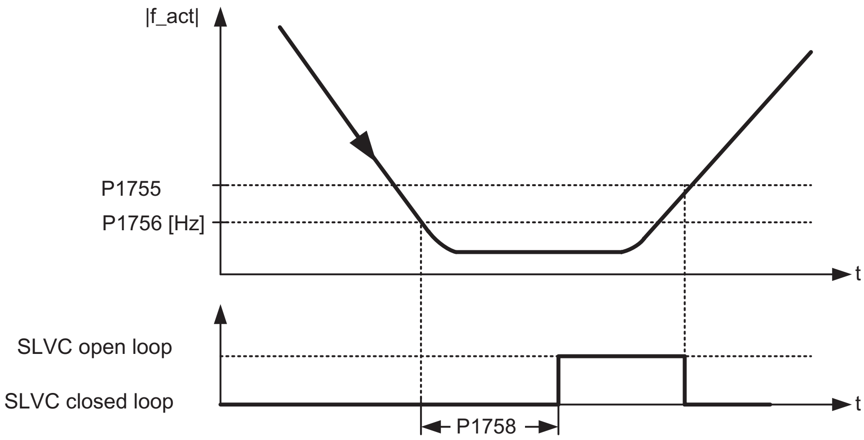
### 8.23.2.1 Vector control without speed encoder

## Description

| | |
|---|---|
| Parameter range: | P1400 … P1780 |
| | P1610, P1611 |
| | P1750 |
| | P1755, P1756, P1758 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP7000 |

When Vector control is used without a speed encoder (SLVC) then the position of the flux and the actual speed must be determined using the motor model. In this case, the model is supported by the accessible currents and voltages. At low frequencies (≈ 0 Hz), the model is not able to determine the speed. Inability of the model to determine the speed at ≈ 0 Hz, uncertainty in model parameters and measurement inaccuracy are the reasons why there is a changeover from closed-loop to open-loop controlled operation in this range.

The changeover between closed-loop controlled and open-loop controlled operation is controlled using the time and frequency conditions (P1755, P1756, P1758) (see figure below). The system does not wait for the time condition if the setpoint frequency at the ramp-function generator input and the actual frequency simultaneously lie below P1756.




$$P1756\ [Hz] = P1755\ [Hz] \cdot \frac{P1756\ [\%]}{100\ [\%]}$$

Figure 8-77 Changeover condition for SLVC

In the open-loop controlled mode, the speed actual value is the same as the setpoint. For suspended loads or when accelerating, parameter P1610 (constant torque boost) and P1611 (torque boost when accelerating) must be modified in order to allow the motor to provide the steady-state and/or dynamic load torque. If P1610 is set to 0 %, then only the magnetizing current r0331 is impressed for a value of 100 % of the rated motor current P0305. In order that the motor does not stall when accelerating, P1611 can be increased or the acceleration pre-control can be used for the speed controller. This is also practical in order that the motor is not thermally overloaded at low speeds.

For Vector control without speed actual value encoder the SINAMICS G120 has, in the low frequency range, the following outstanding features with respect to other AC inverters:

- Closed-loop controlled operation down to ≈ 1 Hz
- Can start in the closed-loop controlled mode (immediately after the motor has been energized)
- The low frequency range (0 Hz) is passed-through in closed-loop controlled operation.

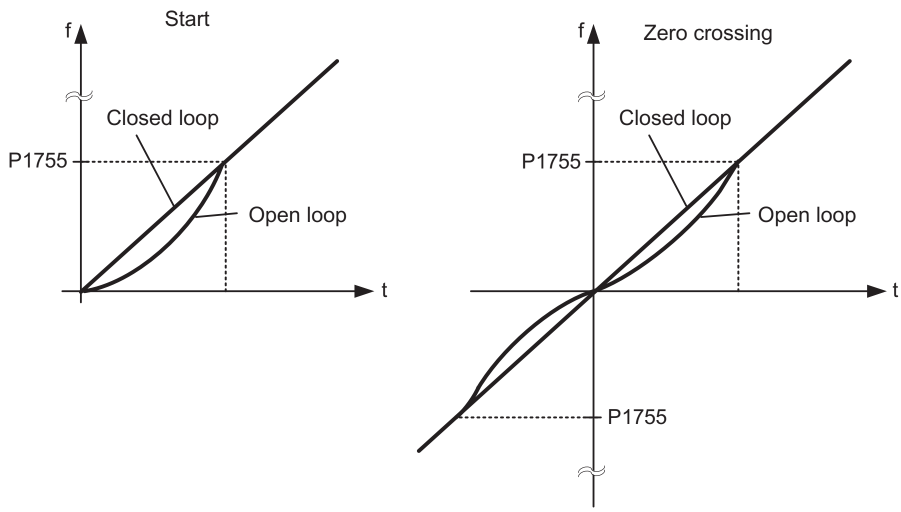



Figure 8-78 Starting and passing through 0 Hz in closed-loop control

The following advantages are obtained as a result of closed-loop controlled operation down to approx. 1 Hz (this can be selected using parameter P1755) as well as the possibility to immediately start closed-loop controlled at 0 Hz or to reverse closed-loop controlled (this can be set using parameter P1750):

- No changeover operation is required within the closed-loop control (smooth behavior –no frequency dips)
- Continuous closed-loop speed-torque control is possible down to approx. 1 Hz.

---

**Note**

For closed-loop controlled reversing or closed-loop controlled starting from 0 Hz it must be taken into account that when staying too long (> 2 s or > P1758) in the range around 0 Hz, that the closed-loop control automatically changes over from closed-loop into the open-loop controlled mode.

---

### 8.23.2.2 Vector control with speed encoder

## Description

| | |
|---|---|
| Parameter range: | P1400 … P1740<br>P0400 … P0494 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP7000 |

For Vector control with speed encoder (VC), a pulse encoder evaluation as well as a pulse encoder, e.g. an encoder with 1024 pulses per revolution is required. In addition to the correct wiring, the pulse encoder module must be activated, corresponding to the encoder type, using the parameter range P0400 … P0494.

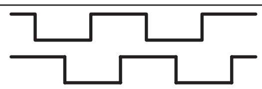
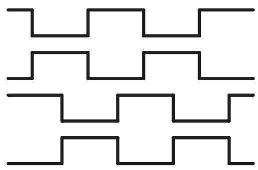
| Parameter | Terminal | Track | Encoder output |
|---|---|---|---|
| P0400 = 2 | A<br>B |  | single-ended |
| | A<br>AN<br>B<br>BN |  | differential |

Figure 8-79 P0400 settings for a pulse encoder

Advantages of Vector control with encoder:

- The speed can be closed-loop controlled down to 0 Hz (i.e. at standstill)
- Stable control behavior over the complete speed range
- Constant torque in the rated speed range
- When compared to closed-loop speed control without encoder, the dynamic response for motors with encoder is significantly higher as the speed is directly measured and is incorporated in generating the model of current components $i_d$, $i_q$.

### 8.23.2.3 Speed controller

## Speed controller

| | |
|---|---|
| Parameter range: | P1300, P1400 … P1780 |
| | SLVC: P1470, P1472, P1452 |
| | VC: P1460, P1462, P1442 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP7500, FP7510 |

Both of the control techniques (SLVC and VC) have the same speed controller structure which includes the following components:

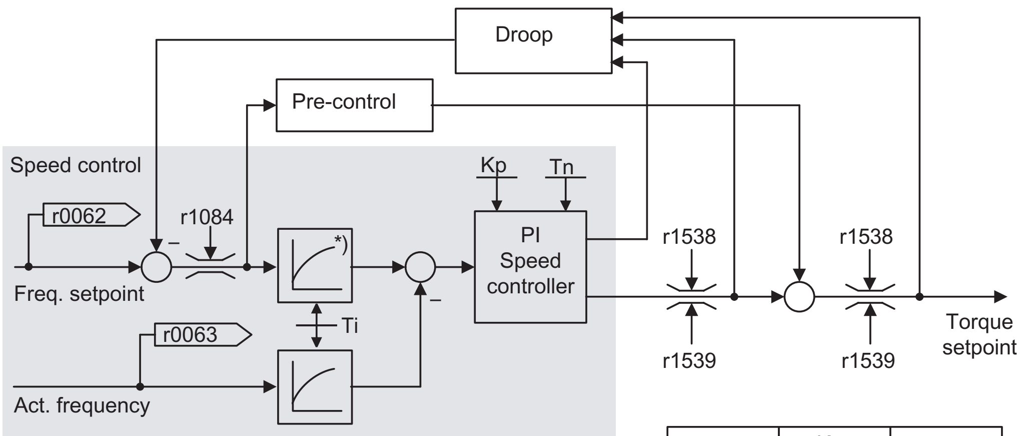
- PI controller
- Speed controller pre-control
- Droop

The sum of the output quantities forms the speed setpoint, which is reduced to the permissible level using the torque setpoint limiting function.

## Speed controller (SLVC: P1470, P1472, P1452 VC: P1460, P1462, P1442)

The speed controller (see figure below) receives its setpoint r0062 from the setpoint channel, the actual value r0063 either directly from the speed actual value encoder for VC or through the motor model for SLVC. The system error is amplified by the PI controller and, together with the pre-control, forms the torque setpoint.

For increasing load torques, when the droop function is active, the speed setpoint is proportionally reduced so that the load on an individual motor within a group (where two or several motors are mechanically coupled) is reduced when excessively high torques occur.




*) only active, if pre-control is enabled (P1496>0)

| | Ti | Kp | Tn |
|---|---|---|---|
| SLVC: | P1452 | P1470 | P1472 |
| VC: | P1442 | P1460 | P1462 |

Figure 8-80 Speed controller

If the moment of inertia was entered, the speed controller ($K_p$,$T_n$) can be calculated using the automatic parameterization (P0340 = 4). The controller parameters are defined according to the symmetrical optimum as follows:

$T_n = 4 * T_\sigma$

$K_p = ½ * r0345 / T_\sigma = 2 * r0345 / T_n$

$T_\sigma$ = sum of the low delay times

If oscillations occur with these particular settings, then the speed controller gain $K_p$ should be manually reduced. It is also possible to increase the speed actual value smoothing (this is the usual procedure for gearbox play or high-frequency torsional oscillations) and then re-call the controller calculation as the value is incorporated in the computation of $K_p$ and $T_n$.

The following interrelationships apply for the optimization routine:

- If $K_p$ is increased then the controller becomes faster and the overshoot is reduced. However, the signal ripple and oscillations in the speed controller loop are increased.
- If $T_n$ is reduced, then the controller also becomes faster. However, the overshoot increases.

When manually adjusting the speed control, the simplest procedure is to initially define the possible dynamic response using $K_p$ (and the speed actual value smoothing) in order to then reduce the integral action time as far as possible. In this case it is important to ensure that the closed-loop control must also remain stable in the field-weakening range.

When oscillations occur in the closed-loop speed control, it is generally sufficient to increase the smoothing time in P1452 for SLVC or P1442 for VC (or to reduce the controller gain) in order to dampen oscillations.

The integral output of the speed controller can be monitored using r1482 and the unlimited controller output can be monitored using r1508 (torque setpoint).

---

Note

When compared to closed-loop control with encoder, the dynamic response for sensorless motors is significantly reduced. This is because the speed can only be derived from the inverter output quantities for current and voltage which have the appropriate noise level.

---

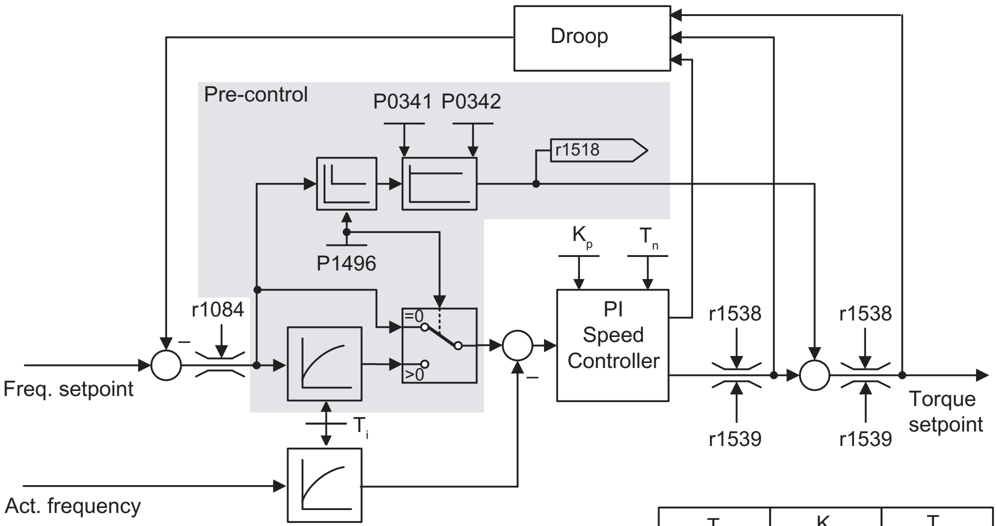
## Speed controller pre-control (P1496, P0341, P0342)

The control behavior of the speed control loop can be improved if the speed controller of the inverter also generates values for the current setpoints (corresponds to the torque setpoint) from the speed setpoint. The torque setpoint $m_v$, is calculated as follows:

$$m_v = P1496 \cdot \Theta \cdot \frac{dn}{dt} = P1496 \cdot P0341 \cdot P0342 \cdot \frac{dn}{dt}$$

This is entered into the current controller through an adaptation element directly as an additive control quantity (this is enabled using P1496).

The motor moment of inertia P0341 is directly calculated during the quick commissioning or the complete parameterization (P0340 = 1). The factor P0342 between the total moment of inertia and motor moment of inertia must be manually determined.




| | $T_i$ | $K_p$ | $T_n$ |
|---|---|---|---|
| SLVC: | P1452 | P1470 | P1472 |
| VC: | P1442 | P1460 | P1462 |

Figure 8-81 Speed controller with pre-control

When correctly adapted, the speed controller only has to correct noise quantities/disturbances in its control loop and this is achieved with a relatively low manipulated quantity change. On the other hand, speed setpoint changes bypass the speed controller and are therefore executed faster.

The effect of the pre-control quantity can be adapted, depending on the particular application, using the pre-control factor P1496. Using P1496 = 100 %, the pre-control is calculated according to the motor and load moment of inertia (P0341, P0342). In order that the speed controller does not work against the torque setpoint which is entered, a balancing filter is automatically used. The time constant of the balancing filter corresponds to the equivalent delay time of the speed control loop. The speed controller pre-control is correctly set (P1496 = 100 %, calibrated using P0342), if the I component of the speed controller (r1482) does not change during a ramp-up or ramp-down in the range n > 20 % * P0310. This means, using the pre-control, it is possible to approach a new speed setpoint without overshoot (prerequisite: The torque limiting does not intervene and the moment of inertia remains constant).

If the speed controller is pre-controlled, then the speed setpoint (r0062) is delayed with the same smoothing (P1442 or P1452) as the actual value (r1445). This ensures that when accelerating, there is no setpoint – actual value difference (r0064) at the controller input which would have been exclusively caused by the signal propagation time.

When the **speed pre-control is activated**, it must be ensured that the **speed setpoint is continuously entered and without any significant noise level** (avoid torque surges). An appropriate signal can be generated by smoothing the analog signal P0753 or by activating the rounding-off function of the ramp-function generator P1130 to P1133.

---

**Note**

The ramp-up and ramp-down times (P1120, P1121) of the ramp-function generator in the setpoint channel should only be set so fast that when accelerating and braking, the motor speed can follow the setpoint. This then guarantees the optimum functioning of the speed controller pre-control.

The starting time r0345 is a measure for the overall moment of inertia of the machine and describes that time in which the unloaded motor can accelerate from standstill to the rated motor speed P0311 with the rated motor torque r0333.

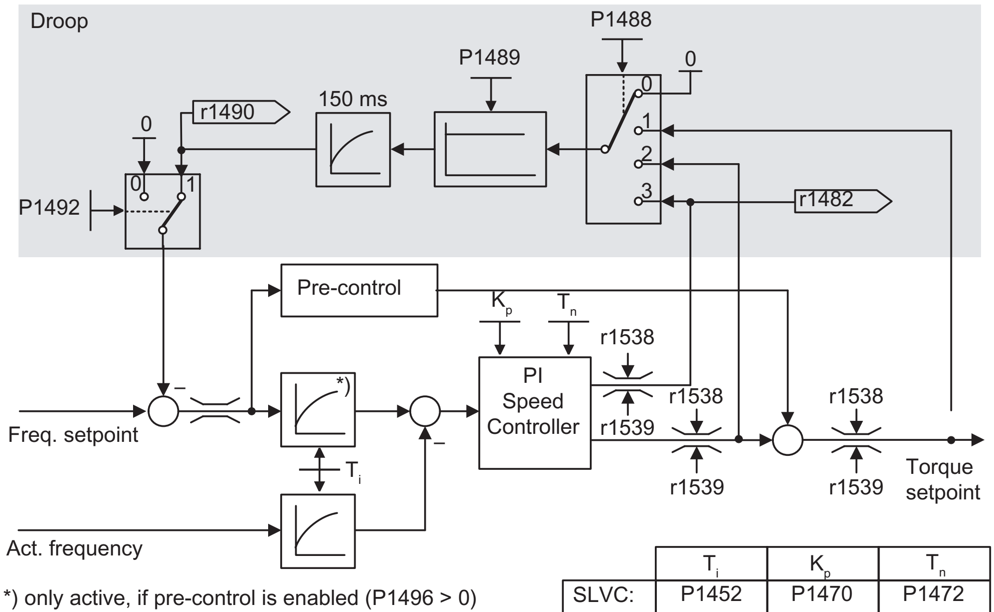
$$r0345 = T_{starting} = \Theta \cdot \frac{2 \cdot \pi \cdot n_{Mot,rated}}{60 \cdot M_{Mot,rated}} = P0341 \cdot P0342 \cdot \frac{2 \cdot \pi \cdot P0311}{60 \cdot r0333}$$

If these secondary conditions match the particular application, then the starting time can be used as the shortest value for the ramp-up and ramp-down times.

---

## Droop (P1488 … P1492)

The droop (enabled using P1488) means that with increasing load torque, the speed setpoint is proportionally reduced.




| | $T_i$ | $K_p$ | $T_n$ |
|---|---|---|---|
| SLVC: | P1452 | P1470 | P1472 |
| VC: | P1442 | P1460 | P1462 |

Figure 8-82 Speed controller with droop

Droop is the simplest method to implement load sharing control. However, this load sharing control can only be used if the motors are operated more or less under steady-state conditions (i.e. at constant speed). For motors, which are frequently accelerated and braked with high speed changes, this technique is only conditionally suitable.

The most simple load sharing control is, e.g., used for applications where two or several motors are mechanically coupled or operate on a common shaft and which have to fulfill the requirements above. In this case, the droop controls torsional stressing associated with the mechanical coupling by changing the speeds of the individual motors (excessive torques are reduced for an individual motor).

## Prerequisite

- All of the motors must be operated with closed-loop Vector speed control (with or without speed actual value encoder)
- The ramp-up and ramp-down times of the ramp-function generator must be identical for all of the motors.

### 8.23.2.4 Closed-loop torque control

## Description

| | |
|---|---|
| Parameter range: | P1300, P1500 … P1511<br>P1400 … P1780 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP7200, FP7210, FP7700, FP7710 |

For sensorless closed-loop speed control SLVC (P1300 = 20) or for closed-loop speed control with sensor VC (P1300 = 21), it is possible to changeover to closed-loop torque control (slave motor) using BICO parameter P1501. It is not possible to changeover between closed-loop speed and torque control if the closed-loop torque control is directly selected using P1300 = 22 or 23. The torque setpoint and supplementary torque setpoint can be selected using parameter P1500 and also using BICO parameter P1503 (CI: Torque setpoint) or P1511 (CI: Supplementary torque setpoint). The supplementary torque acts both for the closed-loop torque control as well as for the closed-loop speed control (see figure below). As a result of this feature, a pre-control torque for the speed control can be implemented using the supplementary torque setpoint.

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**Note**

For safety reasons, it is presently not possible to assign fixed torque setpoints.

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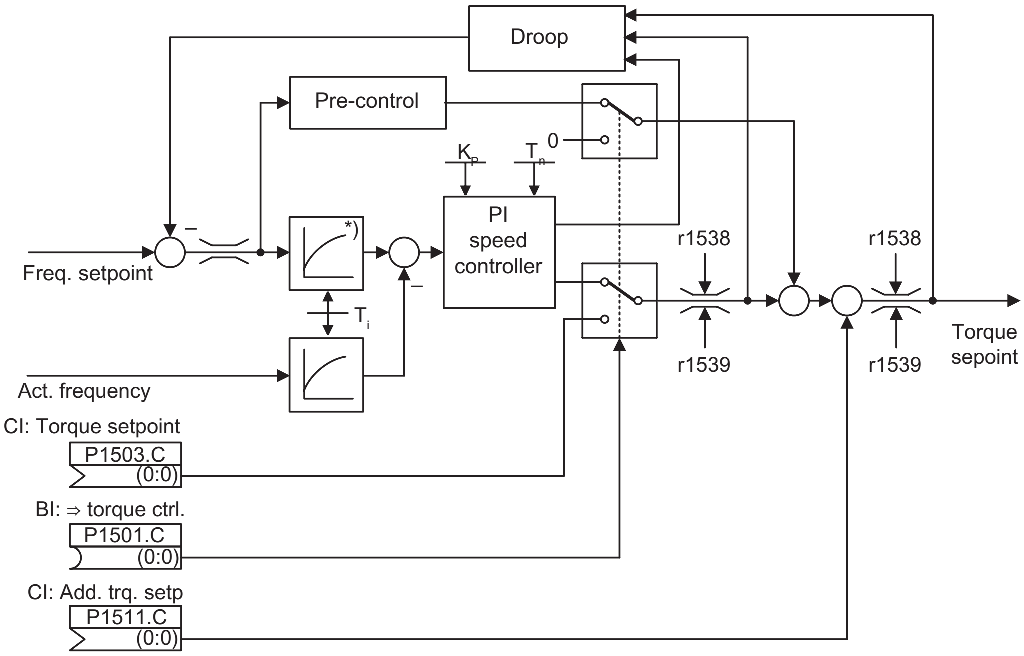


*) only active, if pre-control is enabled (P1496 > 0)

| | $T_i$ | $K_P$ | $T_n$ |
|---|---|---|---|
| SLVC: | P1452 | P1470 | P1472 |
| VC: | P1442 | P1460 | P1462 |

Figure 8-83 Closed-loop speed and torque control

The sum of both torque setpoints is limited in the same way as the torque setpoint of the speed control. Above the maximum speed (plus 3%), a speed limiting controller reduces the torque limits in order to prevent the motor accelerating any further.

A "real" closed-loop torque control (with automatically set speed) is only possible in the closed-loop controlled range but not in the open-loop controlled range. In the open-loop controlled range, the torque setpoint changes the setpoint speed through a ramp-up integrator (integration time ~ P1499 * P0341 * P0342). This is the reason that sensorless closed-loop torque control in the area around standstill (0 speed) is only suitable for applications which require an accelerating torque and not a load torque (e.g. traversing motors). For closed-loop torque control with sensors, this restriction does not apply.

If the closed-loop torque control is active, and a fast stop command (OFF3) is output, then the system automatically changes-over to closed-loop speed control and braking of the motor is started. If a normal stop command (OFF1) is output, there is no changeover. Instead, the system waits until a higher-level control has brought the motor to a standstill, in order to inhibit the pulses. This is necessary in order to allow the master and slave motors to be shut down together. For P1300 = 22 or 23, for OFF1, the motor is directly powered-down (as for OFF2).

### 8.23.2.5 Switch-over from Frequency to Torque Control

## Switch-over the Control Mode

**Caution**

With the fail-safe functions SLS and SS1 the closed-loop torque control is not recommended. The relation of torque and speed is dependend on the application.

The closed-loop torque control is switched-on via parameter P1501 during operation or selected with parameter P1300 = 22, 23.

Table 8-31 Closed-loop torque control

| Control mode | | P1501 = ON |
|---|---|---|
| Closed-loop speed control | P1300 = 20, 21 | OFF1 command is not recognized. |
| | + fail-safe functions SLS, SS1 | A safety fault is generated when the actual frequency leaves the safety envelope. |
| Closed-loop torque control | P1300 = 22, 23 | OFF1 command recognized as OFF2. |
| | + fail-safe functions SLS, SS1 | A safety fault is generated when the actual frequency leaves the safety envelope. |

**Caution**

**With fail-safe functions the closed-loop torque control can lead to safety fault**

While you are in closed-loop torque control mode either P1300 = 22 or 23, and if SLS or SS1 will be initiated this will cause to a safety fault. For fail-safe function initiate Safe Torque Off (STO).

### 8.23.2.6 Limiting the torque setpoint

#### Description

| | |
|---|---|
| Parameter range: | P1520 … P1531 |
| | P0640, r0067 |
| | r1407 bit 08, r1407 bit 09 |
| Warnings: | - |
| Faults: | - |
| Function chart number: | FP7700, FP7710 |

All of the following limits act on the torque setpoint which is either entered at the speed controller output for closed-loop speed control or as torque input for closed-loop torque control. The minimum is used from the various limits. This minimum is cyclically computed in the inverter and displayed in parameters r1538, r1539.

- r1538 Upper torque limit
- r1539 Lower torque limit

This means that these cyclic values limit the torque setpoint at the speed controller output/torque input and indicate the instantaneously maximum possible torque. If the torque setpoint is limited in the inverter, then this is displayed using the following diagnostic parameters

- r1407 bit 08 Upper torque limit active
- r1407 bit 09 Lower torque limit active

#### Torque limiting

The value specifies the maximum permissible torque whereby different limits are parameterizable for motoring and regenerative operation.

- P1520 CO: Upper torque limit value
- P1521 CO: Lower torque limit value
- P1522 CI: Upper torque limit value
- P1523 CI: Lower torque limit value
- P1525 Scaling, lower torque limit value

The currently active torque limit values are displayed in the following parameters:

- r1526 CO: Upper torque limit value
- r1527 CO: Lower torque limit value

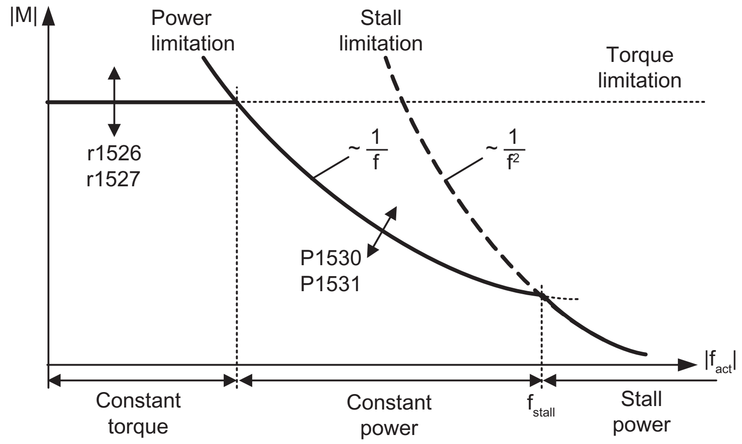


Figure 8-84 Torque limits

## Power limits

This value specifies the maximum permissible power, whereby different limits can be parameterized for motoring and regenerative operation.

- P1530 Motor power limit
- P1531 Regenerative power limit

## Stall limiting

The stall limiting (locked rotor limiting) is internally calculated in the motor from the motor data.

## Current limiting

The current limiting additionally limits the maximum torque which the motor can provide. If the torque limit is increased, more torque is only available if a higher current can flow. It may be necessary to also adapt the current limit. The current limiting is influenced by:

- P0640
- Thermal motor protection
- Thermal inverter protection

After limiting, the instantaneous maximum possible inverter current is displayed in parameter r0067 (limited output current).

# Technical data 9

## 9.1 CU240S Performance ratings

### SINAMICS G120 Control Unit 240 (CU240)

Table 9-1 CU240 Performance ratings

| Feature | Specification |
|---|---|
| Operating voltage | 24 V DC from Power Module or External 24 V DC (20.4 V … 28.8 V, 0.5 A) supply using the control terminals 31 and 32 |
| Control method (CU type dependent) | V/f control, output frequency between 0 Hz and 650 Hz: Linear V/f control, Linear V/f control with FCC, Parabolic V/f control, Multi-point V/f control, V/f control for textile applications, V/f control with FCC for textile applications, V/f control with independent voltage setpoint, Vector control, output frequency between 0 Hz and 200 Hz: Sensorless Vector Control, Sensorless Vector Torque Control, Speed control with Encoder feedback, Torque control with Encoder feedback. |
| Fixed frequencies | 16 programmable |
| Skip frequencies | 4 programmable |
| Setpoint resolution | 0.01 Hz digital; 0.01 Hz serial; 10 bit analog (motor potentiometer 0.1 Hz [0.1 % in PID mode]) |
| Digital inputs (CU type dependent) | Up to 9 programmable digital inputs, isolated; PNP, SIMATIC-compatible, low < 5 V, high > 10 V, maximum input voltage 30 V |
| Analog inputs (CU type dependent) | Up to 2 programmable, both can be configured as additional digital inputs. 0 V … 10 V, 0 mA … 20 mA and -10 V … +10 V (AI0) 0 V … 10 V and 0 mA … 20 mA (AI1) |
| Relay outputs | 3 programmable, 30 V DC / 0 A …0.5 A (resistive) |
| Analog outputs | 2 programmable AO0: 0 V … 10 V & 0 mA … 20 mA, AO1: 0 mA … 20 mA |
| Dimensions (BxHxD) | 73 mm x 178 mm x 55 mm |
| Weight | 0.52 kg |

# 9.2 Technical data of PROFIBUS DP

## Technical data

To display information about the current operating state of the inverter and the communication link, the PROFIBUS DP has three LEDs on the standard control unit and seven on the Safety-Integrated unit.

Its voltage is supplied through the inverter system connector.

The PROFIBUS DP is connected to the PROFIBUS system using a 9-pin sub-D type socket which is complaint with the PROFIBUS standard. All connections to this interface are short-circuit-proof and isolated.

The PROFIBUS DP supports baud rates of 9.6 kbaud to 12 Mbaud.

# Spare parts/Accessories 10

## 10.1 Control Unit accessories

### Operator Panel (OP)

The OP is a parameterization tool that is fitted directly to the SINAMICS G120 inverter via the Option port. It can also be used for up and download of parameter sets. A detailed description is given in the operation section.

### PC Connection Kit

The PC Connection Kit is used to connect a PC (with STARTER software) to the inverter via the Option port. It consists of a Null modem cable (3 m) and a PC inverter connector module.

### Multi Media Card (MMC)

The Multi Media Card (MMC) is used to safe parameters from a Control Unit. Thus safed parameter can be transferred to another Control Unit. A detailed description is given in the operation section.

## Screen Termination Kit

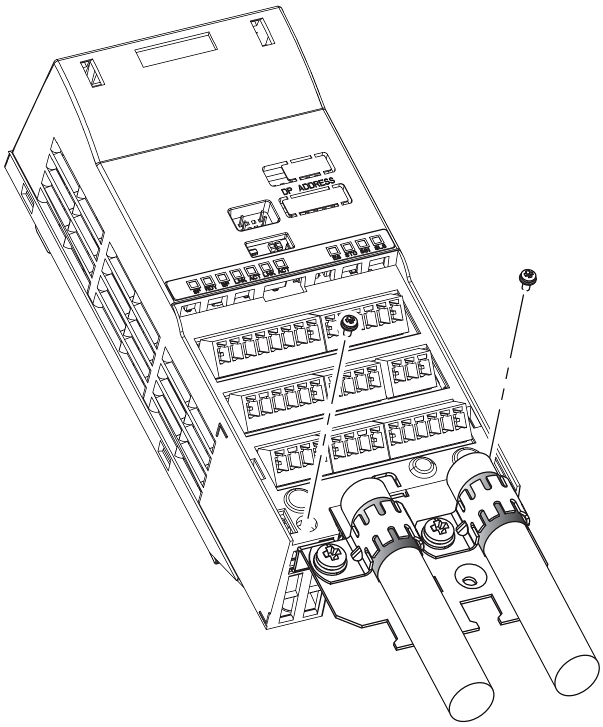


Figure 10-1 Screen Termination Kit

To prevent inductive and capacitive interference from effecting the correct function of the system we recommend the screen termination kit. For correct installation refer to the installation section.

# Appendix A

## A.1 Electromagnetic Compatibility

### Electromagnetic compatibility

All manufacturers/assemblers of electrical apparatus which “performs a complete intrinsic function and is placed on the market as a single unit intended for the end user” must comply with the EMC directive EC/89/336.

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

### Self certification

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

### Technical construction file

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

### EMC Standards

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

# A.2 Definition of the EMC Environment and Categories

## Classification of EMC performance

The EMC environment and categories are defined within the EMC Product Standard EN 61800-3, as follows:

### First Environment

An environment that includes domestic premises and establishments that are connected directly to a public low-voltage power supply network without the use of an intermediate transformer.

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**Note**

For example: houses, apartments, commercial premises or offices in a residential building.

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### Second Environment

An environment that includes industrial premises and establishments that are not connected directly to a public low-voltage power supply network.

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**Note**

For example: industrial and technical areas of buildings fed from a dedicated transformer.

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- Category C1

  Power Drive System (PDS) of rated voltage less than 1000 V intended for use in the First (Domestic) Environment.
- Category C2

  Power Drive System (PDS) of rated voltage less than 1000 V, which is neither a plug in device nor a movable device, and when used in the First (Domestic) Environment, is only intended to be installed and commissioned by a professional.

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  **Note**

  A professional is a person or an organization having necessary skills in installing and/or commissioning a Power Drive System (PDS), including their EMC aspects.

  ---
- Category C3

Power Drive System (PDS) of rated voltage less than 1000 V intended for use in the Second (Industrial) Environment and not intended for use within the First (Domestic) Environment.

Table A-1 Compliance Table

| Model | Remarks |
|---|---|
| **Category C1 - First Environment** | |
| -- | The SINAMICS G120 drives are not intended for use within the Category C1 Environment. |
| **Category C2 - First Environment - Professional Use** | |
| Filtered Variants<br>6SL3224-0BE**-*A*0 | Drives FSB … FSF (400 V, 2.2 kW … 90 kW) |
| | All units (except FSA) with integral filter. |
| | Class A: 25 m screened cable type CY |
| | The FSA power variant (400 V, 370 W … 1.5 kW) requires either a footprint filter option (6SE6400-2FA00-6AD0) or additional power-line filtering at the "system level". |
| | When used in the First (Domestic) Environment this product may cause radio interference in which case mitigation measures may be required. |
| **Category C3 - Second Environment** | |
| Unfiltered Variants<br>6SL3224-0BE**-*U*0 | All units are available as unfiltered variants. |
| | Drives FSA … FSF (400 V, 370 W … 90 kW) |
| | The use of unfiltered drives within an industrial installation is only possible if it forms part of a system which includes additional power-line filtering at the "system level" or, alternatively, the use of filtered variants. |

**Note**

All drives should be installed and commissioned in accordance with the manufacturer's guidelines and in accordance with good EMC practices.

For further information refer to SIEMENS application note “EMC Design Guidelines”.

# A.3 EMC Overall Performance

## EMC Emissions

The SINAMICS G120 drives have been tested in accordance with the emission requirements of the category C2 (domestic) environment.

Table A-2 Conducted & Radiated Emissions

| EMC Phenomenon | Standard | Level |
|---|---|---|
| Conducted Emissions | EN 55011 | Class A |
| Radiated Emissions | EN 55011 | Class A |

**Note**

To achieve this performance the default switching frequency should not be exceeded.

In order to achieve conducted emissions to EN 55011 Class B there is a range of PM240 external filter options available.

Achieving radiated emissions to EN 55011 Class B is largely dependent on the drive being correctly installed inside a metallic enclosure. The limits will not be met if the drive is not enclosed or installed in accordance with good EMC practices.

## Harmonic Currents

The harmonic current emissions from the SINAMICS G120 drives is as follows:

Table A-3 Harmonic Currents

| Rating | Typical Harmonic Current (% of rated input current) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5th | 7th | 11th | 13th | 17th | 19th | 23rd | 25th |
| FSA … FSF<br>(400 V, 370 W … 90 kW) | 73 | 52 | 25 | 23 | 22 | 15 | 12 | 10 |

**Note**

Units installed within the category C2 (domestic) environment require supply authority acceptance for connection to the public low-voltage power supply network. Please contact your local supply network provider.

Units installed within the category C3 (industrial) environment do not require connection approval.

## EMC Immunity

The SINAMICS G120 drives have been tested in accordance with the immunity requirements of category C3 (industrial) environment:

Table A-4 EMC Immunity

| EMC Phenomenon | Standard | Level | Performance Criterion |
|---|---|---|---|
| Electrostatic Discharge (ESD) | EN 61000-4-2 | 4 kV Contact discharge | A |
| | | 8 kV Air discharge | |
| Radio-frequency Electromagnetic Field | EN 61000-4-3 | 80 MHz … 1000 MHz<br>10 V/m | A |
| Amplitude modulated | | 80 % AM at 1 kHz | |
| Fast Transient Bursts | EN 61000-4-4 | 2 kV @ 5 kHz | A |
| Surge Voltage | EN 61000-4-5 | 1 kV differential (L-L) | A |
| 1.2/50 µs | | 2 kV common (L-E) | |
| Conducted | EN 61000-4-6 | 0.15 MHz … 80 MHz<br>10 V/rms | A |
| Radio-frequency Common Mode | | 80 % AM at 1 kHz | |
| Mains Interruptions & Voltage Dips | EN 61000-4-11 | 100 % dip for 3 ms | A |
| | | 30 % dip for 10 ms | B |
| | | 60 % dip for 100 ms | C |
| | | 95 % dip for 5000 ms | D |
| Voltage Distortion | EN 61000-2-4<br>Class 3 | 10 % THD | A |
| Voltage Unbalance | EN 61000-2-4<br>Class 3 | 3 % Negative Phase Sequence | A |
| Frequency Variation | EN 61000-2-4<br>Class 3 | Nominal 50 Hz or 60 Hz (± 4 %) | A |
| Commutation Notches | EN 60146-1-1<br>Class B | Depth = 40 % | A |
| | | Area = 250 % x degrees | |

**Note**

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

# A.4 Standards

**European Low Voltage Directive**

The SINAMICS G120 product range complies with the requirements of the Low Voltage Directive 73/23/EEC as amended by Directive 98/68/EEC. The units are certified for complaince with the following standards:

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

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

**European Machinery Directive**

The SINAMICS G120 inverter series does not fall under the scope of the Machinery Directive. However, the products have been fully evaluated for compliance with the essential Health & Safety requirements of the directive when used in a typical machine application. A Declaration of Incorporation is available on request.

**European EMC Directive**

When installed according to the recommendations described in this manual, the SINAMICS G120 fulfils all requirements of the EMC Directive as defined by the EMC Product Standard for Power Drive Systems EN 61800-3

**Underwriters Laboratories**

UL and CUL LISTED POWER CONVERSION EQUIPMENT for use in a pollution degree 2 environment.

Note: UL certification is presently in progress.

**ISO 9001**

Siemens plc operates a quality management system, which complies with the requirements of ISO 9001.

# A.5 Acceptance Log

## A.5.1 Documentation of acceptance test

### Overview

| | |
|---|---|
| Acceptance test No. | |
| Date | |
| Person carrying-out | |

Table A-5 Machine description and overview/block diagram

| | |
|---|---|
| Designation | |
| Type | |
| Serial No. | |
| Manufacturer | |
| End customer | |
| Block/overview diagram of the machine | |

Table A-6 Fail-safe functions for each drive

| Drive No. | FW version | SI version | Fail-safe function |
|---|---|---|---|
| | r0018 = | r9770 = | |
| | r0018 = | r9770 = | |
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| | r0018 = | r9770 = | |
| | r0018 = | r9770 = | |

Table A-7 Description of the fail-safe equipment/devices

| Drive No. | Example:<br>Wiring of the STO terminals (protective door, EMERGENCY STOP), grouping of the STO terminals, etc. |
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## A.5.2 Function test of the acceptance test

### Description

The function test must be carried-out separately for each individual drive (assuming that the machine permits this to be done).

### Executing the test

| | | |
|---|---|---|
| First commissioning | Please mark | |
| Series commissioning | | |

### Function test "Safe Torque Off" (STO)

This test comprises the following steps:

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

| No. | Description | Status |
|---|---|---|
| 1. | Initial state<br>• Drive in the "ready" state (P0010 = 0)<br>• No safety faults and alarms<br>• r9772.0 = r9772.1 = 0 (STO de-selected and inactive)<br>• P9659 = time intervals for the forced checking procedure correctly set | |
| 2. | Operate the drive | |
| 3. | Check that the expected drive operates | |
| 4. | Select STO while issuing the command to operate | |
| 5. | Check the following:<br>• The drive coasts-down<br>• The drive is braked by the mechanical brake and held if a brake is being used<br>• No safety faults<br>• r9772.0 = r9772.1 = 1 (STO selected and active), r9772.14 = 1 if Safe Brake Control is enabled | |
| 6. | De-select STO | |
| 7. | Check the following:<br>• No safety faults<br>• r9772.0 = r9772.1 = 0 (STO de-selected and inactive) , r9772.14 = 0 | |
| 8. | Check that the expected drive operates if so the following is tested:<br>• That the wiring between the control unit and power module is correct<br>• Correct assignment, drive No. – inverter power module – motor<br>• That the hardware is correctly functioning<br>• That the shutdown paths have been correctly wired<br>• Correct assignment of the STO terminals on the control unit<br>• Correct parameterization of the STO function<br>• Routine for the forced checking procedure of the shutdown paths | |

## Function test "Safe Stop 1" (SS1)

This test comprises the following steps:

Table A-9 "Safe Stop 1" function (SS1)

| No. | Description | Status |
|---|---|---|
| 1. | Initial state<br>• Drive in the "ready" state (P0010 = 0)<br>• No safety faults and alarms<br>• r9772.0 = r9772.1 = 0 (STO de-selected and inactive)<br>• r9772.4 = r9772.5 = 0 (SLS de-selected and inactive) | |
| 2. | Operate the drive | |
| 3. | Check that the expected drive operates | |
| 4. | Select SS1 while issuing the traversing command | |
| 5. | Check the following:<br>• Drive speed decreases corresponding to the selected ramp time (if required, use a stop watch)<br>• After the parameterized minimum speed has been fallen below, the drive coasts-down<br>• The drive is braked and held by the mechanical brake if a brake is being used<br>• No safety faults<br>• r9772.1 = 1 (STO active)<br>• r9772.2 = 1 (SS1 selected)<br>• r9772.14 = 1 if safe brake monitoring is enabled | |
| 6. | De-select SS1 | |
| 7. | Check the following:<br>• No safety faults<br>• r9772.1 = 0 (STO inactive)<br>• r9772.2 = 0 (SLS de-selected)<br>• r9772.14 = 0 | |
| 8. | Check that the expected drive operates if so the following is tested:<br>• The wiring between the control unit and power module is correct<br>• Correct assignment, drive No. – inverter power module – motor<br>• Correct functioning of the hardware<br>• Correct wiring of the shutdown paths<br>• Correct assignment, STO terminals on the control unit<br>• Correct parameterization of the SS1 function | |

## Function test "Safely-Limited Speed" (SLS)

This test comprises the following steps:

Table A-10 "Safely-Limited Speed" function (SLS)

| No. | Description | Status |
|---|---|---|
| 1. | Initial state<br>• Drive in the "ready" state (P0010 = 0)<br>• No safety faults and alarms<br>• r9772.4 = r9772.5 = 0 (SLS de-selected and inactive) | |
| 2. | Operate the drive (if the machine permits it, at a higher speed than the parameterized safely-limited speed) | |
| 3. | Check that the expected drive operates | |
| 4. | Select SLS while issuing the traversing command | |
| 5. | Check the following:<br>• r9772.4 = 1 (SLS selected)<br>• Drive speed decreases corresponding to the selected ramp time (if required, use an oscilloscope)<br>• After the parameterized safely-limited speed has been fallen below, the speed remains below this limit<br>• No safety faults<br>• r9772.5 = 1 (SLS active) | |
| 6. | De-select SLS | |
| 7. | Check the following:<br>• No safety faults<br>• r9772.4 = r9772.5 = 0 (SLS de-selected and inactive) | |
| 8. | Check that the expected drive operates if so the following is tested:<br>• The wiring between the control unit and power module is correct<br>• Correct assignment, drive No. – inverter power module – motor<br>• Correct functioning of the hardware<br>• Correct wiring of the shutdown paths<br>• Correct parameterization of the SLS function | |

## A.5.3 Completing the acceptance log

### Parameters of the fail-safe functions

| | Specified value checked? | |
|---|---|---|
| | Yes | No |
| Control unit | | |

### Checksums

| Drive | | Checksums | |
|---|---|---|---|
| Name | Drive No. | Control unit (r9798) | Control unit (r9898) |
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## Data back-up/archiving

| | Memory medium | | | Saved where |
|---|---|---|---|---|
| | Type | Designation | Date | |
| Parameters | | | | |
| PLC program | | | | |
| Circuit diagrams | | | | |

## Signatures

### Commissioning engineer

Confirms that the above listed tests and checks have been correctly carried-out.

| Date | Name | Company/department | Signature |
|---|---|---|---|
| | | | |

### Machinery construction OEM

Confirms the correctness of the parameterization documented above.

| Date | Name | Company/department | Signature |
|---|---|---|---|
| | | | |

# List of abbreviations

B

## B.1 Abbreviations

### Abbreviations used with the SINAMICS G120 Products

Table B-1 Abbreviations used with the SINAMICS G120 Products

| Abbreviations | State |
|---|---|
| A | |
| AC | Alternating Current |
| A/D | Analog digital converter |
| ADR | Address |
| AFM | Additional frequency modification |
| AG | Automation Unit |
| AI | Analog input |
| AK | Request Identifier |
| AO | Analog output |
| AOP | Advanced operation panel |
| ASIC | Application-specific integrated circuit |
| ASP | Analog setpoint |
| ASVM | Asymmetric space vector modulation |
| B | |
| BCC | Block check character |
| BCD | Binary-coded decimal code |
| BI | Binector input |
| BIA | Berufsgenossenschaftliches Institut für Arbeitssicherheit |
| BICO | Binector/connector |
| BO | Binector output |
| C | |
| C | Commissioning |
| CB | Communication board |
| CCW | Counter-clockwise |
| CDS | Command data set |
| CI | Connector input |
| CM | Configuration management |
| CMD | Command |

| Abbreviations | State |
|---|---|
| CO | Connector output |
| CO/BO | Connector output/Binector output |
| COM | Common (terminal is connected to NO or NC) |
| CT | Commissioning, ready to run |
| CU | Control Unit |
| CUT | Commissioning, run, ready to run |
| CW | Clockwise |
| D | |
| D/A | Digital analog converter |
| DC | Direct current |
| DDS | Drive data set |
| DI | Digital input |
| DIP | DIP switch |
| DO | Digital output |
| DP | Distributed I/Os |
| DP-V1 | Acyclic data transfer (extended PROFIBUS function) |
| DS | Drive state |
| E | |
| ECD | Equivalent circuit diagram |
| EEC | European Economic Community |
| EEPROM | Electrical erasable programmable read-only memory |
| ELCB | Earth leakage circuit breaker |
| EMC | Electromagnetic compatibility |
| EMF | Electromagnetic force |
| ES | Engineering System |
| FAQ | Frequently asked question |
| F | |
| FB | Function block |
| FFB | Freely Assignable Function block |
| FCC | Flux current control |
| FCL | Fast current limiting |
| FF | Fixed frequency |
| FFB | Free function block |
| FOC | Field orientated control |
| FREQ | Frequency |
| FSA | Frame size A |
| FSB | Frame size B |
| FSC | Frame size C |
| FSD | Frame size D |
| FSE | Frame size E |
| FSF | Frame size F |
| G | |

| Abbreviations | State |
|---|---|
| GSD | Device Data File (Geräte Stamm Datei) |
| GSG | Getting Started Guide |
| GUI ID | Global unique identifier |
| H | |
| HIW | Main actual value |
| HMI | Human machine interface |
| HO | High Overload (Constant Torque) |
| HSW | Main setpoint |
| HTL | High-voltage transistor logic |
| I | |
| I/O | In-/output |
| IBN | Commissioning |
| IGBT | Insulated gate bipolar transistor |
| IND | Sub-index |
| J | |
| JOG | JOG |
| K | |
| KIB | Kinetic buffering |
| L | |
| LCD | Liquid crystal display |
| LED | Light emitting diode |
| LGE | Length |
| LO | Light Overload (Variable Torque) |
| LWL | Fiber Optic conductor |
| LSTO | Latched Safe Torque Off |
| M | |
| MHB | Motor holding brake |
| MLP | Multi-Language Pack |
| MOP | Motor operated potentiometer |
| N | |
| NC | Normally closed |
| NEMA | National Electrical Manufacturers Association |
| NO | Normally open |
| O | |
| OLM | Optical Link Module |
| OLP | Optical Link Plug |
| OM | Object Manager |
| OP | Operator Panel |
| OPI | Operating Instructions |
| PA | |
| PID | Proportional, integral, derivative controller |
| PKE | Parameter ID |

| Abbreviations | State |
|---|---|
| PKW | Parameter ID value area (Parameterkennung Wert) |
| PLC | Programmable logic control |
| PM | Power module |
| PM-IF | Power module interface |
| PNU | Parameter Number |
| PNO | PROFIBUS Nutzerorganisation |
| PPO | Parameter process data object |
| PTC | Positive temperature coefficient |
| PWE | Parameter value |
| PWM | Pulse-width modulation |
| Pxxxx | Write parameter |
| PZD | Process data area (Prozeßdaten) |
| Q | |
| QC | Quick commissioning |
| R | |
| RAM | Random-access memory |
| RCCB | Residual current circuit breaker |
| RCD | Residual current device |
| RFG | Ramp-function generator |
| RFI | Radio frequency interference |
| ROM | Read-only memory |
| RPM | Revolutions per minute |
| rxxxx | read-only parameters of analogue signals |
| S | |
| SBC | Safe Break Control |
| SLVC | Sensorless vector control |
| SLS | Safe-Limited Speed |
| SOL | Serial option link |
| SS1 | Safe Stop 1 |
| STO | Safe Torque Off |
| STW | Control word |
| STX | Start of text |
| SVM | Space vector modulation |
| T | |
| TTL | Transistor-transistor logic |
| U | |
| USS | Universal serial interface |
| V | |
| V/f | Voltage/frequency |
| VC | Vector control |
| VT | Variable torque |
| W | |

| Abbreviations | State |
|---|---|
| WEA | Automatic restart |
| Z | |
| ZSW | Status word |
| ZUSW | Additional setpoint |

# Index

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