Function Manual 07/2007

SINAMICS S120

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SINAMICS

S120
Drive Functions

Function Manual

Applies to:
Firmware version FW2.5 SP1

(FH1), 07/2007
6SL3097-2AB00-0BP4

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.

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

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

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

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

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

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

Qualified Personnel

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

Prescribed Usage

Note the following:

⚠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.

Trademarks

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

Disclaimer of Liability

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

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Automation and Drives
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90327 NÜRNBERG
GERMANY

Order number: 6SL3097-2AB00-0BP4
℗ 08/2007

Foreword

SINAMICS documentation

The SINAMICS documentation is organized in 2 parts:

- General documentation / catalogs
- Manufacturer/service documentation

A current overview of the documentation in the available languages is provided in the Internet:

http://www.siemens.com/motioncontrol

Select the menu items "Support" --> "Technical Documentation" --> "Overview of Publications."

The Internet version of DOConCD (DOConWEB) is available on the Internet:

http://www.automation.siemens.com/doconweb

Information on the range of training courses and FAQs (Frequently Asked Questions) is available on the Internet:

http://www.siemens.com/motioncontrol

Follow the menu item "Support".

Usage phases and their tools/documents (as an example)

Table 1 Usage phases and the available documents/tools

Usage phase	Document/tool
Orientation	SINAMICS S Sales Documentation
Planning/configuration	• SIZER configuration tool • Configuration Manuals, Motors
Decision/ordering	SINAMICS S Catalogs
Installation/assembly	• SINAMICS S120 Equipment Manual for Control Units and Additional System Components • SINAMICS S120 Equipment Manual for Booksize Power Units • SINAMICS S120 Equipment Manual for Chassis Power Units • SINAMICS S120 Equipment Manual for AC Drives

Usage phase	Document/tool
Commissioning	• STARTER parameterization and commissioning tool • SINAMICS S120 Getting Started • SINAMICS S120 Commissioning Manual • SINAMICS S120 CANopen Commissioning Manual • SINAMICS S120 Function Manual • SINAMICS S List Manual
Usage/operation	• SINAMICS S120 Commissioning Manual • SINAMICS S List Manual
Maintenance/servicing	• SINAMICS S120 Commissioning Manual • SINAMICS S List Manual

Target group

This documentation is intended for machine manufacturers, commissioning engineers, and service personnel who use the SINAMICS S drive system.

Benefits

The Function Manual describes all the procedures and operational instructions required for the commissioning of functions and servicing of SINAMICS S120.

The Function Manual is structured as follows:

Chapter 1	Infeed
Chapter 2	Extended setpoint channel
Chapter 3	Servo control
Chapter 4	Vector control
Chapter 5	Vector V/f control (r0108.2 = 0)
Chapter 6	Basic functions
Chapter 7	Function modules
Chapter 8	Monitoring and protective functions
Chapter 9	Safety Integrated basic functions
Chapter 10	PROFIBUS DP/PROFINET IO communication
Chapter 11	Applications
Chapter 12	Basic information about the drive system

Advice for beginners:

First read the chapter on basic functions and then read the relevant chapters.

Search guides

The following guides are provided to help you locate information in this manual:

1. Contents
2. List of abbreviations
3. Index

Standard scope

The scope of the functionality described in this document can differ from the scope of the functionality of the drive system that is actually supplied.

- Other functions not described in this documentation might be able to be executed in the drive system. However, no claim can be made regarding the availability of these functions when the equipment is first supplied or in the event of servicing.
- Functions can be described in the documentation that are not available in a particular product version of the drive system. The functionality of the supplied drive system should only be taken from the ordering documentation.
- Extensions or changes made by the machine manufacturer must be documented by the machine manufacturer.

For reasons of clarity, this documentation does not contain all of the detailed information on all of the product types. This documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

Technical Support

In case of questions, please contact us through the following hotline:

European and African time zones

A&D Technical Support

Tel.: +49 (0) 180 5050 - 222
Fax: +49 (0) 180 5050 - 223
Internet: http://www.siemens.de/automation/support-request

Asian and Australian time zones

A&D Technical Support

Tel: +89 1064 719 990
Fax: +86 1064 747 474
E-mail: adsupport.asia@siemens.com

America time zone

A&D Technical Support

Tel: +1 423 262 2522
Fax: +1 423 262 2200
E-mail: techsupport.sea@siemens.com

Note

Country-specific telephone numbers for technical support are provided under the following Internet address:

http://www.siemens.com/automation/service&support

Questions on the manual

Please send any questions about the technical documentation (e.g. suggestions for improvement, corrections) to the following fax number or E-Mail address:

Fax: +49 (0) 9131 / 98 - 63315
Email: docu.motioncontrol@siemens.com
Fax form: Refer to the reply form at the end of this manual

Internet address for SINAMICS

http://www.siemens.com/sinamics.

EC Declaration of Conformity

The EC Declaration of Conformity for the EMC Directive can be obtained from:

- Internet

http://www.ad.siemens.de/csinfo
Product/Order no: 15257461

- Branch offices

For the responsible regional offices of the A&D MC business division of Siemens AG.

Notation

The following notation and abbreviations are used in this documentation:

Notation for parameters (examples):

- p0918 Adjustable parameter 918
- r1024 Display parameter 1024
- p1070[1] Adjustable parameter 1070, index 1
- p2098[1].3 Adjustable parameter 2098, index 1, bit 3
- p0099[0...3] Adjustable parameter 99 indices 0 to 3
- r0945[2](3) Display parameter 945 index 2 of drive object 3
- p0795.4 Adjustable parameter 795 bit 4

Notation for faults and alarms (examples):

- F12345 Fault 12345
- A67890 Alarm 67890

ESD Notes

> ⚠ CAUTION
>
> Electrostatic sensitive devices (ESD) are single components, integrated circuits or devices that can be damaged by electrostatic fields or electrostatic discharges.
>
> Regulations for the ESD handling:
>
> During the handling of electronic components, pay attention to the grounding of the person, workplace and packaging!
>
> Electronic components may be touched by persons only when
>
> - these persons are grounded using an ESD bracelet, or
> - these persons in ESD areas with a conducting floor wear ESD shoes or ESD grounding straps.
>
> Electronic components should be touched only when this is unavoidable. The touching is permitted only on the front panel or on the circuit board edge.
>
> Electronic components must not be brought into contact with plastics or clothing made of artificial fibers.
>
> Electronic components may only be placed on conducting surfaces (table with ESD coating, conducting ESD foamed material, ESD packing bag, ESD transport container).
>
> Electronic components may not be placed near display units, monitors or televisions (minimum distance from the screen > 10 cm).
>
> Measurements may be made on electronic components when the measuring unit is grounded (e.g. with a protective conductor) or prior to measuring with a potential-free measuring unit, the measuring head is briefly discharged (e.g. by touching a bare metal housing).

Safety instructions

⚠ DANGER

- Commissioning must not start until you have ensured that the machine in which the components described here are to be installed complies with Directive 98/37/EC.
- SINAMICS devices and AC motors must only be commissioned by suitably qualified personnel.
- The personnel must take into account the information provided in the technical customer documentation for the product, and be familiar with and follow the specified danger and warning notices.
- When electrical equipment and motors are operated, the electrical circuits automatically conduct a dangerous voltage.
- When the machine or system is operated, hazardous axis movements can occur.
- All of the work carried-out on the electrical machine or system must be carried-out with it in a no-voltage condition.
- SINAMICS devices with AC motors must only be connected to the power supply via an AC-DC residual-current-operated device with selective switching once verification has been provided that the SINAMICS device is compatible with the residual-current-operated device in accordance with EN 50178, Chapter 5.2.11.2.

⚠ WARNING

- The successful and safe operation of this equipment and motors is dependent on correct transport, proper storage, installation and mounting as well as careful operator control, service and maintenance.
- For special versions of the drive units and motors, information and data in the Catalogs and quotations additionally apply.
- In addition to the danger and warning information provided in the technical customer documentation, the applicable national, local, and plant-specific regulations and requirements must be taken into account.
- Only protective extra-low voltages (PELV) that comply with EN60204-1 may be connected to all connections and terminals between 0 and 48 V.

⚠ CAUTION

- The motors can have surface temperatures of over +80 °C.
- This is the reason that temperature-sensitive components, e.g. cables or electronic components may neither be in contact nor be attached to the motor.
- When attaching the connecting cables, you must ensure that:

  – they are not damaged

  – they are not under tension

  – they cannot come into contact with any rotating parts

CAUTION
• As part of routine tests, SINAMICS devices with AC motors undergo a voltage test in accordance with EN 50178. Before the voltage test is performed on the electrical equipment of industrial machines to EN 60204-1, Section 19.4, all connectors of SINAMICS equipment must be disconnected/unplugged to prevent the equipment from being damaged. • Motors should be connected-up according to the circuit diagram provided. otherwise they can be destroyed.

Note

When operated in dry operating areas, SINAMICS equipment with AC motors conforms to Low-Voltage Directive 73/23/EEC.

Contents

1 Infeed

1.1 Active Infeed

1.1.1 Introduction

General

Note

Line Modules (Active Line Modules, Basic Line Modules, Smart Line Modules) of different types must not be operated simultaneously on the same DC link.

Features

- Controlled DC link voltage whose level can be adjusted (independent of line voltage fluctuations)
- Regenerative feedback capability
- Specific reactive current setting
- Low line harmonics, sinusoidal line current (cosφ = 1

Description

Active Infeed closed-loop control works in conjunction with the line reactor and the Active Line Module as a step-up converter. The level of the DC link voltage can be defined through parameters, and, by means of the control, it is independent of line voltage fluctuations.

The open and closed-loop control firmware for the Active Line Module runs on the Control Unit assigned to it. The Active Line Module and Control Unit communicate via DRIVE-CLiQ.

1.1.2 Active Infeed closed-loop control Booksize

Schematic structure

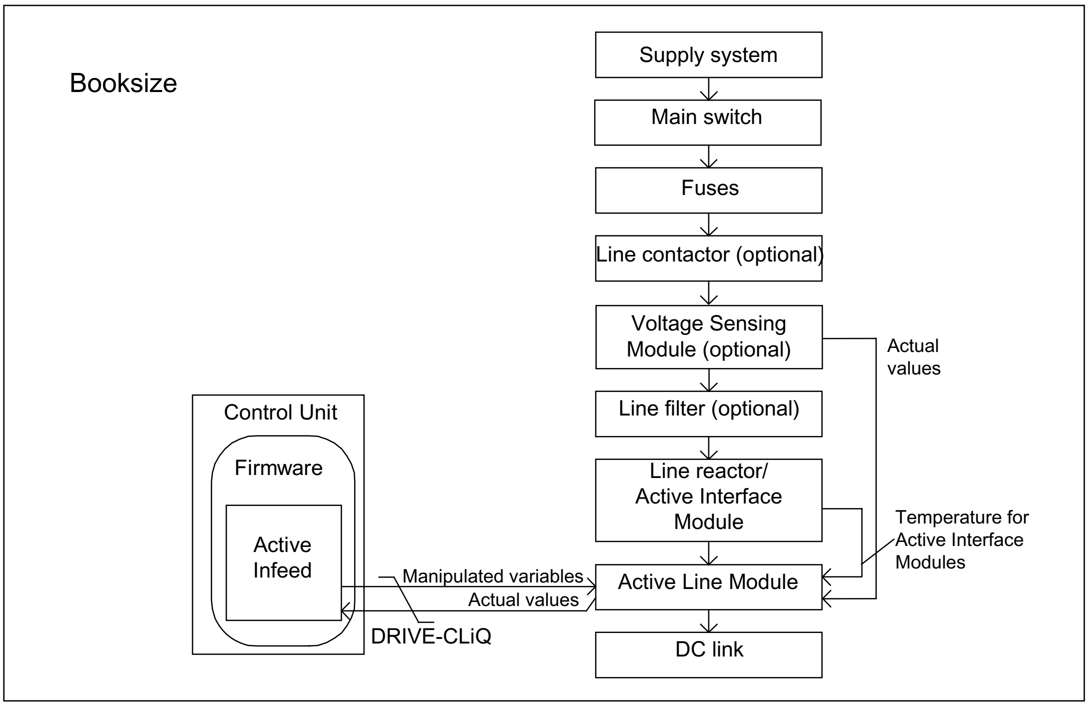


Figure 1-1 Schematic structure of Active Infeed Booksize

Active Infeed closed-loop control for Active Line Modules Booksize

The Active Line Module can be operated in two different modes depending on the parameterized line supply voltage (p0210):

- Active Mode

  In Active Mode, the DC link voltage is regulated to a variable setpoint (p3510), which results in a sinusoidal line current (cosφ = 1). The level of the reactive current is also controlled and can be specifically defined.
- Smart Mode

  Energy recovery capability is maintained in Smart Mode, although there is a lower DC link voltage in comparison to the Active Mode. The DC link voltage is dependent on the current line voltage.

The DC link voltage setpoint (p3510) and the control type are preset as follows during commissioning in line with the connection voltage (p0210):

Table 1-1 Presetting the control type and DC link voltage booksize

Supply voltage p0210 [V]	380-400	401-415	416-440	460	480
Control type p3400.0	"0" = Active Mode		"1" = Smart Mode		
Vdc_soll p3510 [V]	600	625	562-594 1)	621 1)	648 1)

Supply voltage p0210 [V]	380-400	401-415	416-440	460	480
[1] Voltages specified for the smart mode are derived from the rectified line supply voltage. The DC link voltage setpoint (p3510) has no effect in this control mode.					

Voltage Sensing Module (VSM10) used with S120 Active Line Module

Using a Voltage Sensing Module (VSM10) to sense the line voltage, drives can also be operated in systems with heavy frequency fluctuations beyond the range defined in IEC61000-2-4 if specific conditions are met. Heavy frequency fluctuations may occur e.g. in (isolated) diesel-electric systems but not in large interconnected systems such as the European interconnected supply network.
In non-European countries, e.g. in countries with power distribution over a wide geographical region
(countries with a large surface such as Australia, USA, China), line voltage dips occur more frequently, the dips are somewhat lower and, above all, they can occur for longer periods of time up to several seconds. In such line systems, the use of the VSM10 Module is urgently recommended.

The VSM10 Module helps to control extreme line faults, e.g. caused by thunderstorms or rainstorms, without interruptions.

Commissioning

During commissioning, the device supply voltage (p0210) and the selection of an optional line filter (p0220) must be parameterized.

After automatic commissioning, the relevant Wideband Line Filter is preset as the line filter. If the drive line-up is set up differently, then the line filter type must be adjusted using p0220.

When it is first switched on with a new/modified network, an automatic controller setting should be implemented using the line/DC link identification routine (p3410).

Note

In a supply system without regenerative feedback capability (e.g. generators), regenerative operation must be inhibited via the binector input p3533.

CAUTION
When an Active Interface Module is connected, it must be parameterized via p0220 = 4x and the temperature sensor must be connected to X21 of the Active Line Module.

The DC link voltage (p3510) can be set within the following limits:

- Upper limit:
  - Maximum DC link voltage (p0280)
  - Product of line voltage (p0210) and max. step-up factor (r3508)
- Lower limit: Supply voltage (p0210) multiplied by 1.42

1.1.3 Active Infeed closed-loop control Chassis

Schematic structure

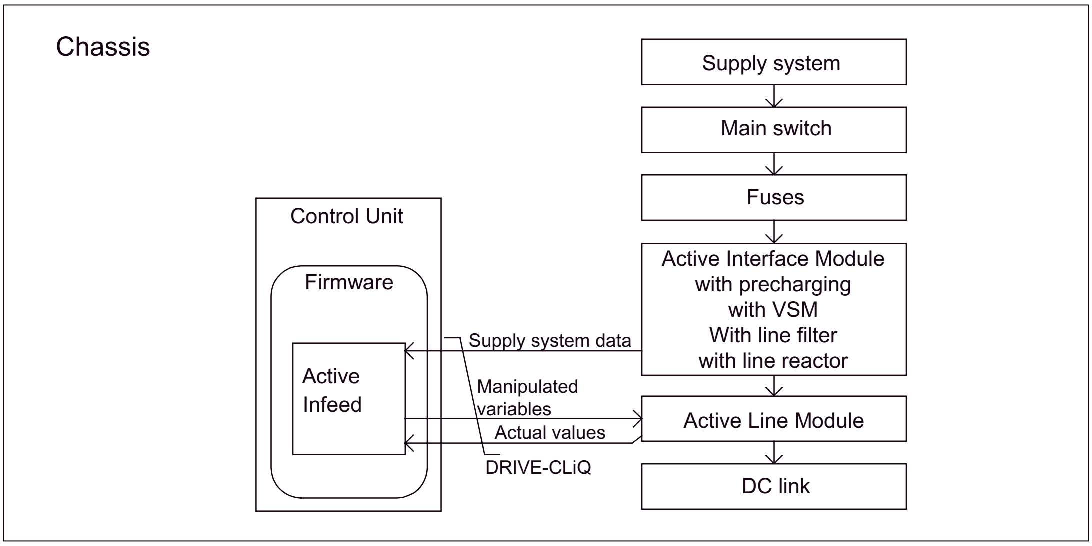


Figure 1-2 Schematic structure of Active Infeed

Operating mode of Active Infeed closed-loop control for Chassis Active Line Modules.

Active Line Modules Chassis only function in Active Mode.

In Active Mode, the DC link voltage is regulated to a variable setpoint (p3510), which results in a sinusoidal line current (cosφ = 1).

The DC link voltage setpoint (p3510) is preset depending on the supply voltage (p0210) using the equation p3510 = 1.5 * p0210.

Commissioning

The device supply voltage (p0210) must be parameterized during commissioning. The necessary line filter (p0220) is preset.

When it is first switched on with a new/modified network, an automatic controller setting should be implemented using the line/DC link identification routine (p3410).

Note

In a supply system without regenerative feedback capability (e.g. generators), regenerative operation must be inhibited via the binector input p3533.

The DC link voltage (p3510) can be set within the following limits:

- Upper limit:
  – Maximum DC link voltage (p0280)
  – Product of line voltage (p0210) and max. step-up factor (r3508)
- Lower limit: Supply voltage (p0210) multiplied by 1.42

1.1.4 Integration

Function diagrams (see SINAMICS S List Manual)

- 1774 Overviews - Active Infeed
- 8920 Control word sequential control infeed
- ...
- 8964 Messages and monitoring, supply frequency and Vdc monitoring

Overview of key parameters (see SINAMICS S List Manual)

- r0002 Infeed/operating display
- r0046 CO/BO: Infeed missing enable signals
- p0210 Device supply voltage
- p0220 Infeed line filter type
- p0280 DC link voltage maximum steady-state
- p0840 BI: ON/OFF1
- p0844 BI: 1. OFF2
- p0852 BI: Enable operation
- p0898 CO/BO: Control word sequential control infeed
- p0899 CO/BO: Status word sequential control infeed
- p2138 CO/BO: Control word, faults/alarms
- p2139 CO/BO: Status word, faults/alarms 1
- p3400 Infeed configuration word
- r3405 CO/BO: Status word infeed
- p3410 Infeed configuration word identification
- p3508 Infeed step-up factor maximum
- p3510 Infeed DC link voltage setpoint
- p3533 BI: Infeed, inhibit regenerative operation
- p3610 Infeed reactive current fixed setpoint
- p3611 CI: Infeed reactive current supplementary setpoint

1.1.5 Line and DC link identification

The characteristic line supply and DC link quantities are determined using the automatic parameter identification routine. They provide the basis to optimally set the controllers in the Line Module.

An optimal setting of the current and voltage control is achieved with the help of the line supply and DC link identification routine. The dynamic response of the current control can be adjusted with p3560.

Note

If the line supply environment changes, or the components connected to the DClink (e.g. after installing and mounting the equipment at the customer's site or after expanding the drive group), then the line supply/DC link identification routine should be repeated with p3410 = 5. Only then can it be guaranteed that the infeed operates with the optimum controller settings.

When the identification function is activated, alarm A06400 is output.

Identification methods

For additional identification methods, see the SINAMICS S List Manual.

- p3410 = 4: An identification run for the total inductance and DC link capacitance is initiated when the pulses are next enabled (two measuring routines with different current magnitudes). Data determined during identification (r3411 and r3412) is entered into p3421 and p3422 and the controller is recalculated. At the same time, the parameters for current controller adaptation are determined (p3620, p3622). All of the parameters for the Infeed Module are then automatically stored in a non-volatile memory.

  The infeed continues to operate without any interruption with the new controller parameters.

- p3410 = 5: The same measurements and write operations are always carried-out for p3410 = 4. Before the first identification run, however, the parameter values for line inductance and DC link capacitance are reset (p3421 = p0223 and p3422 = p0227).

  p3410 is automatically set to 0 after an identification run has been successfully completed.

  Note

  Identification using p3410 = 5 should preferably be used.

  It may be necessary to reset the closed-loop controller to the factory settings if an identification run was unsuccessful, for example.

Overview of key parameters (see SINAMICS S List Manual)

- p3410 Infeed identification method
- r3411 Infeed inductance identified
- r3412 Infeed DC-link capacitance identified
- p3560 Infeed Vdc controller proportional gain

1.1.6 Active Infeed open-loop control

Description

The Active Line Module can be controlled via the BICO interconnection by means of terminals or the field bus. The operating status is indicated on the operating display r0002. The missing enable signals for operation (r0002 = 00) are mapped in parameter r0046. The EP terminals (enable pulses) must be connected in accordance with the Equipment Manual. The drive unit must have been commissioned for the first time.

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0/1 edge at the "Acknowledge error" (p2103) signal.

Switching on the Active Line Module:

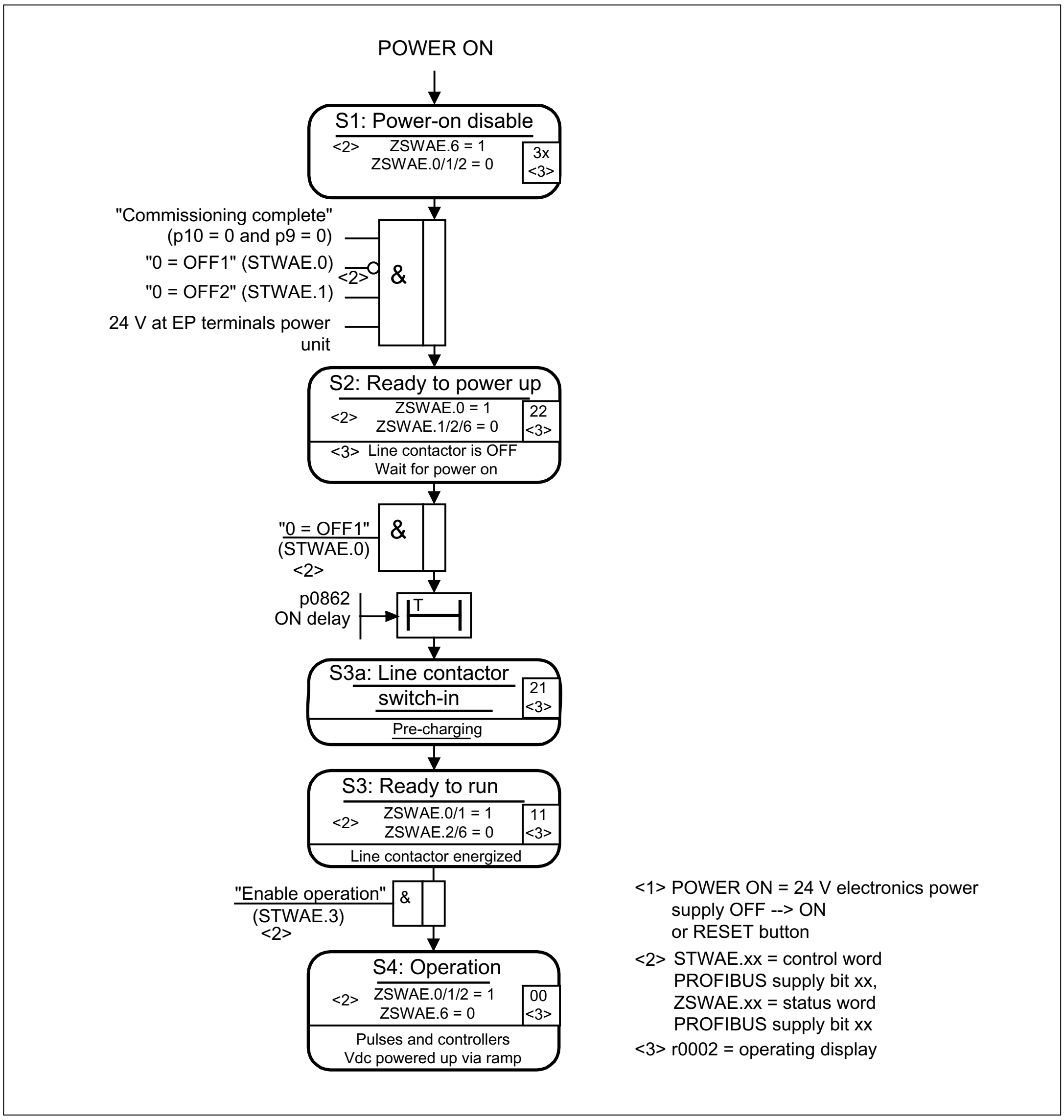


Figure 1-3 Active Infeed power-up

Note

Under the condition that the drive system was commissioned with STARTER and no PROFIdrive telegram was activated, the infeed can be powered-up by issuing an enable signal at the EP terminals and a positive signal edge at OFF1 (p0840).

Switching off the Active Line Module

To switch off the Active Line Module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490. This allows the attached drives to be braked in a controlled manner. Before the infeed is switched off, the drives connected to the DC link should be in pulse inhibit mode.

Control and status messages

Table 1-2 Active Infeed open-loop control

Signal name	Internal control word	Binector input	Display of internal control word	PROFIdrive telegram 370
ON/OFF1	STWAE.0	p0840 ON/OFF1	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 1 OFF2 and p0845 2 OFF2	r0898.1	A_STW1.1
Enable operation	STWAE.3	p0852 Enable operation	r0898.3	A_STW1.3
Disable motor operation	STWAE.5	p3532 Disable motor operation	r0898.5	A_STW1.5
Inhibit regenerating	STWAE.6	p3533 Inhibit regenerating	r0898.6	A_STW1.6
Acknowledge error	STWAE.7	p2103 1 Acknowledge or p2104 2 Acknowledge or p2105 3 Acknowledge	r2138.7	A_STW1.7
Master ctrl by PLC	STWAE.10	p0854 Master ctrl by PLC	r0898.10	A_STW1.10

Table 1-3 Active Infeed status message

Signal name	Internal status word	Parameter	PROFIdrive telegram 370
Ready to power up	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
Fault active	ZSWAE.3	r2139.3	A_ZSW1.3
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-on disable	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm present	ZSWAE.7	r2139.7	A_ZSW1.7
Master ctrl by PLC	ZSWAE.9	r0899.9	A_ZSW1.9
Pre-charging completed	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.1.7 Reactive current control

A reactive current setpoint can be set to compensate the reactive current or to stabilize the line voltage in infeed mode. The total setpoint is the sum of the fixed setpoint p3610 and the dynamic setpoint via the connector input p3611.

Note

The direction of rotation of the network is compensated automatically with reactive current control. A negative reactive current setpoint causes an inductive reactive current; a positive setpoint generates a capacitive reactive current.

Note

The closed-loop control limits the reactive current setpoint dynamically in such a way that the sum of the active current setpoint and the reactive current setpoint does not exceed the maximum device current.

Note

The reactive current consumption of the line filter selected in the configuration Wizard is automatically covered by the Active Infeed closed-loop control. This means that the display value of the current reactive current setpoint in r0075 no longer corresponds with the parameterized total reactive current setpoint.

Note

The reactive power setpoint of the Line Module with respect to the network can be derived by multiplying the parameterized total reactive current setpoint by 1.73 * rated line voltage.

1.1.8 Harmonics controller

Description

Harmonics in the line voltage cause harmonics in the line currents. Current harmonics can be reduced by activating the harmonics controller.

Example: setting the harmonics controller

The 5th and 7th harmonics are to be compensated:

Table 1-4 Example parameters for the harmonics controller

Index	p3624 harmonics controller order	p3625 scaling
[0]	5	100 %
[1]	7	100 %
The phase currents in parameter p0069[0..2] (U, V, W) can be checked using the STARTER trace function.		

Overview: key parameters

- p3624 Infeed harmonics controller order
- p3625 Infeed harmonics controller scaling
- r0069[0..6] Phase current, actual value

1.2 Smart Infeed

1.2.1 Smart Infeed closed-loop control

General

Note

Line Modules (Active Line Modules, Basic Line Modules, Smart Line Modules) of different types must not be operated simultaneously on the same DC link.

Features

- For Smart Line Modules with a power of ≥ 16 kW
- Unregulated DC link voltage
- Regenerative feedback capability

Description

The firmware for the Smart Line Modules is on the Control Unit assigned to it. The Smart Line Module and Control Unit communicate via DRIVE-CLiQ.

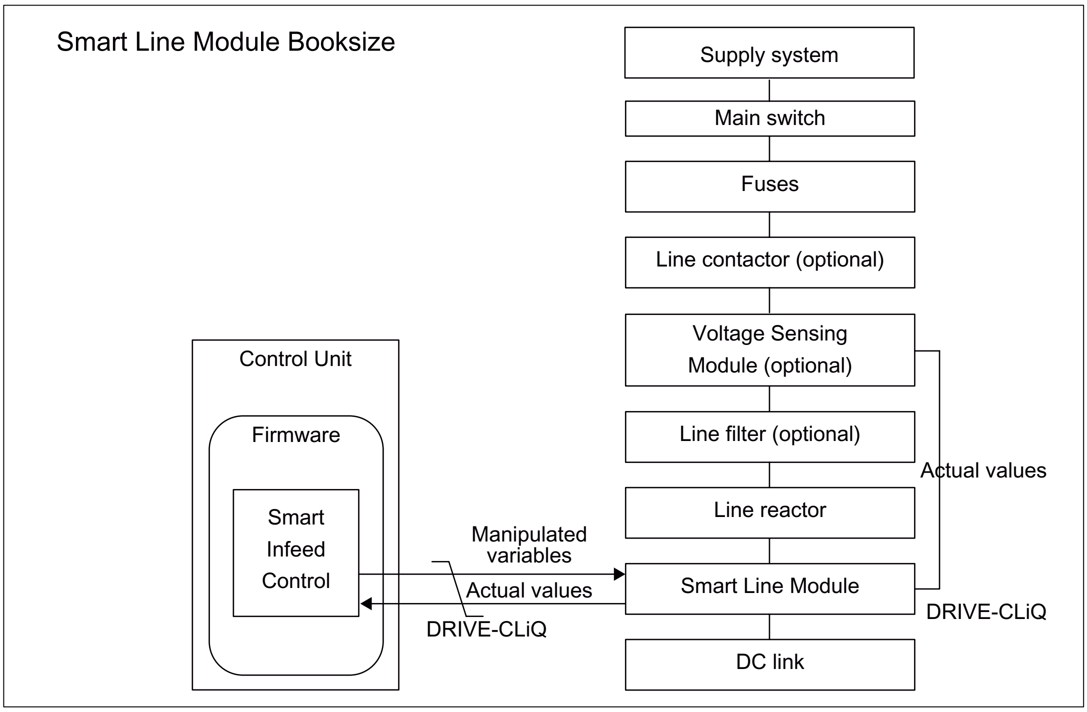


Figure 1-4 Terminal diagram for Smart Infeed Booksize

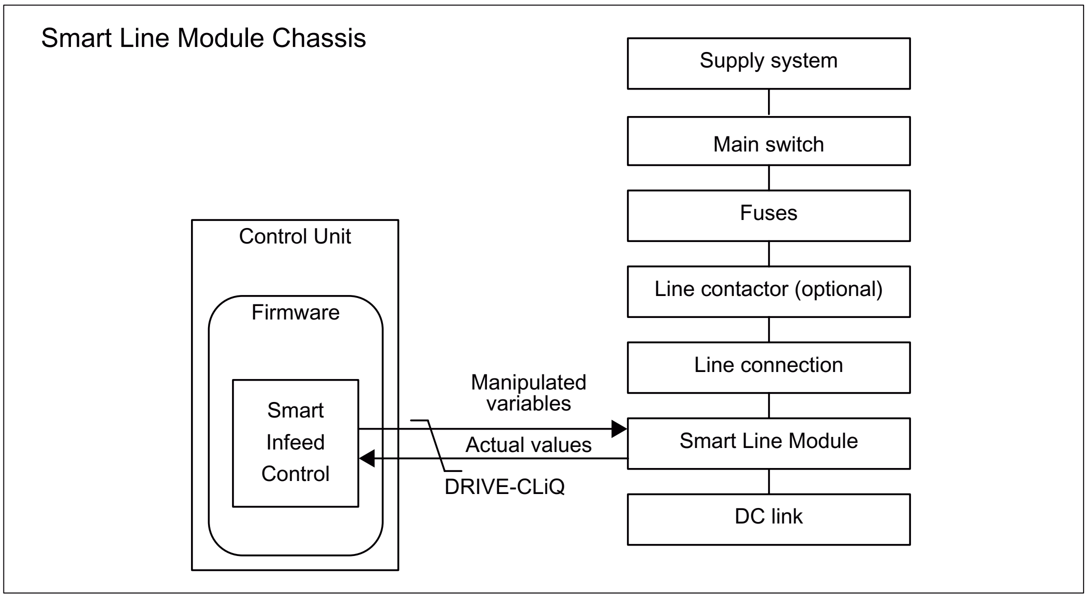


Figure 1-5 Connection diagram Smart Infeed Chassis

Commissioning

The device connection voltage (p0210) must be parameterized during commissioning.

Note

In a supply system without regenerative feedback capability (e.g. generators), regenerative operation must be inhibited via the binector input p3533.

Function diagrams (see SINAMICS S List Manual)

- 1775 Overviews - Smart Infeed
- 8820 Control word sequential control infeed
- 8826 Status word sequential control infeed
- 8828 Status word infeed
- 8832 Processor
- 8834 Missing enables, line contactor control
- 8850 Interface to the Smart Infeed (control signals, actual values)
- 8860 Supply voltage monitoring
- 8864 Power frequency and Vdc monitoring

Overview of key parameters (see SINAMICS S List Manual)

- r0002 Infeed/operating display
- r0046 CO/BO: Infeed missing enable signals
- p0210 Device supply voltage
- p0840 BI: ON/OFF1
- p0844 BI: 1. OFF2
- p0852 BI: Enable operation
- r0898 CO/BO: Control word sequential control infeed
- r0899 CO/BO: Status word sequence control infeed
- r2138 CO/BO: Control word, faults/alarms
- r2139 CO/BO: Status word, faults/alarms 1
- r3405 CO/BO: Status word infeed
- p3533 BI: Infeed, inhibit regenerative operation

1.2.2 Line supply and DC link identification routine for Smart Infeed Booksize

The characteristic line supply and DC link quantities are determined using the automatic parameter identification routine. They provide the basis to optimally set the controllers in the Line Module.

Note

If the line supply environment changes, or the components connected to the DClink (e.g. after installing and mounting the equipment at the customer's site or after expanding the drive group), then the line supply/DC link identification routine should be repeated with p3410 = 5. Only then can it be guaranteed that the infeed operates with an optimum controller setting.

When the identification function is activated, alarm A06400 is output.

CAUTION
The line supply and DC link identification routine is not permissible for Smart Line Modules of the Chassis type.

Identification methods

For additional identification methods, see the SINAMICS S List Manual.

- p3410 = 4: An identification run for the total inductance and DC link capacitance is initiated when the pulses are next enabled (two measuring routines with different current magnitudes). Data determined during identification (r3411 and r3412) is entered into p3421 and p3422 and the controller is recalculated. At the same time, the parameters for current controller adaptation are determined (p6320, p6322). All of the parameters for the Infeed Module are then automatically stored in a non-volatile memory.

  The infeed continues to operate without any interruption with the new controller parameters.

- p3410 = 5: The same measurements and write operations are always carried-out for p3410 = 4. However, before the first identification run, the parameter values for line inductance and DC link capacitance are reset (p3421 = p0223 and p3422 = p0227) and the coarse settings are made for the controller.

  p3410 is automatically set to 0 after an identification run has been successfully completed.

  Note

  Identification using p3410 = 5 should preferably be used.

  It may be necessary to reset the closed-loop controller to the factory settings if an identification run was unsuccessful, for example.

Overview of key parameters (SINAMICS S List Manual)

- p3410 Infeed identification method
- p3421 Infeed inductance
- p3422 Infeed DC link capacity

1.2.3 Smart Infeed open-loop control

Description

The Smart Line Module can be controlled via the BICO interconnection by means of terminals or the field bus. The operating status is indicated on the operating display r0002. The missing enable signals for operation (r0002 = 00) are mapped in parameter r0046. The EP terminals (enable pulses) must be connected in accordance with the Equipment Manual. The drive unit must have been commissioned for the first time.

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0/1 edge at the "Acknowledge error" (p2103) signal.

Switching on the Smart Line Module

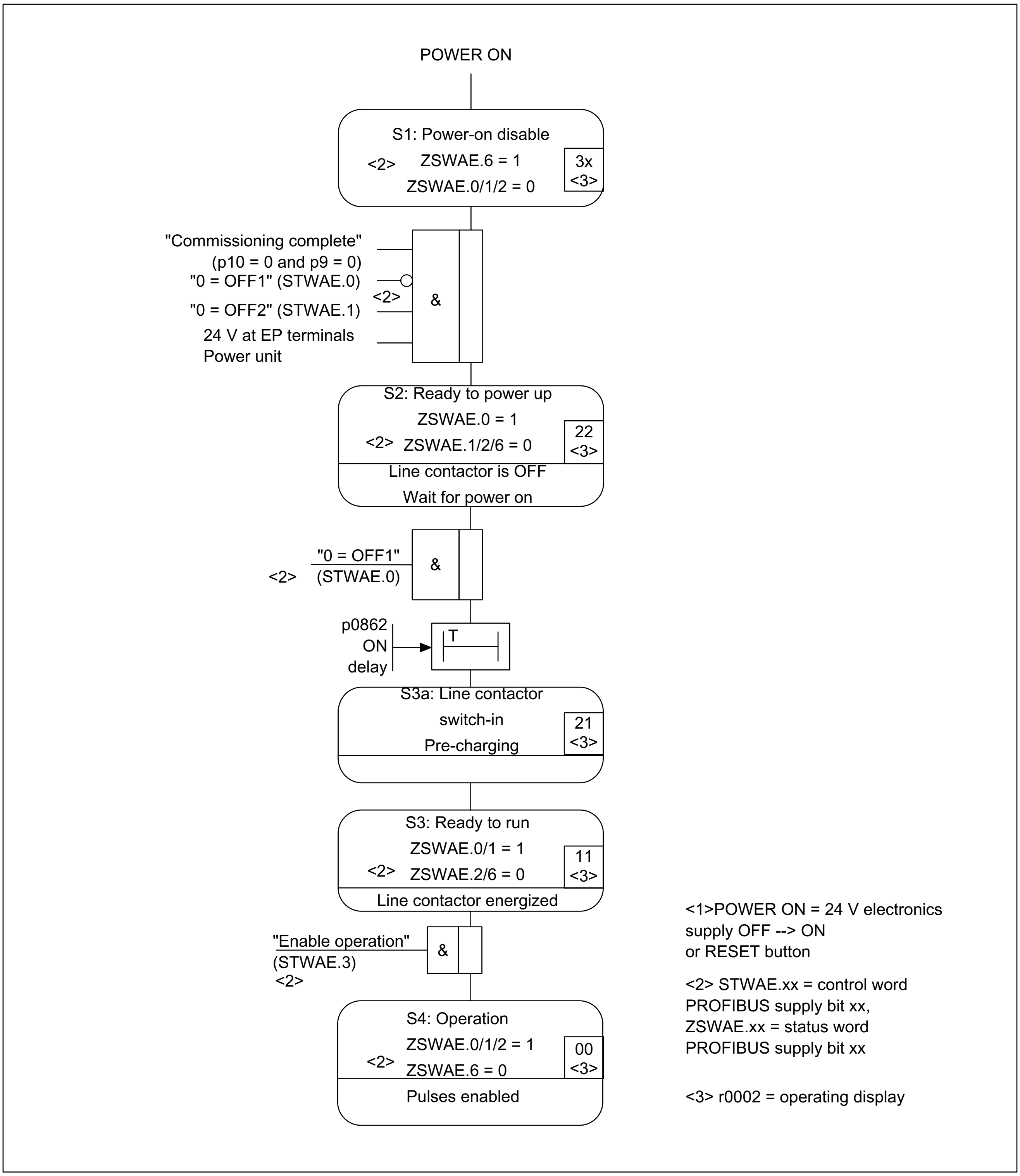


Figure 1-6 Smart Infeed power-up

Note

Under the condition that the drive system was commissioned with STARTER and no PROFIdrive telegram was activated, the infeed can be powered-up by issuing an enable signal at the EP terminals and a positive signal edge at OFF1 (p0840).

Switching off the Smart Line Module

To switch off the Active Line Module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490. This allows the attached drives to be braked in a controlled manner.

Control and status messages

Table 1-5 Smart Infeed open-loop control

Signal name	Internal control word	Binector input	Display of internal control word	PROFIdrive telegram 370
ON/OFF1	STWAE.0	p0840 ON/OFF1	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 1 OFF2 and p0845 2 OFF2	r0898.1	A_STW1.1
Enable operation	STWAE.3	p0852 Enable operation	r0898.3	A_STW1.3
Inhibit regenerating	STWAE.6	p3533 Inhibit regenerating	r0898.6	A_STW1.6
Acknowledge error	STWAE.7	p2103 1 Acknowledge or p2104 2 Acknowledge or p2105 3 Acknowledge	r2138.7	A_STW1.7
Master ctrl by PLC	STWAE.10	p0854 Master ctrl by PLC	r0898.10	A_STW1.10

Table 1-6 Smart Infeed status message

Signal name	Internal status word	Parameter	PROFIdrive telegram 370
Ready to power up	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
Fault active	ZSWAE.3	r2139.3	A_ZSW1.3
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-on disable	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm present	ZSWAE.7	r2139.7	A_ZSW1.7
Master ctrl by PLC	ZSWAE.9	r0899.9	A_ZSW1.9

Signal name	Internal status word	Parameter	PROFIdrive telegram 370
Pre-charging completed	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.3 Basic Infeed

1.3.1 Basic Infeed open-loop control

General

Note

Line Modules (Active Line Modules, Basic Line Modules, Smart Line Modules) of different types must not be operated simultaneously on the same DC link.

Features

- For Basic Line Modules Chassis and Booksize
- Unregulated DC link voltage
- Intregrated control of external braking resistors with 20 kW and 40 kW Basic Line Modules (with temperature monitoring)

Description

Basic Infeed open-loop control can be used to switch on/off the Basic Line Module. The Basic Line Module is an unregulated infeed unit without regenerative feedback capability.

The open-loop control firmware for the Basic Line Module runs on the Control Unit assigned to it. The Basic Line Module and Control Unit communicate via DRIVE-CLiQ.

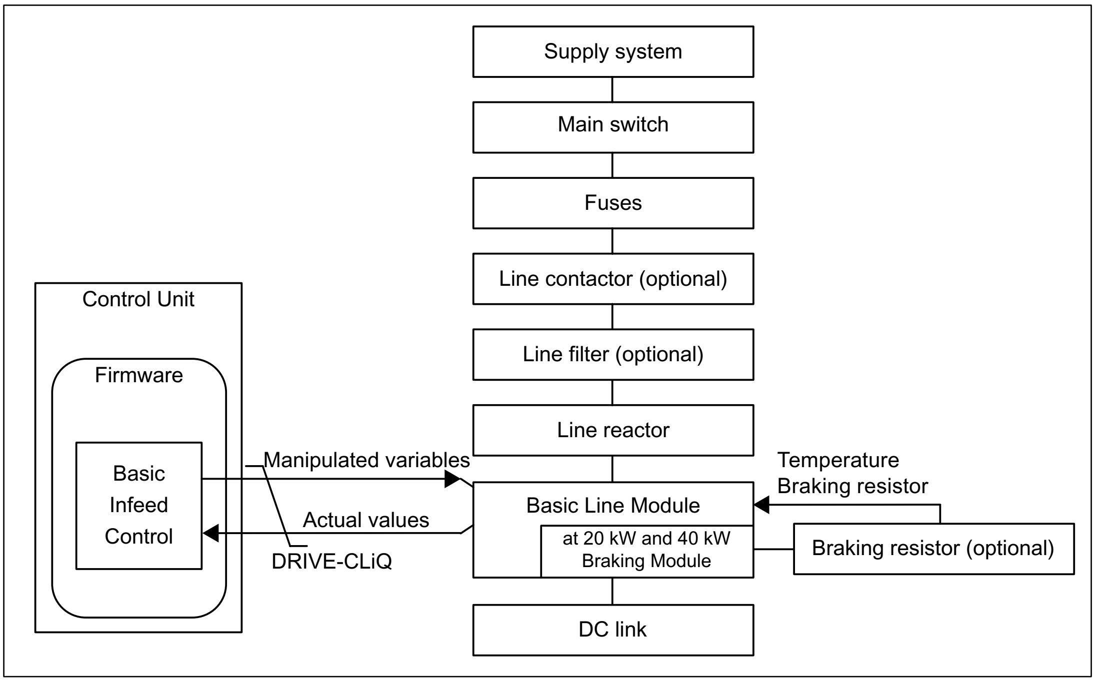


Figure 1-7 Schematic structure of Basic Infeed Booksize

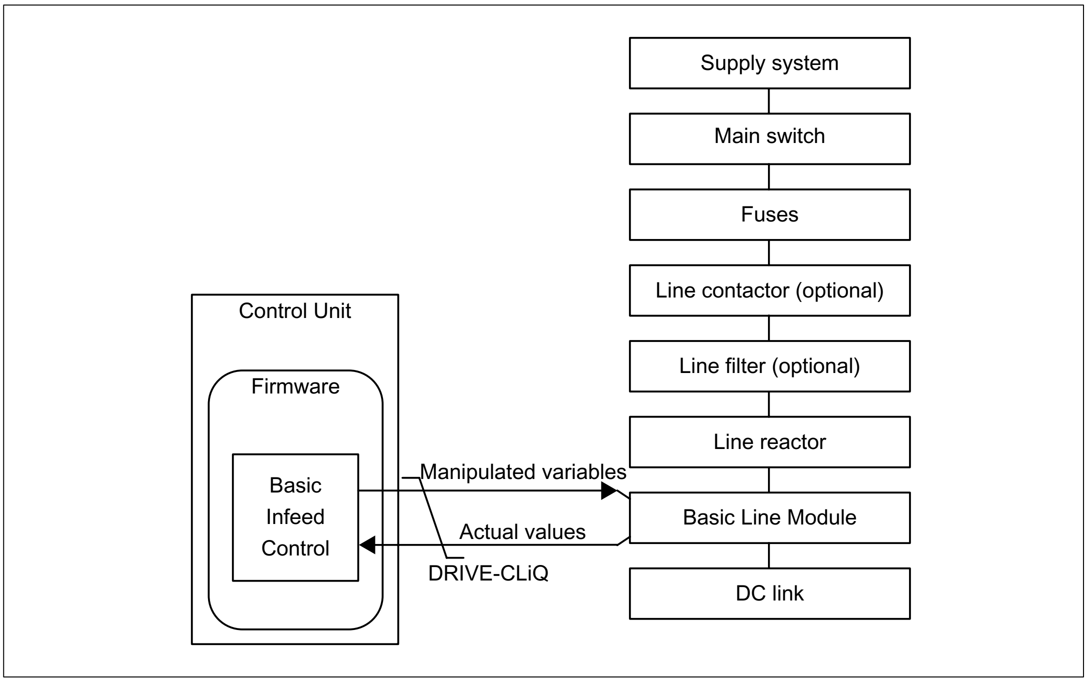


Figure 1-8 Schematic structure of Basic Infeed Chassis

Commissioning

The rated line voltage (p0210) must be parameterized during commissioning.

With 20 KW/40 kW Basic Line Modules, the temperature switch of the external braking resistor must be connected to X21 on the Basic Line Module.

If a braking resistor has not been connected for 20 kW and 40 kW Basic Line Modules Booksize, the braking chopper must be deactivated via p3680 = 1.

Function diagrams (see SINAMICS S List Manual)

- 8720 Control word sequential control infeed
- ...
- 8760 Messages and monitoring functions

Overview of key parameters (see SINAMICS S List Manual)

- r0002 Infeed/operating display
- r0046 CO/BO: Infeed missing enable signals
- p0210 Device supply voltage
- p0840 BI: ON/OFF1
- p0844 BI: 1. OFF2
- r0898 CO/BO: Control word sequential control infeed
- r0899 CO/BO: Status word sequence control infeed
- r2138 CO/BO: Control word, faults/alarms
- r2139 CO/BO: Status word, faults/alarms 1
- p3680 Inhibit braking chopper

1.3.2 Basic Infeed open-loop control

Description

The Basic Line Module can be controlled via the BICO interconnection by means of terminals or the field bus. The operating status is indicated on the operating display r0002. The missing enable signals for operation (r0002 = 00) are mapped in parameter r0046. The EP terminals (enable pulses) must be connected in accordance with the Equipment Manual.

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0/1 edge at the "Acknowledge error" (p2103) signal.

Switching on the Basic Line Module

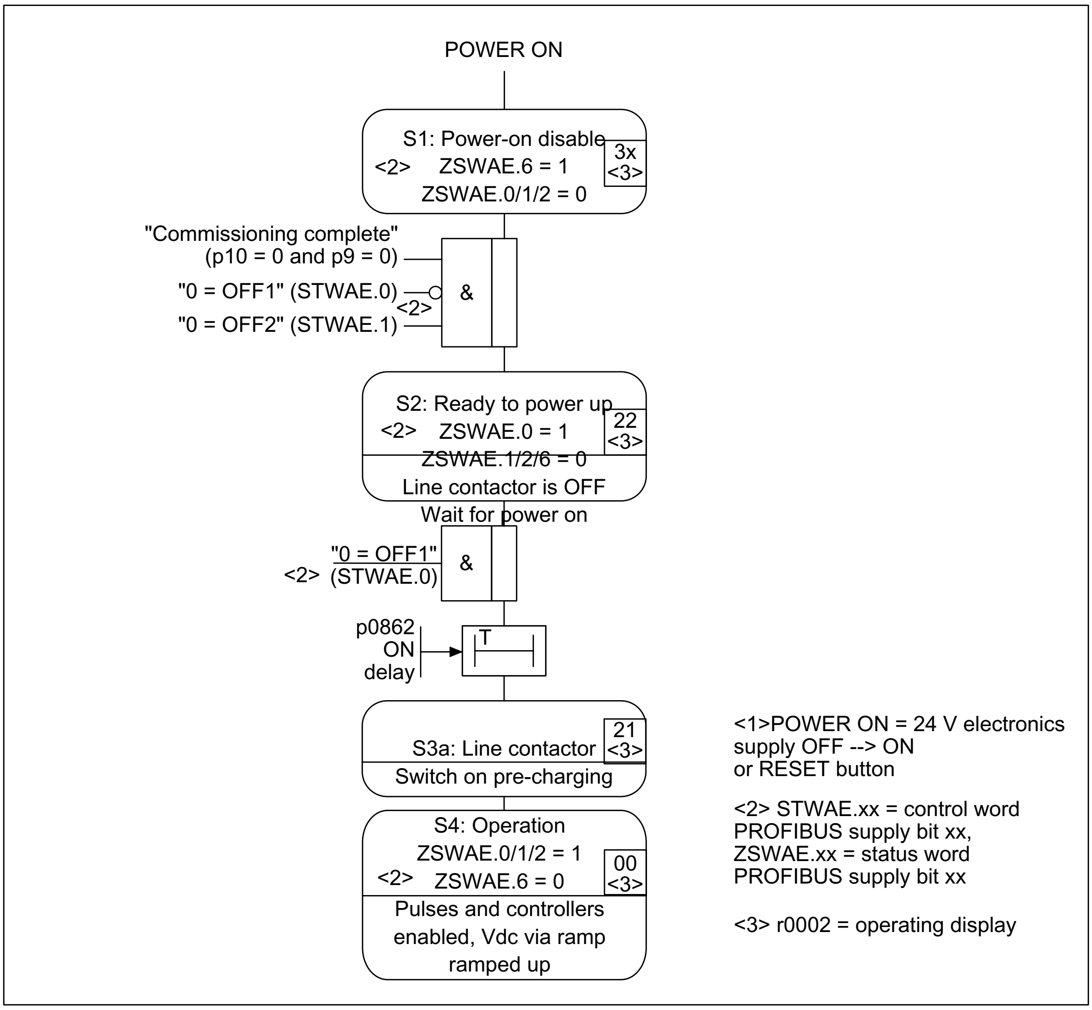


Figure 1-9 Basic Infeed power-up

Note

Under the condition that the drive system was commissioned with STARTER and no PROFIdrive telegram was activated, the infeed can be powered-up by issuing an enable signal at the EP terminals and a positive signal edge at OFF1 (p0840).

Switching off the Basic Line Module

To switch off the Active Line Module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490. This allows the attached drives to be braked in a controlled manner.

Control and status messages

Table 1-7 Basic Infeed open-loop control

Signal name	Internal control word	Binector input	Display of internal control word	PROFIdrive telegram 370
ON/OFF1	STWAE.0	p0840 ON/OFF1	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 1 OFF2 and p0845 2 OFF2	r0898.1	A_STW1.1
Acknowledge error	STWAE.7	p2103 1 Acknowledge or p2104 2 Acknowledge or p2105 3 Acknowledge	r2138.7	A_STW1.7
Master ctrl by PLC	STWAE.10	p0854 Master ctrl by PLC	r0898.10	A_STW1.10

Table 1-8 Basic Infeed status message

Signal name	Internal status word	Parameter	PROFIdrive telegram 370
Ready to power up	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-on disable	ZSWAE.6	r0899.6	A_ZSW1.6
Master ctrl by PLC	ZSWAE.9	r0899.9	A_ZSW1.9
Pre-charging completed	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.4 Line contactor control

Description

This function can be used to control an external line contactor. Opening and closing the line contactor can be monitored by evaluating the feedback contact in the line contactor. The line contactor is used for the electrical isolation of the DC link for the energy supply network.

The line contactor can be controlled using the following drive objects:

- Via bit r0863.1 of drive object INFEED
- Via bit r0863.1 of drive object SERVO/VECTOR

Note

For more information on the line connection, see the Equipment Manuals.

Example of commissioning line contactor control

Assumption:

- Line contactor control via a digital output of the Control Unit (DI/DO 8)
- Line contactor feedback via a digital input of the Control Unit (DI/DO 9)
- Line contactor switching time less than 100 ms

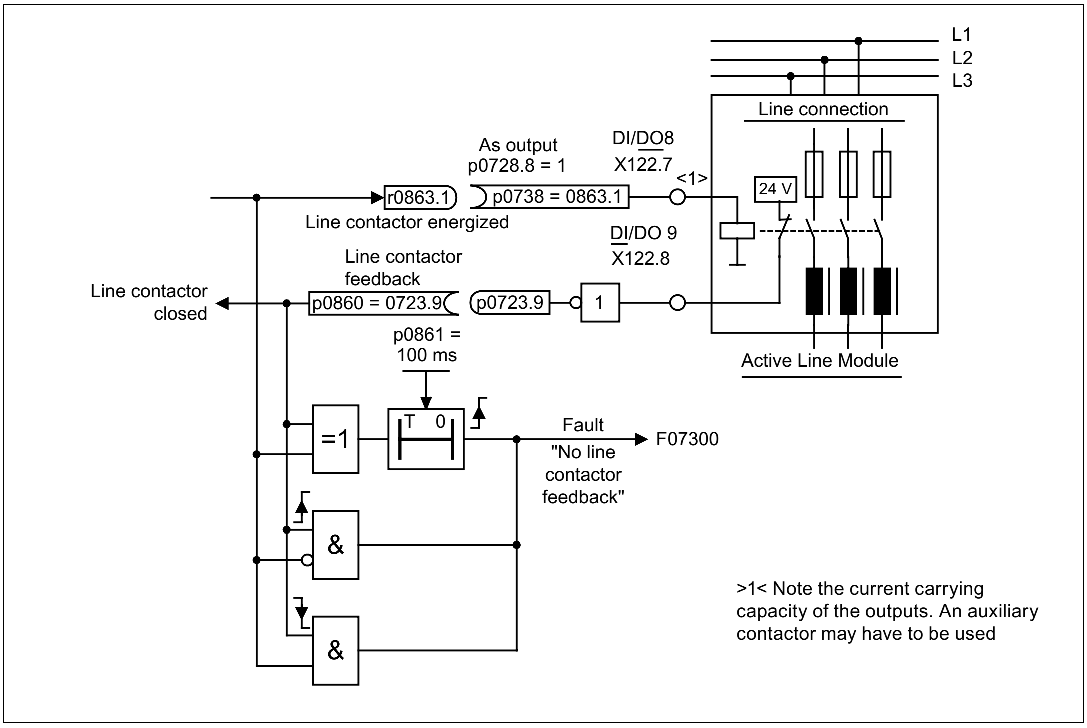


Figure 1-10 Line contactor control

Commissioning steps:

- Connect the line contactor control contact to DI/DO 8.

Note

Note the current carrying capacity of the digital output (see the Equipment Manual). A line contactor may have to be used.

- Parameterize DI/DO 8 as an output (p728.8 = 1).
- Assign p0738 the control signal for the line contactor r0863.1.
- Connect the line contactor feedback contact to DI/DO 9.
- Assign p0860 an inverted input signal r0723.9.
- Enter the monitoring time for the line contactor (100 ms) in p0861.

Function diagrams (see SINAMICS S List Manual)

- 8934 Missing enables, line contactor control

Overview of key parameters (see SINAMICS S List Manual)

- r0863.1 CO/BO: Drive coupling status word/control word
- p0860 BI: Line contactor, feedback signal

1.5 Pre-charging and bypass contactor chassis

Description

Pre-charging is the procedure for charging the DC link capacitors via resistors. Pre-charging is normally carried out from the feeding supply network, although it can also be carried out from a pre-charged DC link. The pre-charging input circuit limits the charging current of the DC link capacitors.

The pre-charging input circuit for Active and Smart Infeed in the chassis design comprises a pre-charging contactor with pre-charging resistors and a bypass contactor. The Active Line Module controls the pre-charging input circuit in the Active Interface Module via terminals.

The pre-charging input circuit in the Active Interface Module of module types FI and GI contains the bypass contactor. The bypass contactor must be provided separately for types HI and JI.

With the Smart Line Module, pre-charging is integrated in the Smart Line Module itself, although the bypass contactor must be provided externally.

For further information: see the Equipment Manual.

Procedure during power ON/OFF

Power ON:

- The pre-charging contactor is closed and the DC link is charged via the pre-charging resistors.
- Once pre-charging is complete, the bypass contactor is closed and the pre-charging contactor opened. The DC link is pre-charged and ready to operate. If pre-charging could not be completed, fault F06000 is output.

Power OFF:

- The pulses are inhibited and the bypass contactor is then opened.

1.6 Derating function for chassis units

Description

An adjusted derating function can greatly reduce the noise level during the operation of the chassis power units (Motor and Power Modules) and enable operation at a multiple of the nominal pulse frequency at nearly nominal current. This is achieved by monitoring the temperature increase between heat-sink and chip by means of temperature sensors. When the operating temperature threshold is exceeded, the pulse frequency or permitted current limit, respectively, is automatically reduced.

This enables the maximum output current of the power unit to be achieved even at high pulse frequencies. The derating curve becomes effective at a later point.

The derating function is effective with Motor Modules (DC/AC units of chassis type) and Power Modules (AC/AC units of chassis type). Units that are connected in parallel operate in the same manner as single units. The dependency of the output current of the pulse frequency for the chassis power units of the SINAMICS S120 is described in the S120 Function Manual, Chassis Power Units.

Functional principle

In order to optimize the use of the power unit also at temperatures below the maximum permitted ambient temperature, the maximum output current is controlled as a function of the operating temperature. This function also accounts for the dynamic response of the thermal performance (rise and decay curves of the operating temperature).

An alarm threshold is calculated that is weighted with the current ambient temperature.

By weighting the alarm threshold with the current ambient temperature, the power unit can output higher currents close to nominal current even at lower ambient temperatures.

Depending on the setting of parameter p290 "Power unit overload response", the pulse frequency or the current will be reduced, or no response will occur if the alarm threshold is exceeded. An alarm (e.g. A07805 "Infeed: Power unit overload") is generated even if no response is desired.

The following quantities can result in a response to thermal overload:

- Heat-sink temperature (r0037.0)
- Chip temperature (r0037.1)
- Power unit overload I2T (r0036)

Possible measures to avoid thermal overload:

- Reduce the output current (closed-loop speed/velocity or torque/force control) or the output frequency (V/f control).
- Reduce the pulse frequency (only for closed-loop vector control).

Parameter r293 "Power unit alarm threshold model temperature" indicates the temperature alarm threshold for the difference between the chip and heat-sink temperatures.

1.7 Parallel connections of 6-pulse and 12-pulse chassis infeeds

Description

With Basic Line Modules and chassis units, in addition to 6-pulse parallel infeed (infeed via two-winding transformer), it is also possible to use a 12-pulse parallel infeed (infeed via three-winding transformer).

6-pulse parallel infeeds (two-winding transformer)

For the parallel operation of 6-pulse infeeds, a common Control Unit should always be used for Basic Line Modules and Smart Line Modules.

For Basic Line Modules, a second, separate Control Unit may be used if redundancy is desired.

12-pulse parallel infeeds (three-winding transformer)

For 12-pulse parallel infeeds via Smart Line Modules, separate Control Units must be provided for each infeed due to the 30° phase offset between the two converter systems.

Parallel operation of two 12-pulse infeeds, controlled by a single Control Unit, is possible with Basic Line Modules. If redundancy is desired, a second, separate Control Unit can be used.

When separate Control Units are used, pre-charging may not be synchronized accurately enough, i.e. a converter system must be able to pre-charge the total capacity of the drive line-up. Pre-charging power for the DC link in parallel operation must be dimensioned so that the capacity of the DC link can be fully charged by a single converter system. Otherwise a separate pre-charging device must be provided.

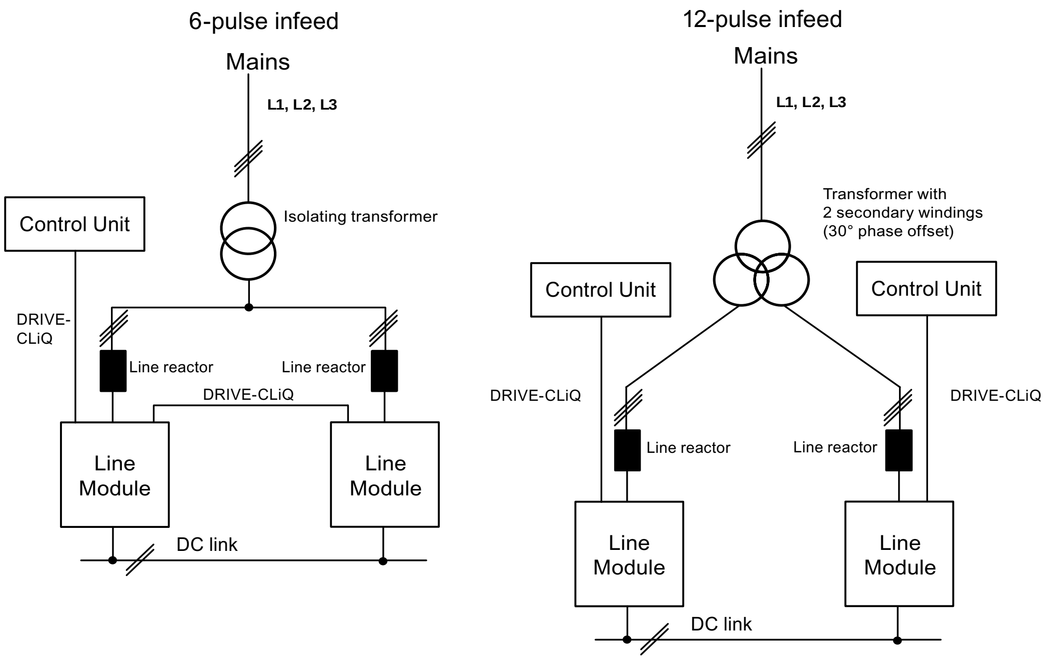


Figure 1-11 Parallel infeeds for 6-pulse and 12-pulse operation

2 Extended setpoint channel

Description

In the servo operating mode, the extended setpoint channel is deactivated by default. If an extended setpoint channel is required, it has to be activated.

Properties of servo mode without the "extended setpoint channel" function module

- The setpoint is directly interconnected to p1155[D] (e.g. from a higher-level control or technology controller)
- A higher number of motors can be controlled with one Control Unit at one setpoint source by moving the ramp-function generator to the higher-level controller.
- Dynamic Servo Control (DSC) only

  When using DSC, the "extended setpoint channel" is not used. This unnecessarily uses the computation time of the Control Unit and, for servo, can be de-activated.
- Deceleration ramp OFF1 via p1121[DDS]
- Deceleration ramp OFF3 via p1135[DDS]
- For PROFIdrive telegrams 2 to 106 and 999 only (free assignment)
- STW 1 bit 5 (freeze ramp-function generator), no function

2.1 Activating the "extended setpoint channel" function module in servo mode

In servo mode, the "extended setpoint channel" function module can be activated via the commissioning Wizard or the drive configuration (configure DDS).

You can check the current configuration in parameter r0108.8. Once you have set the configuration, you have to download it to the Control Unit where it is stored in a non-volatile memory (see the SINAMICS S120 Commissioning Manual).

Note

When the "extended setpoint channel" function module for servo is activated, under certain circumstances, the number of drives in the multi-axis group that can be controlled from a Control Unit is reduced.

2.2 Description

In the extended setpoint channel, setpoints from the setpoint source are conditioned for motor control.

The setpoint for motor control can also originate from the technology controller (see "Technology controller").

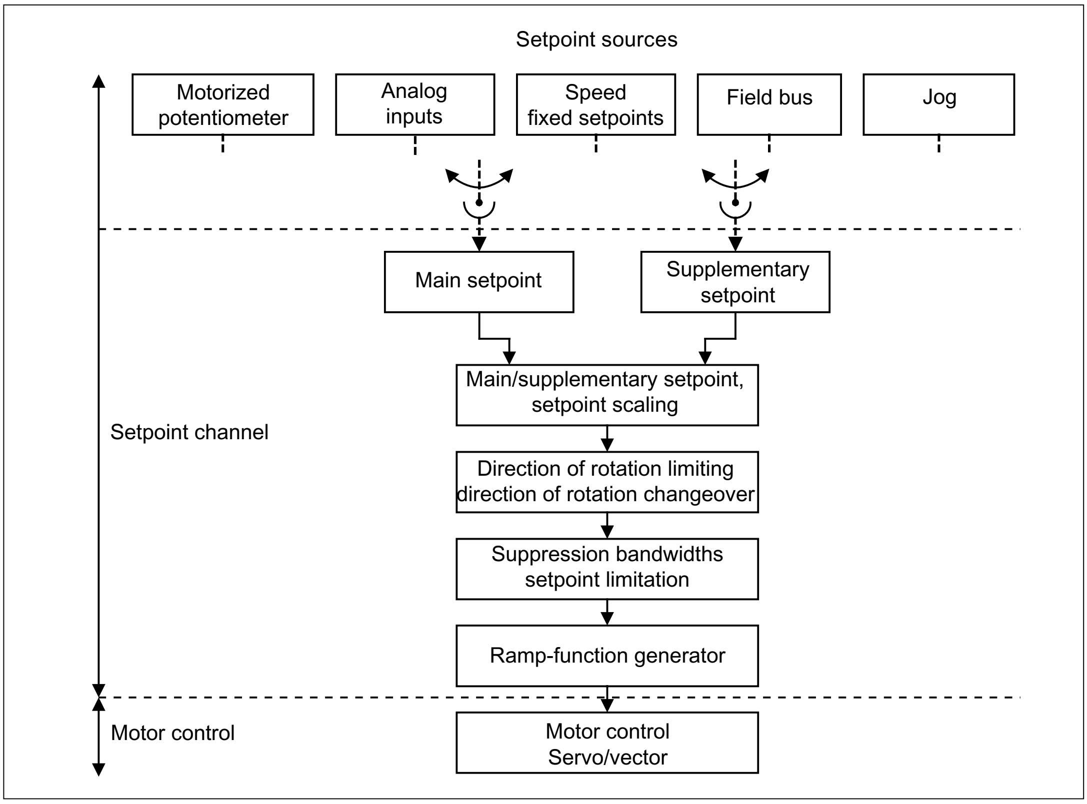


Figure 2-1 Extended setpoint channel

Properties of the extended setpoint channel

- Main/supplementary setpoint, setpoint scaling
- Direction of rotation limiting and direction of rotation changeover
- Suppression bandwidths and setpoint limitation
- Ramp function generator

Setpoint sources

The closed-loop control setpoint can be interconnected from various sources using BICO technology (e.g. to p1070 CI: main setpoint (see function diagram 3030)).

There are various options for setpoint input:

- Fixed speed setpoints
- Motorized potentiometer

- Jog
- Field bus
  - Setpoint via PROFIBUS, for example
- Via the analog inputs of the following exemplary components:
  - e.g. Terminal Board 30 (TB30)
  - e.g. Terminal Module 31 (TM31)
  - e.g. Terminal Module 41 (TM41)

2.3 Jog

Description

This function can be selected via digital inputs or via a field bus (e.g. PROFIBUS). The setpoint is, therefore, predefined via p1058[D] and p1059[D].

When a jog signal is present, the motor is accelerated to the jog setpoint with the acceleration ramp of the ramp-function generator (referred to the maximum speed p1082; see diagram "Function chart: jog 1 and jog 2"). After the jog signal has been deselected, the motor is decelerated via the set ramp of the ramp-function generator.

CAUTION
The jog function is not PROFIdrive compatible!

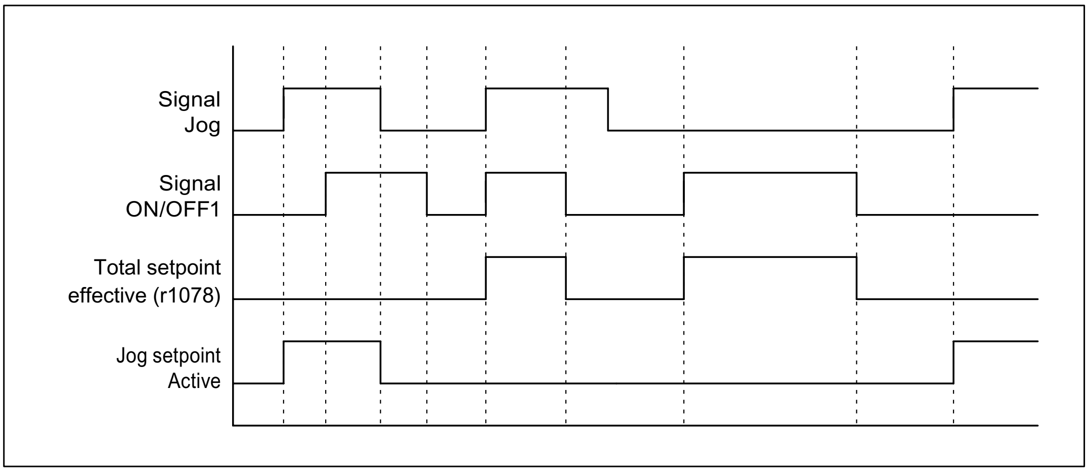


Figure 2-2 Function chart: jog and OFF1

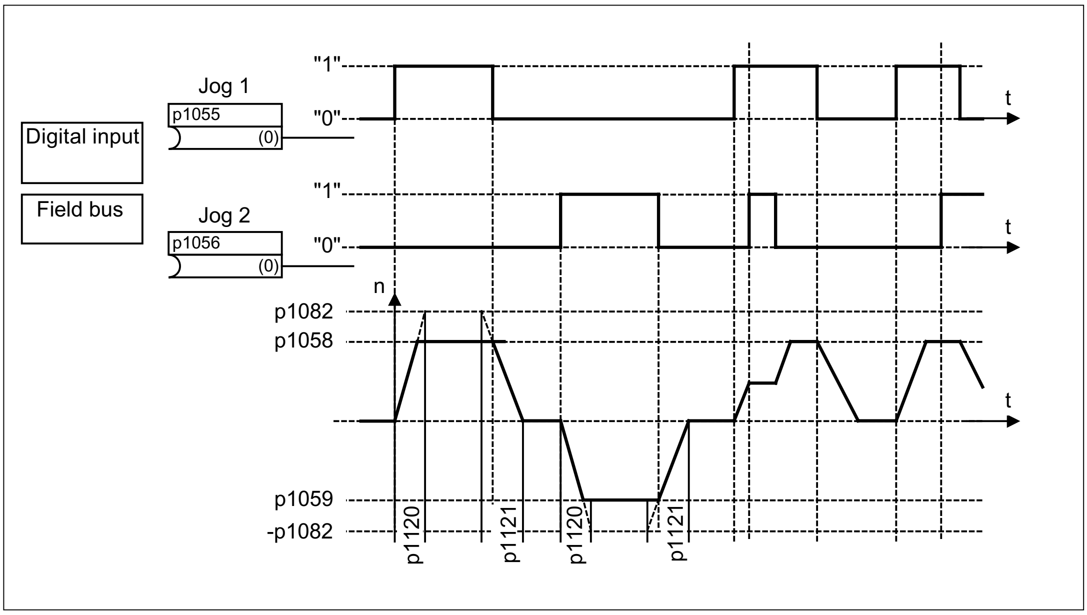


Figure 2-3 Function chart: jog 1 and jog 2

Jog properties

- If both jog signals are issued at the same time, the current speed is maintained (constant velocity phase).
- Jog setpoints are approached and exited via the ramp-function generator.
- The jog function can be activated from the "ready to start" status and from the OFF1 deceleration ramp.
- If ON/OFF1 = "1" and jog are selected simultaneously, ON/OFF1 has priority.
- OFF2 and OFF3 have priority over jogging.
- In jog mode, the main speed setpoints (r1078) and the supplementary setpoints 1 and 2 (p1155 and p1160) are inhibited.
- The suppression bandwidths (p1091 ... p1094) and the minimum limit (p1080) in the setpoint channel are also active in jog mode.
- In jog mode, ZSWA.02 (operation enabled) is set to "0" because the speed setpoint has not been enabled for control.
- The ramp-function generator cannot be frozen (via p1141) in jog mode (r0046.31 = 1).

Jog sequence

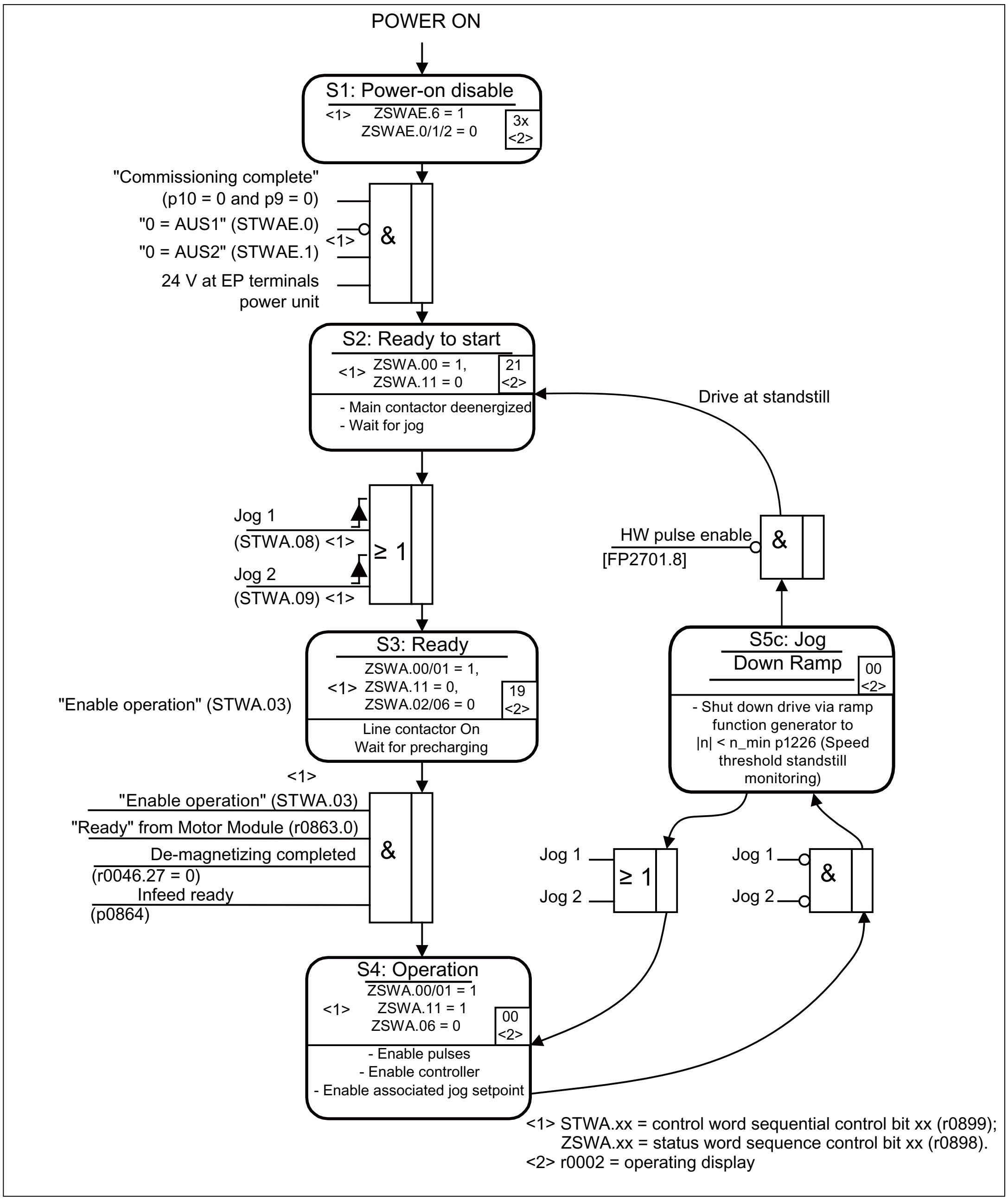


Figure 2-4 Jog sequence

Control and status messages

Table 2-1 Jog control

Signal name	Internal control word	Binector input	PROFIdrive/Siemens telegram 1 ... 116
0 = OFF1	STWA.0	p0840 ON/OFF1	STW1.0
0 = OFF2	STWA.1	p0844 1. OFF2 p0845 2. OFF2	STW1.1
0 = OFF3	STWA.2	p0848 1. OFF3 p0849 2. OFF3	STW1.2
Enable operation	STWA.3	p0852 Enable operation	STW1.3
Jog 1	STWA.8	p1055 Jog bit 0	STW1.8
Jog 2	STWA.9	p1056 Jog bit 1	STW1.9

Table 2-2 Jog status message

Signal name	Internal status word	Parameter	PROFIdrive/Siemens telegram 1 ... 116
Ready to power up	ZSWA.0	r0899.0	ZSW1.0
Ready to run	ZSWA.1	r0899.1	ZSW1.1
Operation enabled	ZSWA.2	r0899.2	ZSW1.2
Power-on disable	ZSWA.6	r0899.6	ZSW1.6
Pulses enabled	ZSWA.11	r0899.11	ZSW1.11

Function diagrams (see SINAMICS S List Manual)

- 2610 Execution control - processor
- 3030 Main/added setpoint, setpoint scaling, jogging

Overview of key parameters (see SINAMICS S List Manual)

- p1055[CDS] BI: Jog bit 0
- p1056[CDS] BI: Jog bit 1
- p1058[DDS] Jog 1 speed setpoint
- p1059[DDS] Jog 2 speed setpoint
- p1082[DDS] Maximum speed
- p1120[DDS] Ramp-function generator ramp-up time
- p1121[DDS] Ramp-function generator ramp-down time

Parameterization with STARTER

The "Speed setpoint jog" parameter screen is selected with the  icon in the toolbar of the STARTER commissioning tool:

2.4 Fixed speed setpoints

Description

This function can be used to specify preset speed setpoints. The fixed setpoints are defined in parameters and selected via binector inputs. Both the individual fixed setpoints and the effective fixed setpoint are available for further interconnection via a connector output (e.g. to connector input p1070 - CI: main setpoint).

Properties

- Number of fixed setpoints: Fixed setpoint 1 to 15
- Selection of fixed setpoints: Binector input bits 0 to 3
  - Binector input bits 0, 1, 2 and 3 = 0 -> setpoint = 0 active
  - Unused binector inputs have the same effect as a "0" signal

Function diagrams (see SINAMICS S List Manual)

- 1550 Overviews - setpoint channel
- 2503 Execution control status word
- 3010 Fixed speed setpoints

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p1001[D] CO: Fixed speed setpoint 1
- ...
- p1015[D] CO: Fixed speed setpoint 15
- p1020[C] BI: Fixed speed setpoint selection Bit 0
- p1021[C] BI: Fixed speed setpoint selection Bit 1
- p1022[C] BI: Fixed speed setpoint selection Bit 2
- p1023[C] BI: Fixed speed setpoint selection Bit 3

Display parameters

- r1024 CO: Fixed speed setpoint effective
- r1197 Fixed speed setpoint current number

Parameterization with STARTER

In the STARTER commissioning tool, the "Fixed setpoints" parameter screen in the project navigator under the relevant drive is activated by double-clicking Setpoint channel -> Fixed setpoints.

2.5 Motorized potentiometer

Description

This function is used to simulate an electromechanical potentiometer for setpoint input.

You can switch between manual and automatic mode for setpoint input. The specified setpoint is routed to an internal ramp function generator. Setting values, start values and braking with OFF1 do not require the ramp function generator of the motorized potentiometer.

The output of the ramp function generator for the motorized potentiometer is available for further interconnection via a connector output (e.g. interconnection to connector input p1070 - CI: main setpoint, an additional ramp function generator is then active).

Properties for manual mode (p1041 = "0")

- Separate binector inputs for Raise and Lower are used to adjust the input setpoint:
  - p1035 BI: Motorized potentiometer, setpoint, raise
  - p1036 BI: Motorized potentiometer, lower setpoint
- Invert setpoint (p1039)
- Configurable ramp function generator, e.g.:
  - Ramp-up/ramp-down time (p1047/p1048) referred to p1082
  - Setting value (p1043/p1044)
  - Initial rounding-off active/not active (p1030.2)
- Non-volatile storage via p1030.3
- Configurable setpoint for Power On (p1030.0)
  - Starting value is the value in p1040 (p1030.0 = 0)
  - Starting value is the stored value (p1030.0 = 1)

Properties for automatic mode (p1041 = "1")

- The input setpoint is specified via a connector input (p1042).
- The motorized potentiometer acts like a "normal" ramp function generator.
- Configurable ramp function generator, e.g.:
  - Switch on/off (p1030.1)
  - Ramp-up/ramp-down time (p1047/p1048)

  - Setting value (p1043/p1044)
  - Initial rounding-off active/not active (p1030.2)
- Non-volatile storage of the setpoints via p1030.3
- Configurable setpoint for Power On (p1030.0)
  - Starting value is the value in p1040 (p1030.0 = 0)
  - Starting value is the stored value (p1030.0 = 1)

Function diagrams (see SINAMICS S List Manual)

- 1550 Setpoint channel
- 2501 Control word sequential control
- 3020 Motorized potentiometer

Overview of key parameters (see SINAMICS S List Manual)

- p1030[DDS] Motorized potentiometer, configuration
- p1035[CDS] BI: Motorized potentiometer, setpoint, raise
- p1036[CDS] BI: Motorized potentiometer, lower setpoint
- p1037[DDS] Motorized potentiometer, maximum speed
- p1038[DDS] Motorized potentiometer, minimum speed
- p1039[CDS] BI: Motorized potentiometer, inversion
- p1040[DDS] Motorized potentiometer, starting value
- p1041[CDS] BI: Motorized potentiometer, manual/automatic
- p1042[CDS] CI: Motorized potentiometer, automatic setpoint
- p1043[CDS] BI: Motorized potentiometer, accept setpoint
- p1044[CDS] CI: Motorized potentiometer, setting value
- r1045 CO: Motorized potentiometer, speed setpoint in front of the ramp function generator
- p1047[DDS]Motorized potentiometer, ramp-up time
- p1048[DDS] Motorized potentiometer, ramp-down time
- r1050 CO: Motorized potentiometer, setpoint after the ramp function generator
- p1082[DDS] Maximum speed

Parameterization with STARTER

In the STARTER commissioning tool, the "Motorized potentiometer" parameter screen in the project navigator under the relevant drive is activated by double-clicking Setpoint channel -> Motorized potentiometer.

2.6 Main/supplementary setpoint and setpoint modification

Description

The supplementary setpoint can be used to incorporate correction values from lower-level controllers. This can be easily carried out using the addition point for the main/supplementary setpoint in the setpoint channel. Both variables are imported simultaneously via two separate or one setpoint source and added in the setpoint channel.

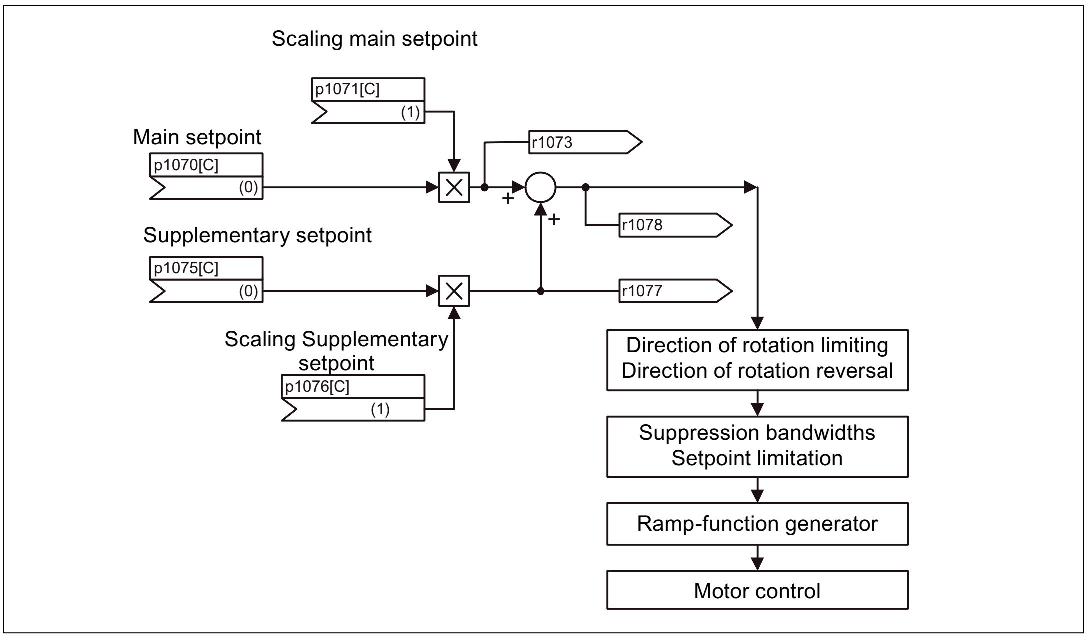


Figure 2-5 Setpoint addition, setpoint scaling

Function diagrams (see SINAMICS S List Manual)

- 1550 Setpoint channel
- 3030 Main/added setpoint, setpoint scaling, jogging

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p1070[C] CI: Main setpoint
- p1071[C] CI: Main setpoint scaling
- p1075[C] CI: Supplementary setpoint
- p1076[C] CI: Supplementary setpoint scaling

Display parameters

r1073[C] CO: Main setpoint effective

r1077[C] CO: Supplementary setpoint effective

r1078[C] CO: Total setpoint effective

Parameterization with STARTER

The "Speed setpoint" parameter screen is selected with the  icon in the toolbar of the STARTER commissioning tool:

2.7 Direction of rotation limiting and direction of rotation changeover

Description

A reverse operation involves a direction reversal. A direction reversal in the setpoint channel can be triggered by selecting direction reversal p1113[CDS].

If, on the other hand, a negative or positive setpoint is not to be preselected via the setpoint channel, this can be prevented via parameter p1110[CDS or p1111[CDS]. However, the following settings for minimum speed (p1080) in the setpoint channel are still operative. With the minimum speed, the motor can turn in a negative direction, although p1110 = 1 is set.

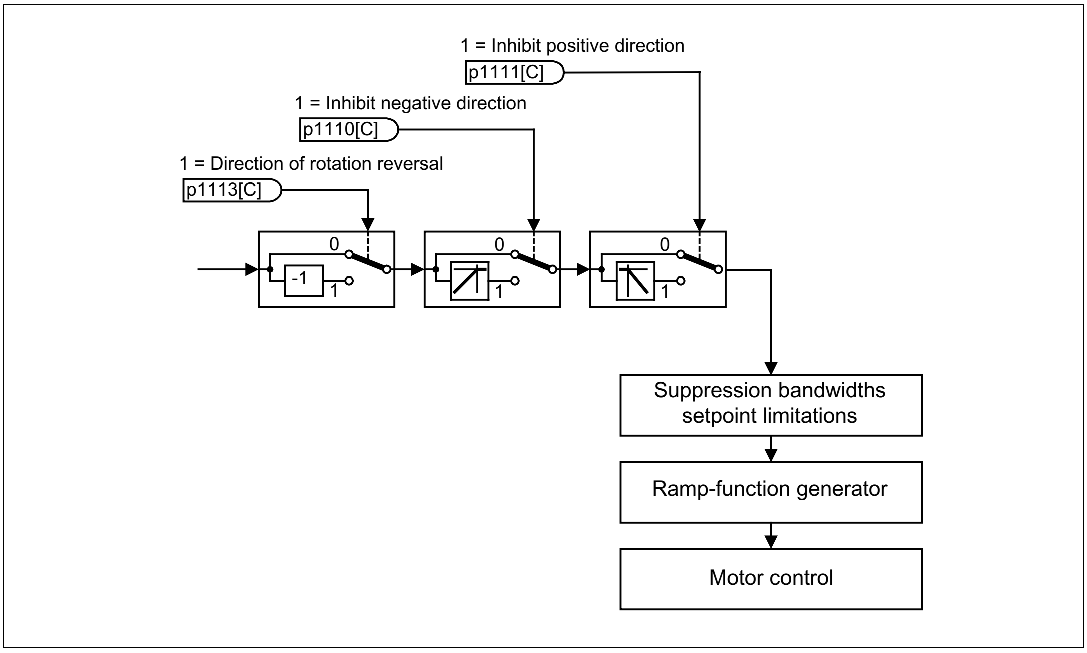


Figure 2-6 Direction of rotation limiting and direction of rotation changeover

Function diagrams (see SINAMICS S List Manual)

- 1550 Setpoint channel
- 3040 Direction limitation and direction reversal

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p1110[CDS] BI: Inhibit negative direction
- p1111[CDS] BI: Inhibit positive direction
- p1113[CDS] BI: Direction reversal

Parameterization with STARTER

The "Speed setpoint" parameter screen is selected with the  icon in the toolbar of the STARTER commissioning tool:

2.8 Suppression bandwidths and setpoint limits

Description

In the range 0 U/min to setpoint speed, a drive train (e.g. motor, coupling, shaft, machine) can have one or more points of resonance, which can result in vibrations. The suppression bandwidths can be used to prevent operation in the resonance frequency range.

The limit frequencies can be set via p1080[DDS] and p1082[DDS]. These limits can be changed during operation with the connectors p1085[CDS] and p1088[CDS].

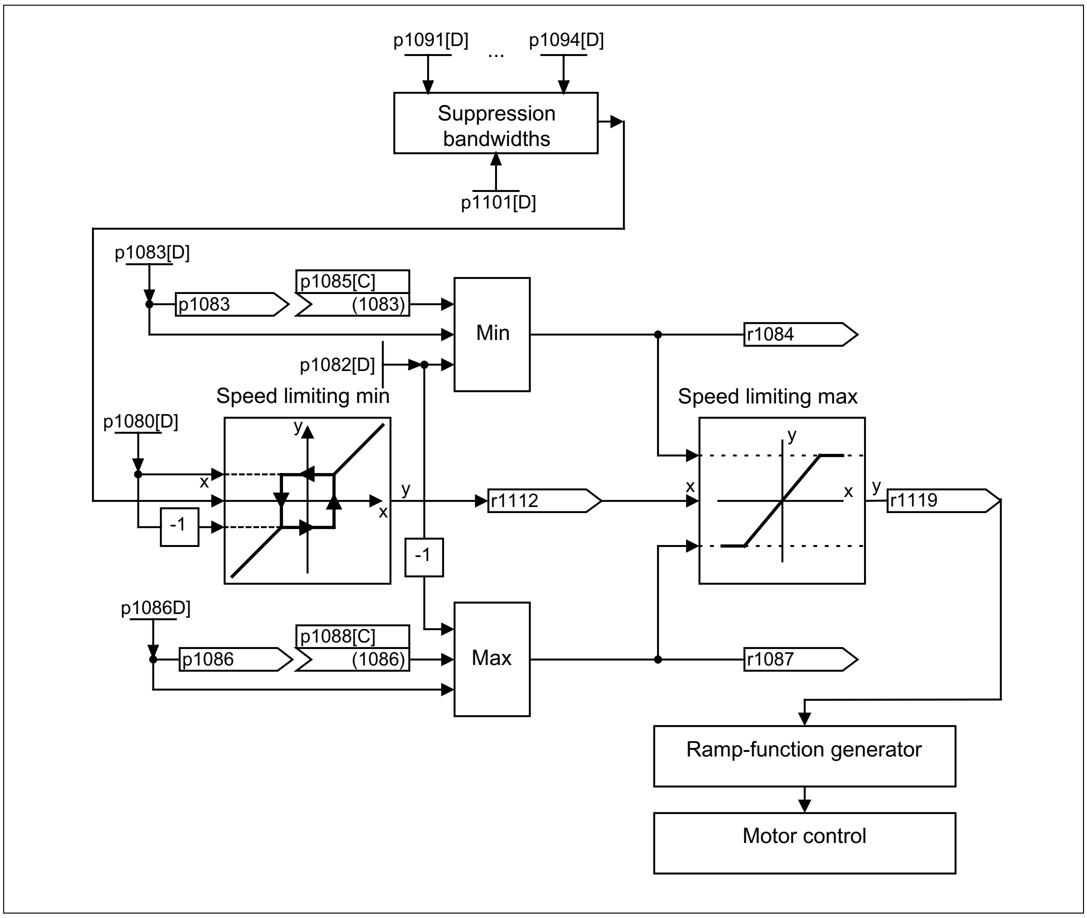


Figure 2-7 Suppression bandwidths, setpoint limitation

Function diagrams (see SINAMICS S List Manual)

- 1550 Setpoint channel
- 3050 Suppression bandwidth and speed limiting

Overview of key parameters (see SINAMICS S List Manual)

Setpoint limitation

- p1080[D] Minimum speed
- p1082[D] Maximum speed
- p1083[D] CO: Speed limit in positive direction of rotation
- r1084 Speed limit positive effective
- p1085[C] CI: Speed limit in positive direction of rotation
- p1086[D] CO: Speed limit negative direction of rotation
- r1087 Speed limit negative effective

- p1088[C] DI: Speed limit negative direction of rotation
- r1119 Ramp-function generator setpoint at the input

Suppression bandwidths

- p1091[D] Suppression speed 1
- ...
- p1094[D] Suppression speed 4
- p1101[D] Suppression speed bandwidth

Parameterization with STARTER

The "speed limitation" parameter screen is selected by activating the following icon in toolbar of the STARTER commissioning tool:

Figure 2-8 STARTER icon for "speed limitation"

2.9 Ramp-function generator

Description

The ramp function generator is used to limit acceleration in the event of abrupt setpoint changes, which helps prevent load surges throughout the drive train. The ramp-up time p1120[DDS] and ramp-down time p1121[DDS] can be used to set an acceleration ramp and a deceleration ramp independently of each other. This allows a controlled transition to be made in the event of setpoint changes.

The maximum speed p1082[DDS] is used as a reference value for calculating the ramps from the ramp-up and ramp-down times. A special adjustable ramp can be set via p1135 for fast stop (OFF3), e.g. for rapid controlled deceleration when an emergency stop button is pressed.

There are two types of ramp function generator:

- Simple ramp function generator with
  - Acceleration and deceleration ramps
  - Ramp for fast stop (OFF3)
  - Tracking can be selected via a binector input
  - Setting values for the ramp function generator
- Extended ramp function generator also has
  - Initial and final rounding off

Note

The ramp function generator cannot be frozen (via p1141) in jog mode (r0046.31 = 1).

Properties of the simple ramp function generator

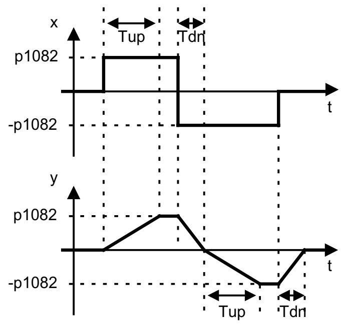


Figure 2-9 Ramp-up and ramp-down with the simple ramp function generator

- RFG ramp-up time Tup p1120[DDS]
- RFG ramp-down time Tdn p1121[DDS]
- OFF3 deceleration ramp
  - OFF3 ramp-down time p1135[DDS]
- Set ramp function generator
  - Ramp function generator setting value p1144[CDS]
  - Set ramp function generator signal p1143[CDS]
- Freezing of the ramp function generator using p1141 (not in jog mode r0046.31 = 0)

Properties of the extended ramp function generator

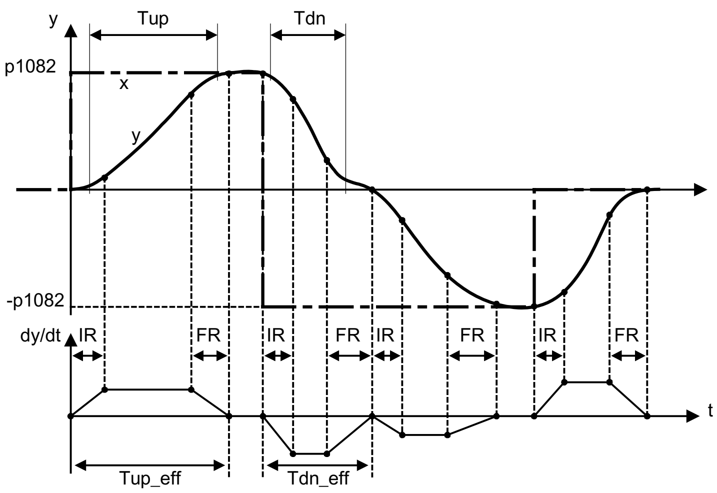


Figure 2-10 Extended ramp function generator

- RFG ramp-up time Tup p1120[DDS]
- RFG ramp-down time Tdn p1121[DDS]
- Initial rounding-off time IR p1130[DDS]
- Final rounding-off time FR p1131[DDS]
- Rounding-off typep1134[DDS]
- Effective ramp-up time
  Tup_eff = Tup + (IR/2 + FR/2)
- Effective ramp-down time
  Tdn_eff = Tdn + (IR/2 + FR/2)
- OFF3 deceleration ramp
  OFF3 ramp-down time p1135[DDS]
  OFF3 initial rounding p1136[DDS]
  OFF3 end rounding p1137[DDS]
- Set ramp function generator
  - Ramp function generator setting value p1144[CDS]
  - Set ramp function generator signal p1143[CDS]
- Ramp function generator rounding-off type p1134[DDS]
  - p1134 = "0": continuous smoothing rounding is always active. Overshoots may occur. If the setpoint changes, final rounding is carried out and then the direction of the new setpoint is adopted.
  - p1134 = "1": non-continuous smoothing changes immediately to the direction of the new setpoint when the setpoint is changed.
- Ramp function generator configuration, deactivate rounding in zero transition p1151[DDS]
- Freezing of the ramp function generator using p1141 (not in jog mode r0046.31 = 0)

Ramp function generator tracking

If the drive is in the area of the torque limits, the actual speed value is removed from the speed setpoint. The ramp function generator tracking updates the speed setpoint in line with the actual speed value and so levels the ramp. p1145 can be used to deactivate ramp function generator tracking (p1145 = 0) or set the permissible following error (p1145 > 1). If the permissible following error is reached, then the speed setpoint at the ramp function generator output will only be further increased in proportion to the speed setpoint.

Ramp function generator tracking can be activated for the simple and the extended ramp function generators.

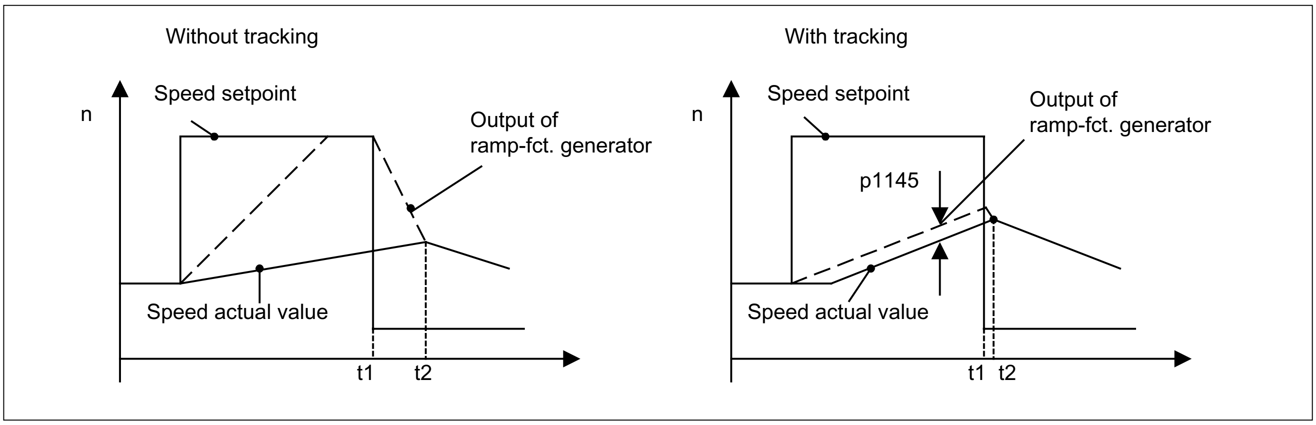


Figure 2-11 Ramp function generator tracking

Without ramp function generator tracking

- p1145 = 0
- Drive accelerates until t2 although setpoint < actual value

With ramp function generator tracking

- At p1145 > 1 (values between 0 and 1 are not applicable), ramp function generator tracking is activated when the torque limit is approached. The ramp function generator output thereby only exceeds the actual speed value by a deviation value that can be defined in p1145.
- t1 and t2 almost identical

Function diagrams (see SINAMICS S List Manual)

- 1550 Setpoint channel
- 3060 Simple ramp function generator
- 3070 Extended ramp function generator
- 3080 Ramp function generator selection, status word, tracking

Signal overview (see SINAMICS S List Manual)

- Control signal STW1.2 OFF3
- Control signal STW1.4 Enable ramp function generator
- Control signal STW1.5 Start/stop ramp function generator
- Control signal STW1.6 Enable setpoint
- Control signal STW2.1 Bypass ramp function generator

Parameterization with STARTER

The "ramp function generator" parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

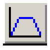


Figure 2-12 STARTER icon for "ramp function generator"

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p1115 Ramp function generator selection
- p1120[DDS] Ramp function generator ramp-up time
- p1121[DDS] Ramp function generator ramp-down time
- p1122[CDS] BI: Bypass ramp function generator
- p1130[DDS] Ramp function generator initial rounding-off time
- p1131[DDS] Ramp function generator final rounding-off time
- p1134[DDS] Ramp function generator rounding-off type
- p1135[DDS] OFF3 ramp-down time
- p1136[DDS] OFF3 initial rounding-off time
- p1137[DDS] OFF3 final rounding-off time
- p1140[CDS] BI: Enable ramp generator
- p1141[CDS] BI: Start ramp function generator
- p1143[CDS] BI: Ramp function generator, accept setting value
- p1144[CDS] CI: Ramp function generator setting value
- p1145[DDS] Ramp function generator tracking
- p1148 [DDS] Ramp function generator tolerance for ramp-up and ramp-down active
- p1151 [DDS] Ramp function generator configuration

Display parameters

- r1119 CO: Ramp function generator setpoint at the input
- p1149 Ramp function generator acceleration
- r1150 CO: Ramp function generator speed setpoint at the output

Servo control 3

This type of closed-loop control enables operation with a high dynamic response and precision for a motor with a motor encoder.

3.1 Speed controller

The speed controller controls the motor speed using the actual values from the encoder (operation with encoder) or the calculated actual speed value from the electric motor model (operation without encoder).

Properties

- Speed setpoint filter
- Speed controller adaptation

Note

Speed and torque cannot be controlled simultaneously. If speed control is activated, this has priority over torque control.

Limits

The maximum speed p1082[D] is defined with default values for the selected motor and becomes active during commissioning. The ramp-function generators refer to this value.

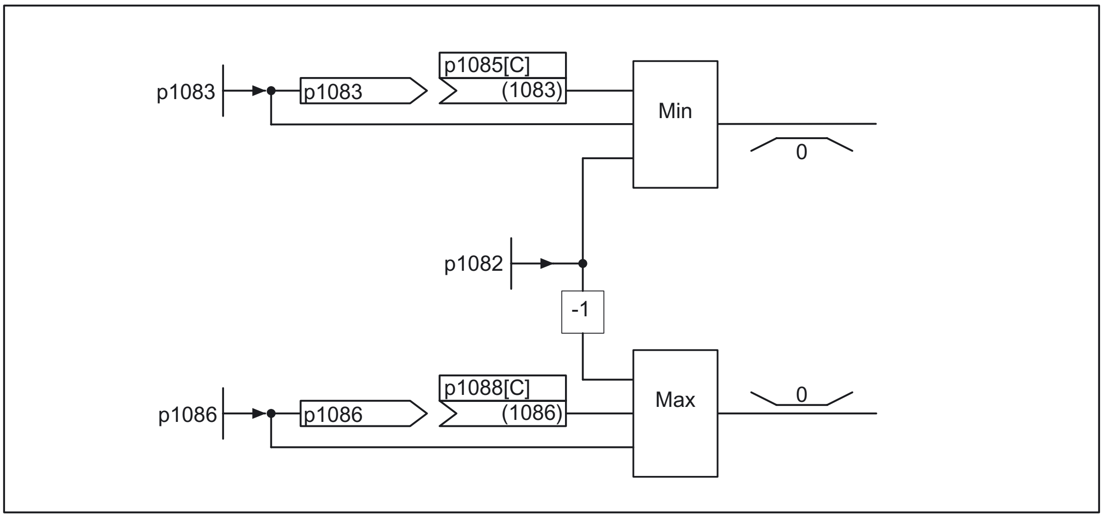


Figure 3-1 Speed controller limitations

3.2 Speed setpoint filter

The two speed setpoint filters are identical in structure and can be used as follows:

- Bandstop
- Low-pass 1st order (PT1) or
- Low-pass 2nd order (PT2)

Both filters are activated via parameter p1414.x. Parameters p1415 and p1421 are used to select the filter elements.

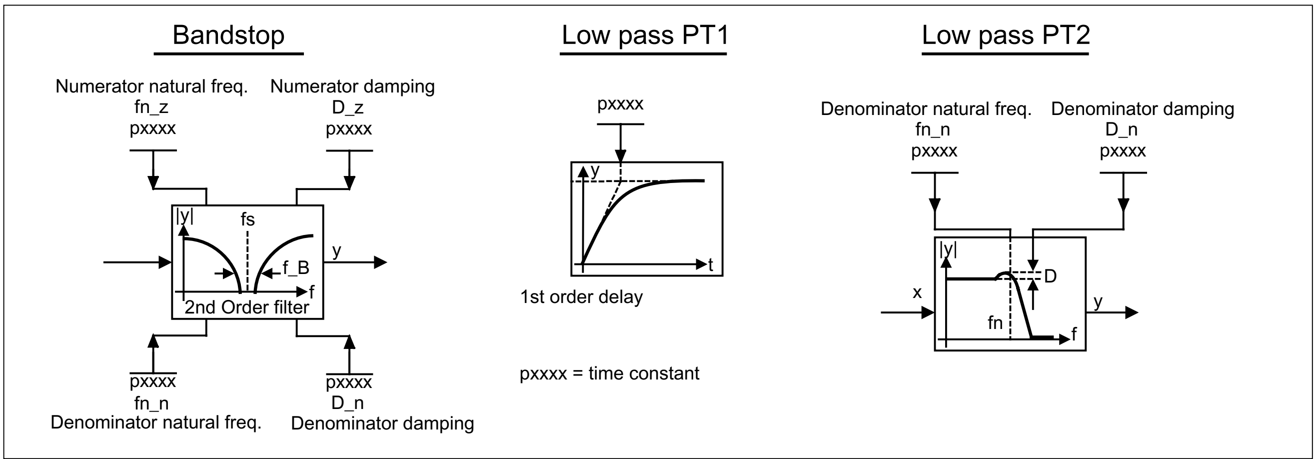


Figure 3-2 Filter overview for speed setpoint filters

Function diagrams (see SINAMICS S List Manual)

- 5020 Speed setpoint filter and speed pre-control

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p1414[DDS] Speed setpoint filter activation
- p1415[DDS] Speed setpoint filter 1 type
- p1416[DDS] Speed setpoint filter 1 time constant
- p1417[DDS] Speed setpoint filter 1 denominator natural frequency
- p1418[DDS] Speed setpoint filter 1 denominator damping
- p1419[DDS] Speed setpoint filter 1 numerator natural frequency
- p1420[DDS] Speed setpoint filter 1 numerator damping
- p1421[DDS] Speed setpoint filter 2 type
- p1422[DDS] Speed setpoint filter 2 time constant
- p1423[DDS] Speed setpoint filter 2 denominator natural frequency
- p1424[DDS] Speed setpoint filter 2 denominator damping

- p1425[DDS] Speed setpoint filter 2 numerator natural frequency
- p1426[DDS] Speed setpoint filter 2 numerator damping

Parameterization

In the STARTER commissioning tool, the "Speed setpoint filter" parameter screen is selected with the icon in the toolbar:

3.3 Speed controller adaptation

Description

Two adaptation methods are available, namely free Kp_n adaptation and speed-dependent Kp_n/Tn_n adaptation.

Free Kp_n adaptation is also active in "operation without encoder" mode and is used in "operation with encoder" mode as an additional factor for speed-dependent Kp_n adaptation.

Speed-dependent Kp_n/Tn_n adaptation is only active in "operation with encoder" mode and also affects the Tn_n value.

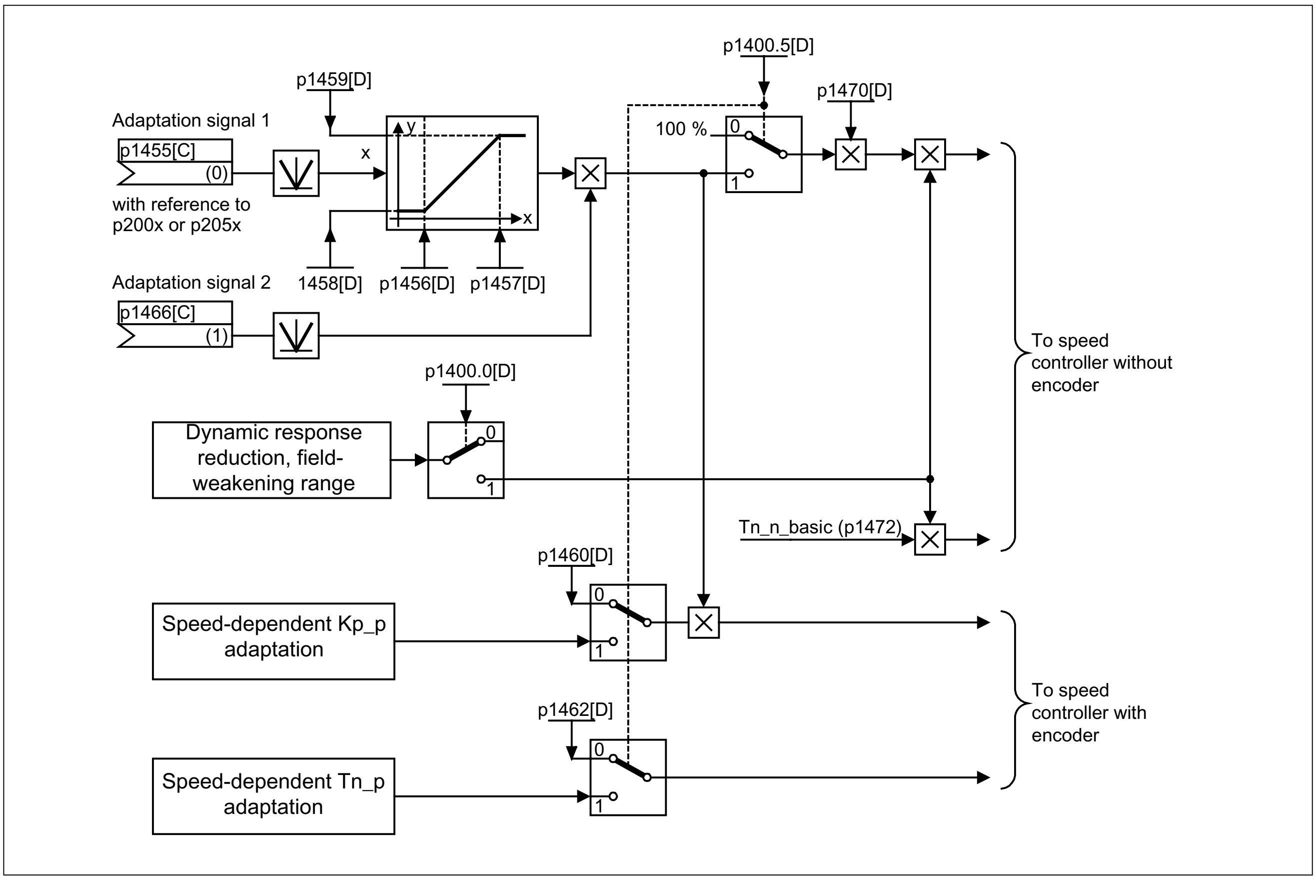


Figure 3-3 Free Kp_n adaptation

Example of speed-dependent adaptation

Note

This type of adaptation is only active in "operation with encoder" mode.

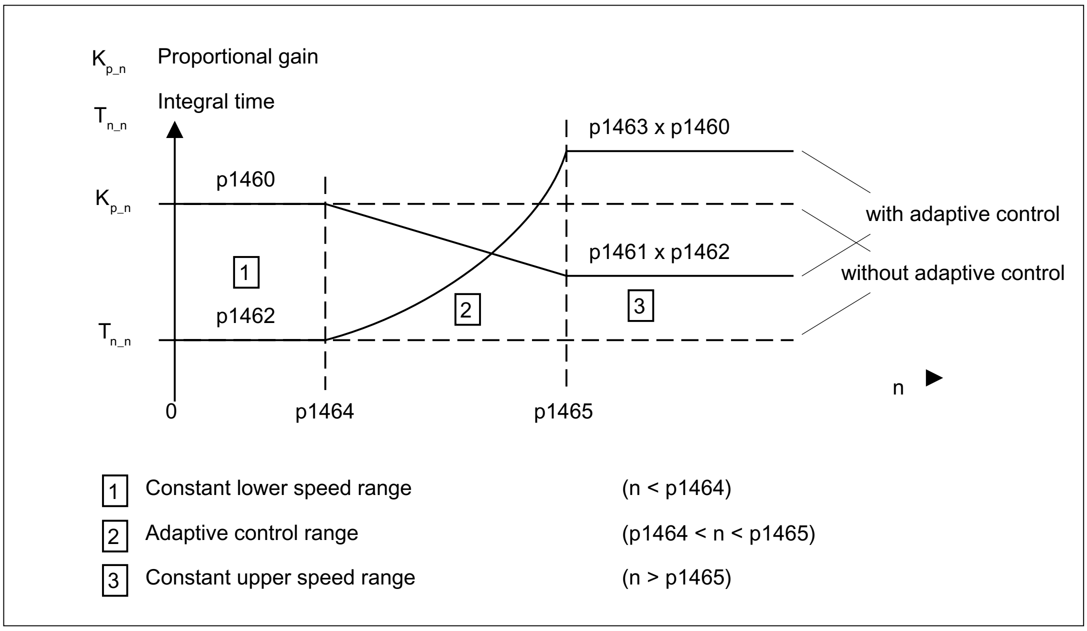


Figure 3-4 Speed controller Kp_n/Tn_n adaptation

Parameterization

The "speed controller" parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

Figure 3-5 STARTER icon for "speed controller"

Function diagrams (see SINAMICS S List Manual)

- 5050 Kp_n and Tn_n adaptation

Overview of key parameters (see SINAMICS S List Manual)

Free Kp_n adaptation

- p1455[0...n] CI: Speed controller P gain adaptation signal
- p1456[0...n] Speed controller P gain adaptation lower starting point
- p1457[0...n] Upper starting point speed controller P gain adaptation

- p1458[0...n] Lower adaptation factor
- p1459[0...n] Upper adaptation factor

Speed-dependent Kp_n/Tn_n adaptation

- p1460[0...n] Speed controller P gain lower adaptation speed
- p1461[0...n] Speed controller Kp adaptation speed upper scaling
- p1462[0...n] Speed controller integral time lower adaptation speed
- p1463[0...n] Speed controller Tn adaptation speed upper scaling
- p1464[0...n] Speed controller lower adaptation speed
- p1465[0...n] Speed controller upper adaptation speed
- p1466[0...n] CI: Speed controller P gain scaling

3.4 Torque-controlled operation

Description

An operating mode switchover (p1300) can be carried out or a binector input (p1501) used to switch from speed control to torque control mode. All torque setpoints from the speed control system are rendered inactive. The setpoints for torque control mode are selected by parameterization.

Properties

- Switchover to torque control mode via:
  - Operating mode selection
  - Binector input
- Torque setpoint can be specified:
  - The torque setpoint source can be selected
  - The torque setpoint can be scaled
  - An additional torque setpoint can be entered
- Display of the overall torque

Commissioning of torque control mode

1. Set torque control mode (p1300 = 23; p1501 = "1" signal)
2. Specify torque setpoint
   - Select source (p1511)
   - Scale setpoint (p1512)
   - Select supplementary setpoint (1513)

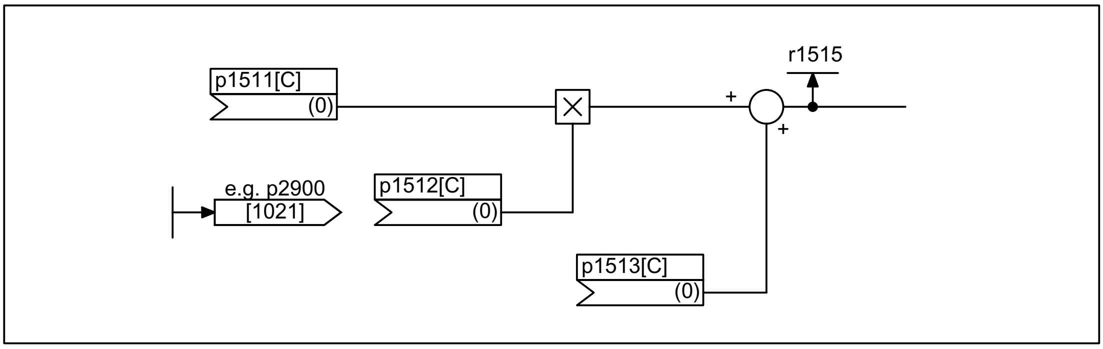


Figure 3-6 Torque setpoint

3. Activate enable signals

OFF responses

- OFF1 and p1300 = 23
  - Reaction as for OFF2
- OFF1, p1501 = "1" signal and p1300 ≠ 23
  - No separate braking response; the braking response takes place by a drive that specifies the torque.
  - The pulses are suppressed when the brake application time (p1217) expires. Standstill is detected when the actual speed value is less than the speed threshold (p1226) or when the monitoring time (p1227) that started when speed setpoint ≤ speed threshold (p1226) has expired.
  - Power-on disable is activated.
- OFF2
  - Immediate pulse suppression, the drive coasts to standstill.
  - The motor brake (if parameterized) is closed immediately.
  - Power-on disable is activated.
- OFF3
  - Switch to speed-controlled operation
  - n_set = 0 is input immediately to brake the drive along the OFF3 deceleration ramp (p1135).
  - When zero speed is detected, the motor brake (if parameterized) is closed.
  - The pulses are suppressed when the motor brake application time (p1217) has elapsed. Standstill is detected when the actual speed value is less than the speed threshold (p1226) or when the monitoring time (p1227) that started when speed setpoint ≤ speed threshold (p1226) has expired.
  - Power-on disable is activated.

Function diagrams (see SINAMICS S List Manual)

- 5060 Torque setpoint, control type switchover
- 5610 Torque limiting/reduction/interpolator

Signal overview (see SINAMICS S List Manual)

- r1406.12 Torque control active

Parameterization

The "torque setpoint" parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

Figure 3-7 STARTER icon for "torque setpoint"

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p1300 Open-loop/closed-loop control operating mode
- p1501[CDS] BI: Change over between closed-loop speed/torque control
- p1511[CDS] CI: Supplementary torque 1
- p1512[CDS] CI: Supplementary torque 1 scaling
- p1513[CDS] CI: Supplementary torque 2

Display parameters

- r1515 Supplementary torque total

3.5 Torque setpoint limitation

Description

The steps required for limiting the torque setpoint are as follows:

1. Define the torque setpoint and an additional torque setpoint
2. Generate torque limits

The torque setpoint can be limited to a maximum permissible value in all four quadrants. Different limits can be parameterized for motor and regenerative modes.

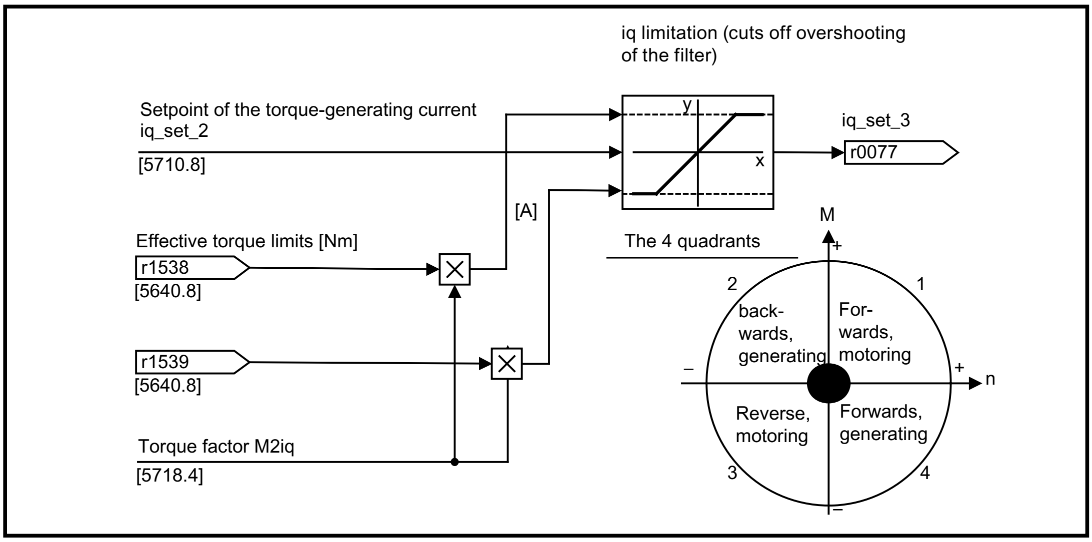


Figure 3-8 Current/torque setpoint limiting

Note

This function is effective immediately without any settings. The user can also define further settings for limiting the torque.

Properties

The connector inputs of the function are initialized with fixed torque limits. If required, the torque limits can also be defined dynamically (during operation).

- A control bit can be used to select the torque limitation mode. The following alternatives are available:
  - Upper and lower torque limit
  - Motor and regenerative torque limit
- Additional power limitation configurable
  - Motor mode power limit
  - Regenerative mode power limit
- The following factors are monitored by the current controller and thus always apply in addition to torque limitation:
  - Stall power
  - Maximum torque-generating current
- Offset of the setting values also possible (see "Example: Torque limits with or without offset").
- The following torque limits are displayed via parameters:
  - Lowest of all upper torque limits with and without offset
  - Highest of all lower torque limits with and without offset

Fixed and variable torque limit settings

Table 3-1 Fixed and variable torque limit settings

Selection	Torque limitation mode			
Mode	Maximum upper or lower torque limits p1400.4 = 0		Maximum motor or regenerative mode torque limits p1400.4 = 1	
Fixed torque limit	Upper torque limit (as positive value)	p1520	Motor mode torque limit (as positive value)	p1520
	Lower torque limit (as negative value)	p1521	Regenerative mode torque limit (as negative value)	p1521
Source for variable torque limit	Upper torque limit	p1522	Motor mode torque limit	p1522
	Lower torque limit	p1523	Regenerative mode torque limit	p1523
Source for variable scaling factor of torque limit	Upper torque limit	p1528	Motor mode torque limit	p1528
	Lower torque limit	p1529	Regenerative mode torque limit	p1529
Torque offset for torque limit	Shifts the upper and lower torque limits together	p1532	Shifts the motor and regenerative mode torque limits together	p1532

Variants of torque limitation

The following variants are available:

1. No settings entered:

   The application does not require any additional restrictions to the torque limits.
2. Fixed limits are required for the torque:

   The fixed upper and lower limits or alternatively the fixed motor and regenerative limits can be specified separately by different sources.
3. Dynamic limits are required for the torque:
   – The dynamic upper and lower limit or, alternatively, the dynamic motor and regenerative limit can be specified separately by different sources.
   – Parameters are used to select the source of the current limit.
4. A torque offset can be parameterized.
5. In addition, the power limits can be parameterized separately for motor and regenerative mode.

NOTICE
Negative values at r1534 or positive values at r1535 represent a minimum torque for the other torque directions and can cause the drives to rotate if no load torque is generated to counteract this (see function diagram 5630 in the SINAMICS S List Manual).

Example: Torque limits with or without offset

The signals selected via p1522 and p1523 include the torque limits parameterized via p1520 and p1521.

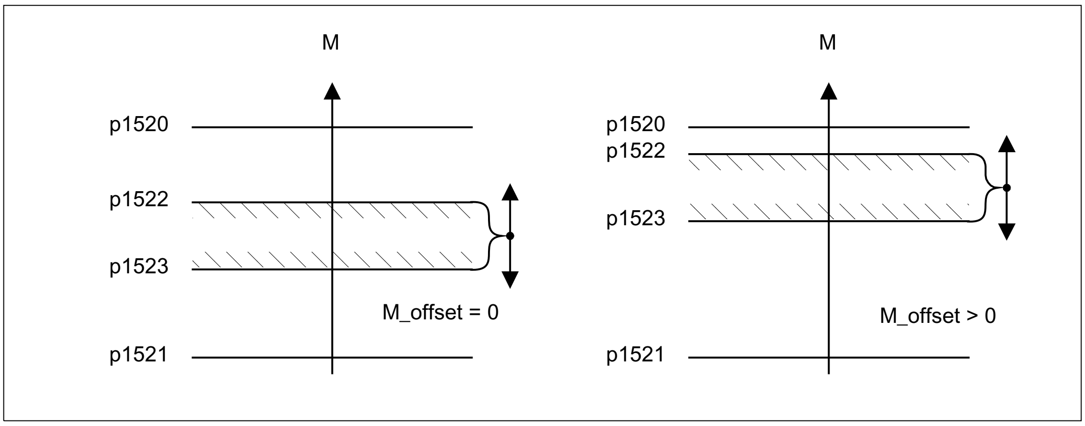


Figure 3-9 Example: Torque limits with or without offset

Activating the torque limits

1. Use parameters to select the torque limitation source.
2. Use a control word to specify the torque limitation mode.
3. The following can also be carried out if necessary:
   - Select and activate additional limitations.
   - Set the torque offset.

Examples

- Traversing to fixed stop
- Tension control for continuous goods conveyors and winders

Function diagrams (see SINAMICS S List Manual)

- 5610 Torque limiting/reduction/interpolator
- 5620 Motor/generator torque limit
- 5630 Upper/lower torque limit
- 5640 Mode changeover, power/current limiting

Parameterization

The "torque limit" parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

Figure 3-10 STARTER icon for "torque limit"

Overview of key parameters (see SINAMICS S List Manual)

- p0640[0...n] Current limit
- p1400[0...n] Speed control configuration
- r1508 CO: Torque setpoint before supplementary torque
- r1509 CO: Torque setpoint before torque limiting
- r1515 Supplementary torque total
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[CDS] CI: Torque limit, upper/motoring
- p1523[CDS] CI: Torque limit, lower/regenerative
- r1526 Torque limit, upper/motoring without offset
- r1527 Torque limit, lower/regenerative without offset
- p1528[0...n] CI: Torque limit, upper/motoring, scaling
- p1529[0...n] CI: Torque limit, lower/regenerative scaling
- p1530[0...n] Motor mode power limit
- p1531[0...n] Regenerative mode power limit
- p1532[0...n] Torque limit offset
- r1533 Maximum torque-generating current of all current limits
- r1534 CO: Torque limit, upper total
- r1535 CO: Torque limit, lower total
- r1536 Maximum motor-mode torque-generating current limit
- r1537 Minimum regenerative-mode torque-generating current
- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit

3.6 Current controller

Properties

- PI controller for current control
- Four identical current setpoint filters
- Current and torque limitation
- Current controller adaptation
- Flux control

Closed-loop current control

No settings are required for operating the current controller. Optimization measures can be taken in certain circumstances.

Current and torque limitation

The current and torque limitations are initialized when the system is commissioned for the first time and should be adjusted according to the application.

Current controller adaptation

The P gain of the current controller can be reduced (depending on the current) by means of current controller adaptation. Current controller adaptation can be deactivated with the setting p1402.2 = 0.

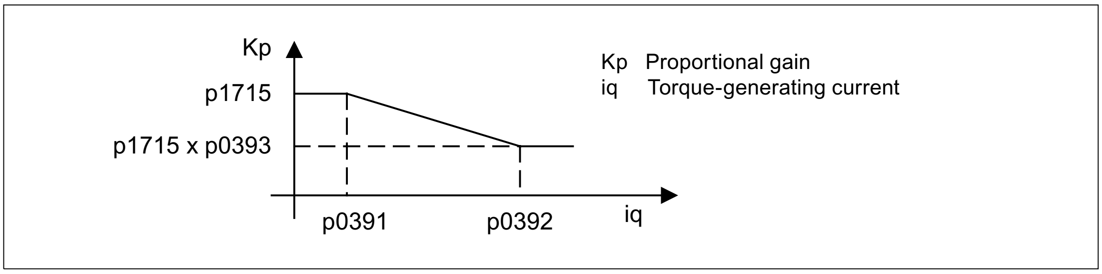


Figure 3-11 Current controller adaptation

Flux controller (for induction motor)

The parameters for the flux controller are initialized when the system is commissioned for the first time and do not usually need to be adjusted.

Commissioning with STARTER

In the STARTER commissioning tool, the "Current controller" parameter screen is selected with the  icon in the toolbar:

Function diagrams (see SINAMICS S List Manual)

- 5710 Current setpoint filters
- 5714 Iq and Id controller
- 5718 Interface to the Motor Module (gating signals, current actual values)
- 5722 Specified field current, flux controller

Overview of key parameters (see SINAMICS S List Manual)

Closed-loop current control

- p1701[0...n] Current controller reference model dead time
- p1715[0...n] Current controller P gain
- p1717[0...n] Current controller integral time

Current and torque limitation

- p0323[0...n] Maximum motor current
- p0326[0...n] Stall torque correction factor
- p0640[0...n] Current limit
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[0...n] CI: Torque limit, upper/motoring
- p1523[0...n] CI: Torque limit, lower/regenerative
- p1524[0...n] CO: Torque limit, upper/motoring, scaling
- p1525[0...n] CO: Torque limit, lower/regenerative scaling
- p1528[0...n] CI: Torque limit, upper/motoring, scaling
- p1529[0...n] CI: Lower or regenerative torque limit scaling
- p1530[0...n] Motor mode power limit
- p1531[0...n] Regenerative mode power limit
- p1532[0...n] Torque offset torque limit

Display parameters

- r1526 Torque limit, upper/motoring without offset
- r1527 Torque limit, lower/regenerative without offset
- r1533 Maximum torque-generating current of all current limits
- r1534 CO: Torque limit, upper total
- r1535 CO: Torque limit, lower total
- r1536 Maximum torque-generating current limit
- r1537 Maximum torque-generating current limit
- r1538 CO: Upper effective torque limit
- r1539 CO: Upper effective torque limit

Current controller adaptation

- p0391[0...n] Current controller adaptation lower starting point
- p0392[0...n] Current controller adaptation upper starting point
- p0393[0...n] Current controller adaptation upper P gain
- p1590[0...n] Flux controller P gain
- p1592[0...n] Flux controller integral time

3.7 Current setpoint filter

Description

The four current setpoint filters connected in series can be parameterized as follows:

- Low-pass 2nd order (PT2: -40 dB/decade) (type 1)
- General filter 2nd order (type 2)
  Bandstop and lowpass with reduction are converted to the parameters of the general filter 2nd order via STARTER.
  - Bandstop
  - Low-pass with reduction by a constant value

The phase frequency curve is shown alongside the amplitude log frequency curve. A phase shift results in a control system delay and should be kept to a minimum.

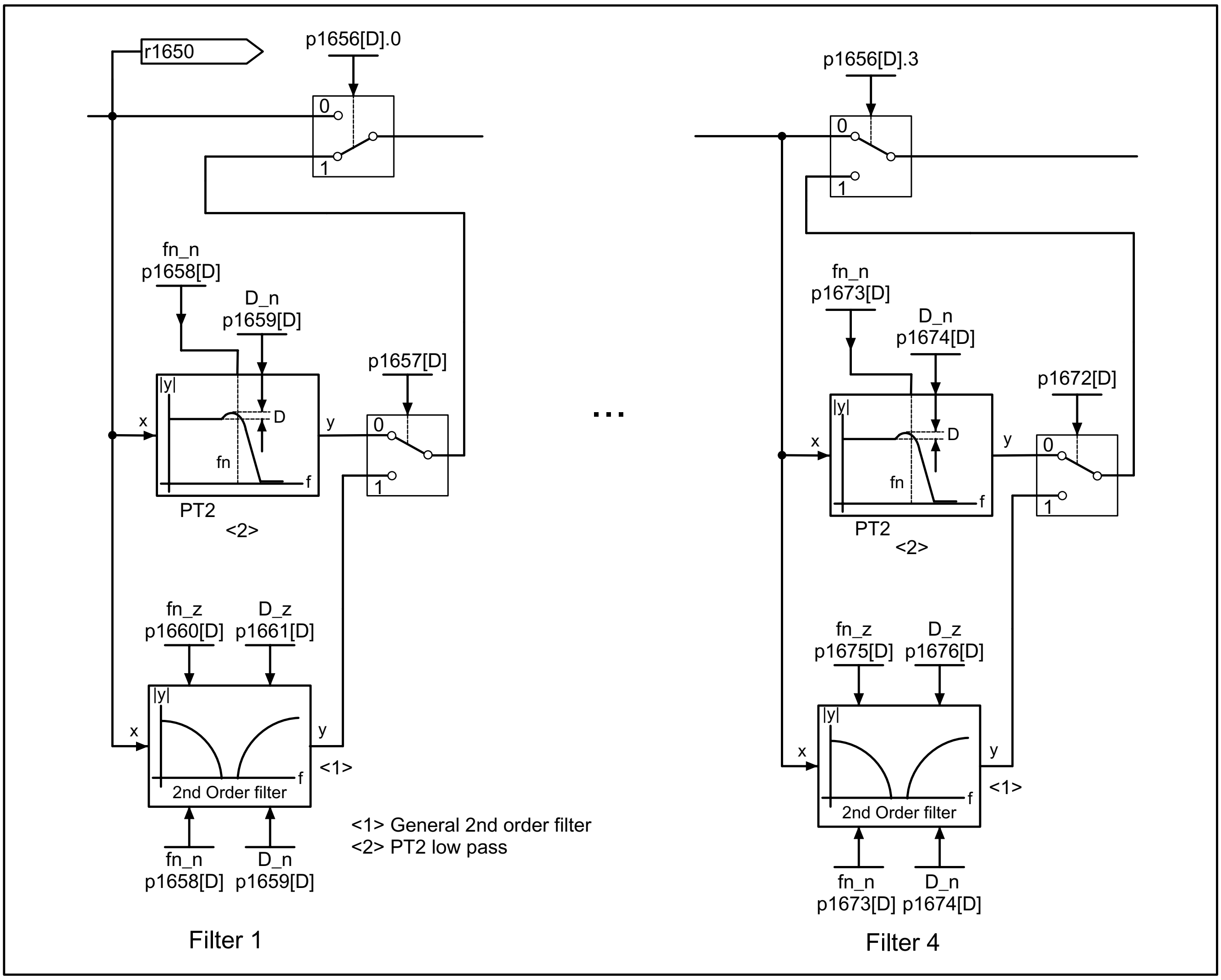


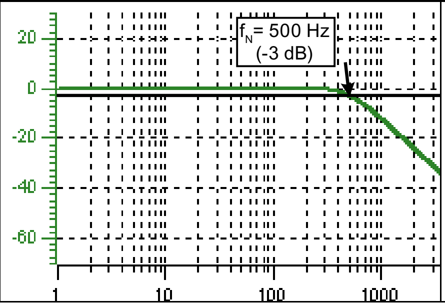
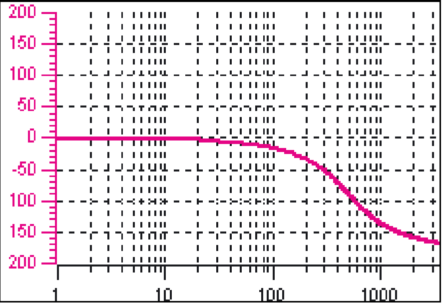
Figure 3-12 Current setpoint filter

Transfer function:

$$H_{(s)} = \frac{1}{\left(\frac{s}{2\pi f_N}\right)^2 + \frac{2D_N}{2\pi f_N} \bullet s + 1}$$

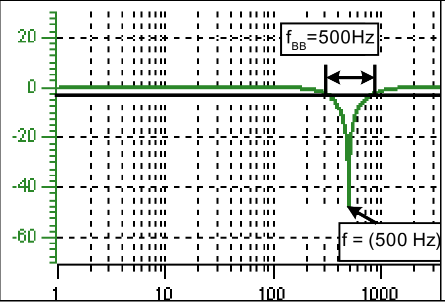
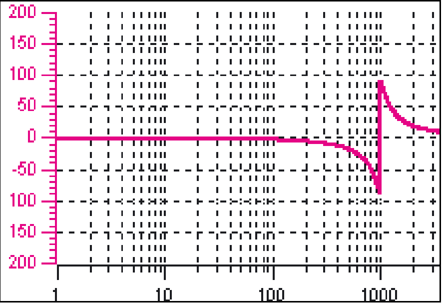
Denominator natural frequency f_N
Denominator damping D_N

Table 3-2 Example of a PT2 filter

STARTER filter parameters	Amplitude log frequency curve	Phase frequency curve
Characteristic frequency f_N 500 Hz Damping D_N 0.7 dB		

Band-stop with infinite notch depth

Table 3-3 Example of band-stop with infinite notch depth

STARTER filter parameters	Amplitude log frequency curve	Phase frequency curve
Blocking frequency f_{Sp} = 500 Hz Bandwidth (-3 dB) f_{BB} = 500 Hz Notch depth K = -∞ dB Reduction Abs = 0 dB		

Simplified conversion to parameters for general order filters:

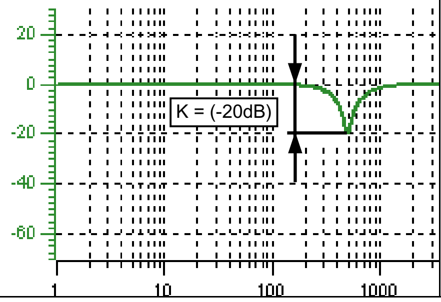
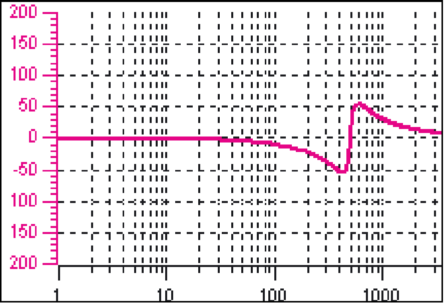
Reduction or increase after the blocking frequency (Abs)

Infinite notch depth at the blocking frequency

- Numerator frequency $f_Z = f_{Sp}$
- Numerator damping $D_Z = 0$
- Denominator natural frequency $f_N = f_{Sp}$
- Denominator damping $D_N = \frac{f_{BB}}{2 \cdot f_{Sp}}$

Band-stop with defined notch depth

Table 3-4 Example of band-stop with defined notch depth

STARTER filter parameters	Amplitude log frequency curve	Phase frequency curve
Blocking frequency f_{Sp} = 500 Hz Bandwidth f_{BB} = 500 Hz Notch depth K = -20 dB Reduction Abs = 0 dB		

Simplified conversion to parameters for general order filters:

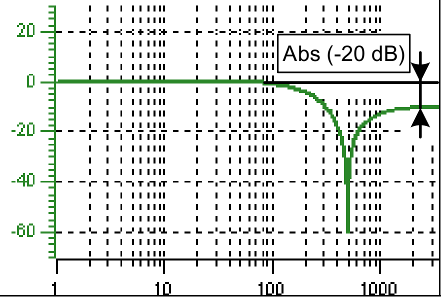
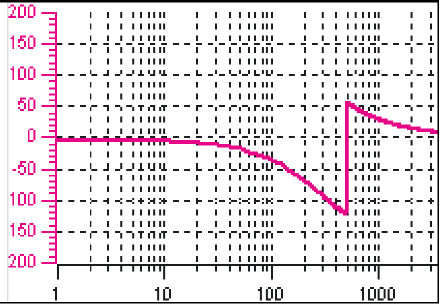
No reduction or increase after the blocking frequency

Defined notch at the blocking frequency K[dB] (e.g. -20 dB)

- Numerator frequency $f_Z = f_{Sp}$
- Numerator damping $$D_Z = \frac{f_{BB}}{2 \bullet f_{Sp} \bullet 10^{\frac{K}{20}}}$$
- Denominator natural frequency $f_N = f_{Sp}$
- Denominator damping $$D_N = \frac{f_{BB}}{2 \bullet f_{Sp}}$$

Band-stop with defined reduction

Table 3-5 Example of band-stop

STARTER filter parameters	Amplitude log frequency curve	Phase frequency curve
Blocking frequency f_{SP} = 500 Hz Bandwidth f_{BB} = 500 Hz Notch depth K = -∞ dB Reduction ABS = -10 dB		

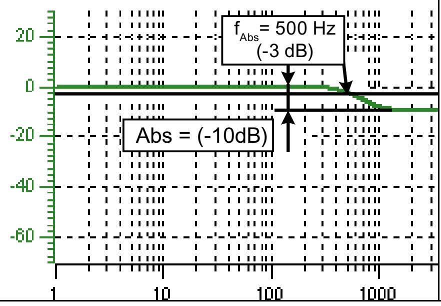
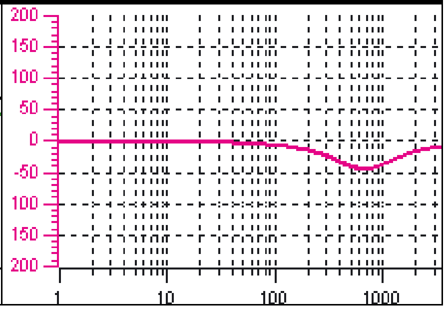
General conversion to parameters for general order filters:

- Numerator natural frequency $$f_Z = \frac{\omega_Z}{2\pi} = f_{Sp}$$
- Numerator damping $$D_Z = 10^{\frac{K}{20}} \bullet \frac{1}{2} \bullet \sqrt{\left(1 - \frac{1}{10^{\frac{Abs}{20}}}\right)^2 + \frac{f_{BB}^2}{f_{Sp}^2 \bullet 10^{\frac{Abs}{10}}}}$$

- Denominator natural frequency $f_N = \frac{\omega_N}{2\pi} = f_{Sp} \bullet 10^{\frac{Abs}{40}}$
- Denominator damping $D_N = \frac{f_{BB}}{2 \bullet f_{Sp} \bullet 10^{\frac{Abs}{40}}}$

General low-pass with reduction

Table 3-6 Example of general low-pass with reduction

STARTER filter parameters	Amplitude log frequency curve	Phase frequency curve
Characteristic frequency f_{Abs} = 500 Hz Damping D = 0.7 Reduction Abs = -10 dB		

Conversion to parameters for general order filters:

- Numerator natural frequency $f_Z = f_{Abs}$ (start of reduction)
- Numerator damping $f_Z = \frac{f_{Abs}}{10^{\frac{Abs}{40}}}$
- Denominator natural frequency f_N
- Denominator damping D_N

Transfer function general 2nd-order filter

$$H_{(s)} = \frac{\left(\frac{s}{2\pi f_Z}\right)^2 + \frac{2D_Z}{2\pi f_Z} \bullet s + 1}{\left(\frac{s}{2\pi f_N}\right)^2 + \frac{2D_N}{2\pi f_N} \bullet s + 1}$$

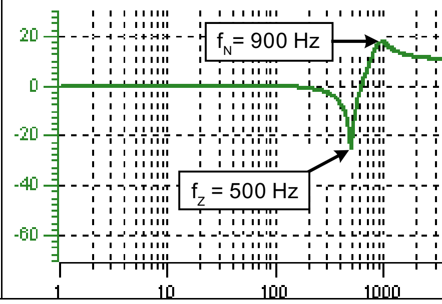
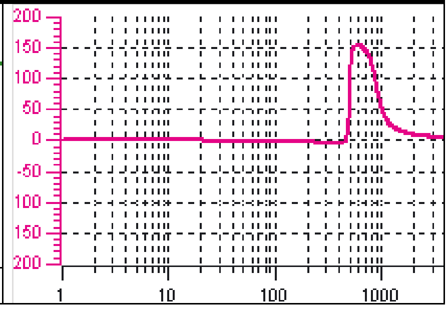
Numerator natural frequency f_Z

Numerator damping D_Z

Denominator natural frequency f_N

Denominator damping D_N

Table 3-7 Example of general 2nd order filter

STARTER filter parameters	Amplitude log frequency curve	Phase frequency curve
Numerator frequency f_Z = 500 Hz Numerator damping D_Z = 0.02 dB Denominator frequency f_N = 900 Hz Denominator damping D_N = 0.15 dB		

Parameterization

The "current setpoint filter" parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

Figure 3-13 STARTER icon for "current setpoint filter"

Function diagrams (see SINAMICS S List Manual)

- 5710 Current setpoint filters

Overview of key parameters (see SINAMICS S List Manual)

- p1656 Activates current setpoint filter
- p1657 Current setpoint filter 1 type
- p1658 Current setpoint filter 1 denominator natural frequency
- p1659 Current setpoint filter 1 denominator damping
- p1660 Current setpoint filter 1 numerator natural frequency
- p1661Current setpoint filter 1 numerator damping
- ...
- p1676 Current setpoint filter 4 numerator damping
- p1699 Filter data transfer

3.8 Note about the electronic motor model

A model change takes place within the speed range p1752*(100%-p1756) and p1752. With induction motors with encoder, the torque image is more accurate in higher speed ranges; the effect of the rotor resistance and the saturation of the main field inductance are corrected. With synchronous motors with encoder, the commutation angle is monitored. If the kT estimator has been activated, the torque image for synchronous motors is more accurate too.

3.9 V/f control for diagnostics

Description

With V/f control, the motor is operated with an open control loop and does require speed control or actual current sensing, for example. Operation is possible with a small amount of motor data.

V/f control can be used to check the following:

- Motor Module
- Power cable between Motor Module <–> motor
- Motor
- DRIVE-CLiQ cable between Motor Module <–> motor
- Encoder and actual encoder value

The following motors can be operated with V/f control:

- Induction motors
- Synchronous motors

CAUTION
V/f control must only be used as a diagnostic function (e.g. to check that the motor encoder is functioning correctly).

Note

In V/f mode, the calculated actual speed value is always displayed in r0063. The speed of the encoder (if installed) is displayed in r0061. If an encoder is not installed, r0061 displays "0".

Note

The operation of synchronous motors with V/f control is allowed only at up to 25 % of the rated motor speed.

Structure of V/f control

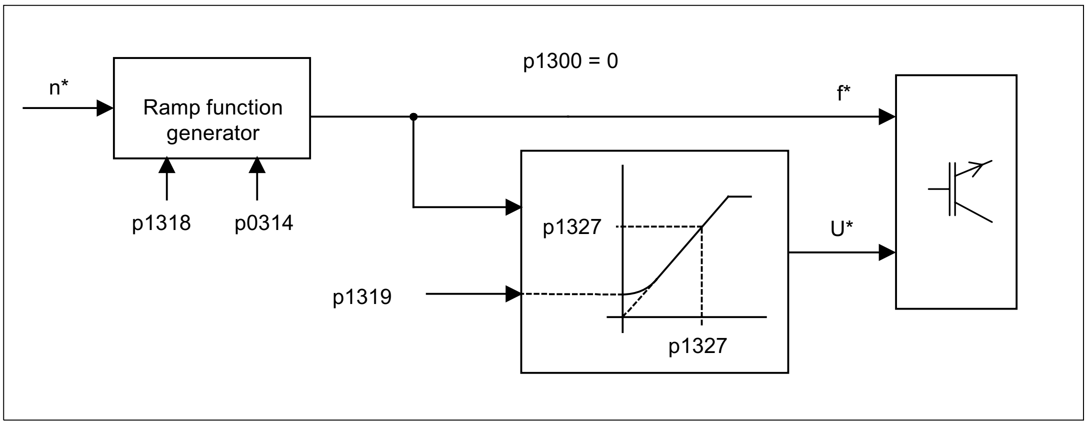


Figure 3-14 Structure of V/f control

Prerequisites for V/f control

1. Initial commissioning has been carried out:
   The parameters for V/f control have been initialized with appropriate values.
2. Initial commissioning has not been carried out:
   The following relevant motor data must be checked and corrected:
   - r0313 Motor pole pair number, actual (or calculated)
   - p0314 motor pole pair number
   - p1318 V/f control ramp-up/ramp-down time
   - p1319 V/f control voltage at zero frequency
   - p1326 V/f control programmable characteristic frequency 4
   - p1327 V/f control programmable characteristic voltage 4

   V/f control can now be commissioned.

Note

With synchronous motors, V/f mode is normally only stable at low speeds. Higher speeds can induce vibrations.

Commissioning V/f control

1. Verify the preconditions for V/f control mode.
2. Set p0311 –> rated motor speed
3. Set p1317 = 1 –> activates the function
4. Activate the enable signals for operation
5. Specify the speed setpoint –> evaluate the diagnostic function

V/f characteristic

The speed setpoint is converted to the frequency specification taking into account the number of pole pairs. The synchronous frequency associated with the speed setpoint is output (no slip compensation).

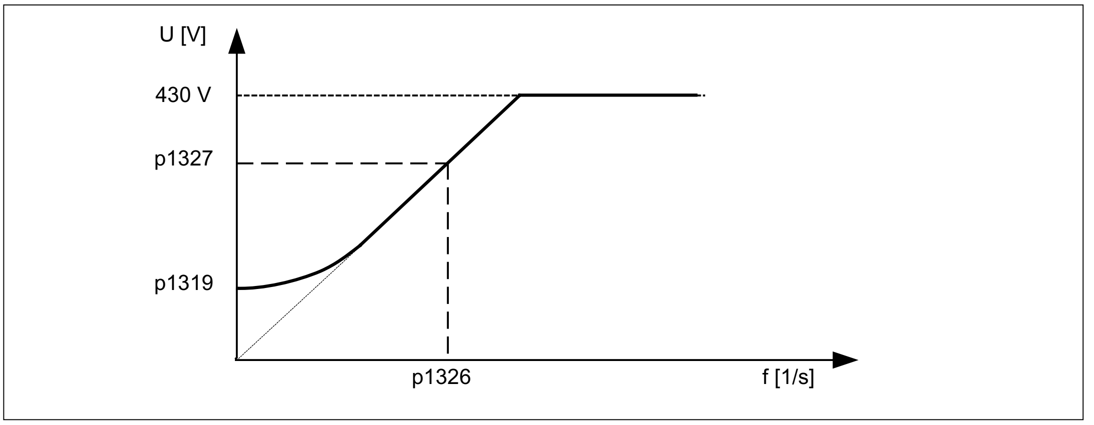


Figure 3-15 V/f characteristic

Function diagrams (see SINAMICS S List Manual)

- 5300 V/f control for diagnostics

Overview of key parameters (see SINAMICS S List Manual)

- p0304 rated motor voltage
- p0310 rated motor frequency
- p0311 rated motor speed
- r0313 Motor pole pair number, actual (or calculated)
- p0314 motor pole pair number
- p031 Motor voltage constant
- p0322 Maximum motor speed
- p0323 Maximum motor current
- p0640 current limit
- p1082 Maximum speed
- p1317 V/f control diagnostics activation
- p1318 V/f control ramp-up/ramp-down time
- p1319 V/f control voltage at zero frequency
- p1326 V/f control programmable characteristic frequency 4
- p1327 V/f control programmable characteristic voltage 4

3.10 Optimizing the current and speed controller

General information

> ⚠ CAUTION
>
> Controller optimization may only be performed by skilled personnel with a knowledge of control engineering.

The following tools are available for optimizing the controllers:

- "Function generator" in STARTER
- "Trace" in STARTER
- "Measuring function" in STARTER
- CU320 measuring sockets

Optimizing the current controller

The current controller is initialized when the system is commissioned for the first time and is adequately optimized for most applications.

Optimizing the speed controller

The speed controller is set in accordance with the motor moment of inertia when the motor is configured for the first time. The calculated proportional gain is set to approximately 30% of the maximum possible gain in order to minimize vibrations when the controller is mounted on the mechanical system of the machine for the first time.

The integral time of the speed controller is always preset to 10 ms.

The following optimization measures are necessary in order to achieve the full dynamic response:

- Increase the proportional gain Kp_n (p1460)
- Change the integral action time Tn_n (p1462)

Automatic controller setting of the speed controller (frequency response analysis) in STARTER

- The automatic speed controller setting has the following features:
  - Section identification using FFT analysis
  - Automatic setting of filters in the current setpoint arm, e.g. for damping resonances
  - Automatic setting of the controller (amplification factor Kp, integral time Tn)
- The automatic controller settings can be verified with the measuring functions.

The "Automatic controller setting" parameter screen is selected with the  icon in the toolbar of the STARTER commissioning tool:

Example of measuring the speed controller frequency response

By measuring the speed controller frequency response and the control system, critical resonance frequencies can, if necessary, be determined at the stability limit of the speed control loop and dampened using one or more current setpoint filters. This normally enables the proportional gain to be increased (e.g. Kp_n = 3* default value).

After the Kp_n value has been set, the ideal integral action time Tn_n (e.g. reduced from 10 ms to 5 ms) can be determined.

Example of speed setpoint step change

A rectangular step change can be applied to the speed setpoint via the speed setpoint step change measuring function. The measuring function has preselected the measurement for the speed setpoint and the torque-generating current.

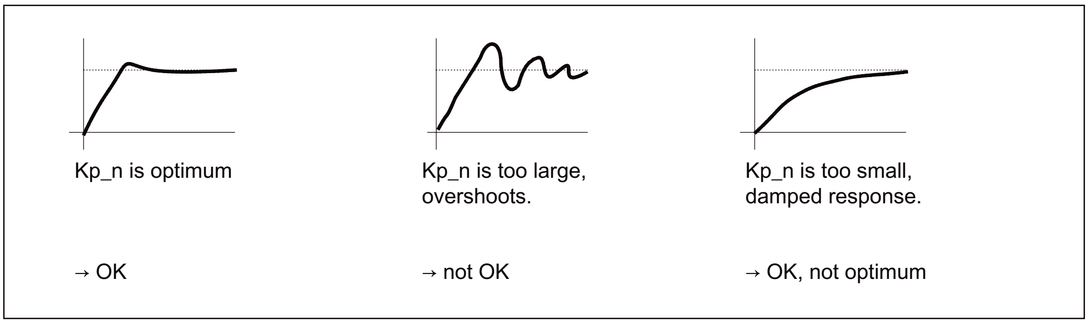


Figure 3-16 Setting the proportional gain Kp

Parameter overview

See "Speed controller".

3.11 Sensorless operation (without an encoder)

NOTICE
The operation of synchronous motors without an encoder must be verified in a test application. Stable operation in this mode cannot be guaranteed for every application. Therefore, the user will be solely responsible for the use of this operating mode.

Description

This allows operation without an encoder and mixed operation (with/without encoder). Encoderless operation with the motor model allows a higher dynamic response and greater stability than a standard drive with V/f control. Compared with drives with an encoder, however, speed accuracy is lower and the dynamic response and smooth running characteristics deteriorate.

Since the dynamic response in operation without an encoder is lower than in operation with an encoder, accelerating torque pre-control is implemented to improve the control dynamic performance. It controls, knowing the drive torque, and taking into account the existing torque and current limits as well as the load moment of inertia (motor moment of inertia: p0341*p0342 + load torque: p1498) the required torque for a demanded speed dynamic performance optimized from a time perspective.

Note

If the motor is operated with and without an encoder (e.g. p0491 not 0 or p1404 < p1082), the maximum current during operation without an encoder can be reduced via p0642 (reference value is p0640) in order to minimize interfering, saturation-related motor data changes during operation without an encoder.

A torque smoothing time can be parameterized via p1517 for the torque pre-control. The speed controller needs to be optimized for operation without an encoder due to the lower dynamic response. This can be carried out via p1470 (P gain) and p1472 (integral time).

In the low-speed range, the actual speed value, the orientation, and the actual flux can no longer be calculated during operation without an encoder due to the accuracy of the measured values and the parameter sensitivity of the technique. For this reason, an open-loop current/frequency control is selected. The switchover threshold is parameterized via p1755 and the hysteresis via p1756.

To accept a high load torque even in the open-loop controlled range, the motor current can be increased via p1612. To do so, the drive torque (e.g. friction torque) must be known or estimated. An additional reserve of approx. 20% should also be added. In synchronous motors, the torque is converted to the current via the motor torque constant (p0316). In the lower speed range, the required current cannot be measured directly on the Motor Module. The default setting is 50% (synchronous motor) or 80% (induction motor) of the rated motor current (p0305). When parameterizing the motor current (p1612), you must take into account the thermal motor load.

Note

Sensorless operation (without an encoder) is not permitted for vertical axes or similar. Sensorless operation is not suitable for a higher-level closed-loop position control either.

The start behavior of synchronous motors from standstill can be improved further by parameterizing the pole position identification (p1982 = 1).

Behavior once pulses have been canceled

Once the pulses have been canceled in operation without an encoder, the current actual speed value of the motor can no longer be calculated. Once the pulses are enabled again, the system must search for the actual speed value.

p1400.11 can be used to parameterize whether the search is to begin with the speed setpoint (p1400.11 = 1) or with speed = 0.0 (p1400.11 = 0). Under normal circumstances, p1400.11 = 0 because the motor is usually started from standstill. If the motor is rotating faster than the changeover speed p1755 when the pulses are enabled, p1400.11 = 1 must be set.

If the motor is rotating and the start value for the search is as of the setpoint (p1400.11 = 1), the speed setpoint must be in the same direction as the actual speed before the pulses can be enabled. A large discrepancy between the actual and setpoint speed can cause a malfunction.

⚠ WARNING

Once the pulses have been canceled, no information about the motor speed is available. The computed actual speed value is then set to zero, which means that all actual speed value messages and output signals are irrelevant.

Switchover between closed-loop/open-loop operation and operation with/without encoder

Operation without an encoder is activated via parameter setting p1300 = 20. If p1300 = 20 or p1404 = 0, operation without an encoder is active across the entire speed range. If the speed value is less than the changeover speed p1755, the motor is operated in accordance with the current/frequency.

During operation with an encoder, a switchover can be made to operation without an encoder when the speed threshold p1404 is exceeded. If p1404 > 0 and p1404 < p1755, a switchover is not made to operation without an encoder until the speed exceeds p1755.

Operation without an encoder is displayed in parameter r1407.1.

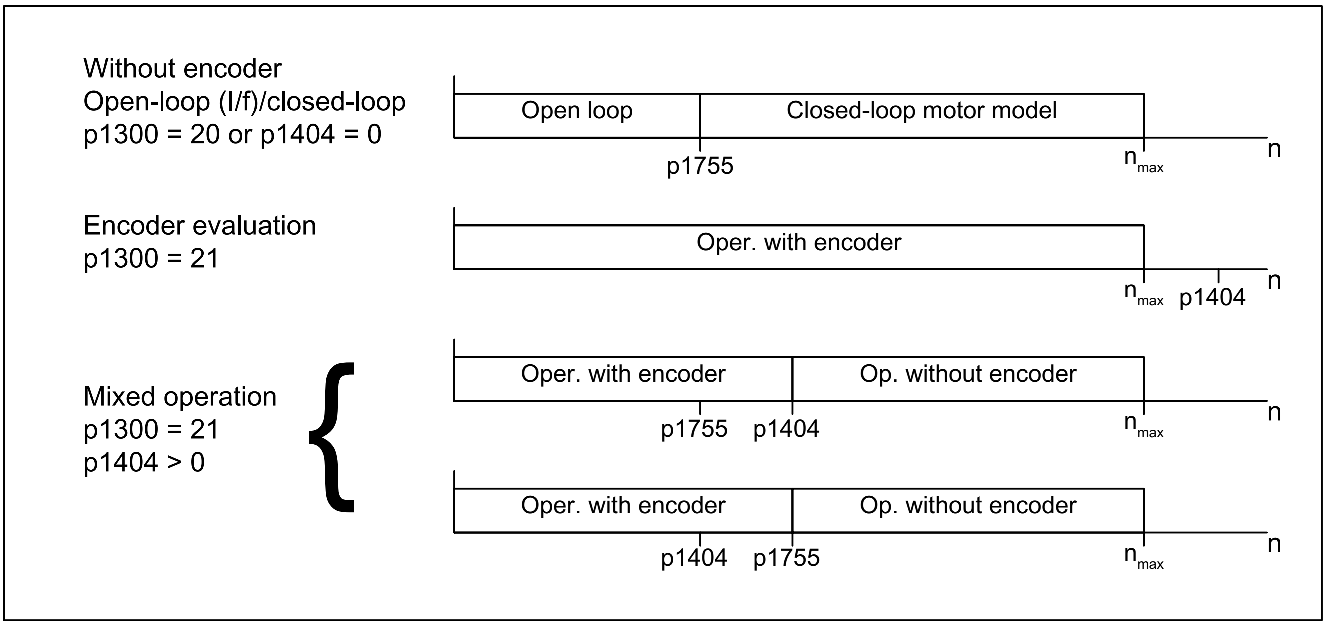


Figure 3-17 Area switchover

Note

In closed-loop control operating mode "Speed controller without encoder", a rotor position encoder is not required. Since a temperature monitor is not usually connected in this case either, this must be parameterized via p0600 = 0 (no sensor).

Series reactor

When high-speed special motors are used, or other low leakage induction motors, a series reactor may be required to ensure stable operation of the current controller.

The series reactor can be integrated via p0353.

Commissioning/optimization

1. Estimate the motor current p1612 on the basis of the mechanical conditions (I = M/kt).
2. Set Kn (p1470) and Tn (p1472) above I/f operation (> p1755). The load moment of inertia should be set to zero here (p1498 = 0), since this deactivates part of the torque pre-control.
3. Determine the load moment of inertia in the speed range above I/f operation (> p1755) by setting p1498 via a ramp response (e.g. ramp time 100 ms) and assessing the current (r0077) and model speed (r0063).

Function diagrams (see SINAMICS S List Manual)

- 5050 Kp_n-/Tn_n adaptation
- 5060 Torque setpoint, control type switchover
- 5210 Speed controller

Overview of key parameters (see SINAMICS S List Manual)

- p0341 motor moment of inertia
- p0342 Ratio between the total moment of inertia and that of the motor
- p0353 Motor series inductance
- p0600 Motor temperature sensor for monitoring
- p0640 current limit
- p0642 Sensorless current reduction
- p1300 Open-loop/closed-loop control operating mode
- p1400.11 Speed control configuration; sensorless operation actual speed value start value
- p1404 Sensorless operation changeover speed
- r1407.1 CO/BO: Status word speed controller; sensorless operation active
- p1470 Speed controller sensorless operation P-gain
- p1472 Speed controller sensorless operation integral-action time
- p1498 Load moment of inertia
- p1517 Accelerating torque smoothing time constant
- p1612 Current setpoint, open-loop control, sensorless
- p1755 Motor model without encoder, changeover speed
- p1756 Motor model changeover speed hysteresis

3.12 Motor data identification

Description

The motor data identification (MotID) is used as tool to determine the motor data, e.g. of third-party motors and can help to improve the torque accuracy (k_T estimator). The drive system must have been commissioned for the first time as basis for using MotID. To do this, either the electrical motor data (motor data sheet) or the rating plate data must be entered and the calculation of the motor/control parameters (p0340) must have been completed.

Commissioning involves the following steps:

- Enter the motor data or the rating plate data and the encoder data
- Complete calculation of the motor and control data as starting value for the MotID (p0340 = 3, if motor data, p0340 = 1, if rating plate data were entered)
- Carry-out a static measurement (p1910)
- For synchronous motors: Carry-out an angular commutation calibration (p1990) and if required, fine synchronization (refer to r1992)
- Carry-out a rotating measurement (p1960)

  Before starting the rotating measurement, the speed controller setting should be checked and optimized (p1460, p1462 and p1470, p1472).

  It is preferable if the rotating MotID is carried-out with the motor de-coupled from the mechanical system. This therefore means that only the motor moment of inertia is determined. The total moment of inertia with mechanical system can be subsequently identified with p1959 = 4 and p1960 = 1. The stress on the mechanical system can be reduced by parameterizing the ramp-up time (p1958) and/or using a speed limit (p1959.14/p1959.15) or using the current and speed limit. The higher the selected ramp-up time, the less accurate the moment of inertia determined.

  Note

  Completion of the individual identification runs can be read via parameters r3925 to r3928.

The enable signals OFF1, OFF2, OFF3 and "enable operation" remain effective and can be interrupt the motor identification routine.

If there is an extended setpoint channel (r0108.08 = 1), parameters p1959.14 = 0 and p1959.15 = 0 and a direction of rotation limit (p1110 or p1111) is active there, then this is observed at the instant of the start via p1960. For p1958 = -1, the ramp-up and ramp-down time of the setpoint channel (p1120 and p1121) are also used for the MotID.

Note

If a ramp-up/ramp-down time or one direction of rotation limit is activated, parts of the motor data identification routine cannot be carried-out. For other parts of the motor data identification routine, the accuracy of the results is diminished because a ramp-up/ramp-down time is selected. If possible, p1958 should be 0 and no direction of rotation limit selected (p1959.14 = 1 and p1959.15 = 1).

> ⚠ **DANGER**
>
> The stationary MotID can result in slight movement of up to 210 degrees electrical.
>
> For the rotating motor data identification routine, motor motion is initiated, which can reach the maximum speed (p1082) and the motor torque corresponding to the maximum current (p0640).
>
> The rotating measurement should be carried out with a motor running at no load (de-coupled from the mechanical system) in order to prevent damage/destruction to the load or be influenced by the load. If the motor cannot be de-coupled from the mechanical system, then the stress on the mechanical system can be reduced by parameterizing the ramp-up time (p1958) and/or using a speed limit (p1959.14/p1959.15) or using the current and speed limit.
>
> If a mechanical distance limit has been set, you are advised not to carry out the rotating measurement.
>
> The emergency STOP functions must be fully operational during commissioning.
>
> To protect the machines and personnel, the relevant safety regulations must be observed.

Motor data

Motor data input requires the following parameters:

Table 3-8 Motor data

Induction motor	Permanent-magnet synchronous motor
• p0304 rated motor voltage • p0305 rated motor current • p0307 rated motor power • p0308 rated motor power factor • p0310 rated motor frequency • p0311 rated motor speed • p0320 rated motor magnetizing current • p0322 maximum motor speed • p0350 motor stator resistance, cold • p0353 motor series inductance • p0354 motor rotor resistance, cold • p0356 motor stator leakage inductance • p0358 motor rotor leakage inductance • p0360 motor magnetizing inductance • p0400ff encoder data	• p0305 rated motor current • p0311 rated motor speed • p0314 motor pole pair number • p0316 motor torque constant • p0322 maximum motor speed • p0323 maximum motor current • p0341 motor moment of inertia • p0350 motor stator resistance, cold • p0353 motor series inductance • p0356 motor stator leakage inductance • p0400ff encoder data

Type plate data

Input of the type plate data requires the following parameters:

Table 3-9 Type plate data

Induction motor	Permanent-magnet synchronous motor
• p0304 rated voltage • p0305 rated current • p0307 rated power • p0308 rated power factor (cos ϕ) • p0310 rated frequency • p0311 rated speed • p0322 maximum motor speed • p0353 motor series inductance • p0400ff encoder data	• p0304 rated voltage • p0305 rated current • p0307 rated power (alternative p0316) • p0311 rated speed • p0314 motor pole pair number or p0315 motor pole pair width • p0322 maximum motor speed • p0323 maximum motor current • p0353 motor series inductance • p0400ff encoder data

Since the type plate data contains the initialization values for identification, you must ensure that it is entered correctly and consistently to enable the above data to be determined.

Parameters to control the MotID

The following parameters influence the MotID:

Table 3-10 Parameters for control

Static measurement (motor data identification)	rotating measurement
• p0640 current limit • p1215 Motor holding brake configuration • p1909 Motor data identification control word • p1910 Motor data identification, stationary • p1959.14/.15 clockwise/counter-clockwise direction or rotation permitted	• p0640 current limit • p1082 Maximum speed • p1958 motor data identification ramp-up/ramp-down time • p1959 Rotating measurement configuration • p1960 Rotating measurement selection
Note: If a brake is being used and is operational (p1215 = 1, 3), then the stationary measurement with closed brake is carried-out. If possible (e.g. no hanging/suspended axis), we recommend that the brake is opened before the MotID (p1215 = 2). This also means that the encoder size can be adjusted and the angular commutation calibrated.	

3.12.1 Motor data identification - induction motor

Induction motor

The data are identified in the gamma equivalent circuit diagram and displayed in r19xx. The motor parameters p0350, p0354, p0356, p0358 and p0360 taken from the MotID refer to the T equivalent circuit diagram of the induction machine and cannot be directly compared. This is the reason that an r parameter is listed in the table, which displays the parameterized motor parameters in the gamma equivalent circuit diagram.

Table 3-11 Data determined using p1910 for induction motors (stationary measurement)

<table>
<tr><th>Determined data (gamma)</th><th>Data that are accepted (p1910 = 1)</th></tr>
<tr><td>r1912 identified stator resistance</td><td>p0350 motor stator resistance, cold
+ p0352 cable resistance</td></tr>
<tr><td>r1913 rotor time constant identified</td><td>r0384
motor rotor time constant/damping time constant, d axis</td></tr>
<tr><td>r1915 stator inductance identified</td><td>-</td></tr>
<tr><td>r1925 threshold voltage identified</td><td>-</td></tr>
<tr><td>r1927 rotor resistance identified</td><td>r0374 motor resistance cold (gamma)
p0354</td></tr>
<tr><td>r1932 d inductance</td><td>r0377 motor leakage inductance, total (gamma)
p0353 motor series inductance
p0356 motor leakage inductance
p0358 motor leakage inductance
p1715 current controller P gain
p1717 current controller integral action time</td></tr>
<tr><td>r1934 q inductance identified</td><td>-</td></tr>
<tr><td>r1936 magnetizing inductance identified</td><td>r0382 motor main inductance, transformed (gamma)
p0360 motor main inductance
p1590 flux controller P gain
p1592 flux controller integral action time</td></tr>
<tr><td>r1973 encoder pulse number identified</td><td>-</td></tr>
<tr><td colspan="2">Note:
The encoder pulse number is only determined with a very high degree of inaccuracy (p0407/p0408) and is only suitable for making rough checks. The sign is negative if inversion is required (p0410.0).</td></tr>
<tr><td>-</td><td>p0410 encoder inversion actual value</td></tr>
<tr><td colspan="2">Note:
If the encoder inversion is changed using MotID, fault F07993 is output, which refers to a possible change in the direction of rotation and can only be acknowledged by p1910 = -2.</td></tr>
</table>

Table 3-12 Data determined using p1960 for induction motors (rotating measurement)

<table>
<tr><th>Determined data (gamma)</th><th>Data that are accepted (p1960 = 1)</th></tr>
<tr><td>r1934 q inductance identified</td><td rowspan="2">-</td></tr>
<tr><td>r1935 q inductance identification current</td></tr>
<tr><td colspan="2">Note:
The q inductance characteristic can be used as basis to manually determine the data for the current controller adaptation (p0391, p0392 and p0393).</td></tr>
<tr><td>r1936 magnetizing inductance identified</td><td>r0382 motor main inductance, transformed (gamma)
p0360 motor main inductance
p1590 flux controller P gain
p1592 flux controller integral action time</td></tr>
<tr><td>r1948 magnetizing current identified</td><td>p0320 rated motor magnetizing current</td></tr>
<tr><td>r1962 saturation characteristic magnetizing current identified</td><td>-</td></tr>
<tr><td>r1963 saturation characteristic stator inductance identified</td><td>-</td></tr>
</table>

Determined data (gamma)	Data that are accepted (p1960 = 1)
Note: The magnetic design of the motor can be identified from the saturation characteristic.	
r1969 moment of inertia identified	p0341 motor moment of inertia * p0342 ratio between the total moment of inertia and that of the motor + p1498 load moment of inertia
r1973 encoder pulse number identified	-
Note: The encoder pulse number is only determined with a very high degree of inaccuracy (p0407/p0408) and is only suitable for making rough checks. The sign is negative if inversion is required (p0410.0).	

3.12.2 Motor data identification - synchronous motor

Synchronous motor

Table 3-13 Data determined using p1910 for synchronous motors (stationary measurement)

Determined data	Data that are accepted (p1910 = 1)
r1912 stator resistance identified	p0350 motor stator resistance, cold + p0352 cable resistance
r1925 threshold voltage identified	-
r1932 d inductance	p0356 motor stator leakage inductance + p0353 motor series inductance p1715 current controller P gain p1717 current controller integral-action time
r1934 q inductance identified	-
r1950 voltage emulation error voltage values	p1952 voltage emulation error, final value
r1951 voltage emulation error, current values	p1953 voltage emulation error, current offset
Note regarding r1950 to p1953: Active when the function module "extended torque control" is activated and activated compensation of the voltage emulation error (p1780.8 = 1).	
r1973 encoder pulse number identified	-
Note: The encoder pulse number is only determined with a very high degree of inaccuracy (p0407/p0408) and is only suitable for making rough checks. The sign is negative if inversion is required (p0410.0).	
r1984 Pole position identification angular difference	p0431 Angular commutation offset
Note: r1984 indicates the difference of the angular commutation offset before being transferred into p0431.	
-	p0410 encoder inversion actual value
Note: If the encoder inversion is changed using MotID, fault F07993 is output, which refers to a possible change in the direction of rotation and can only be acknowledged by p1910 = -2.	

Table 3-14 Data determined using p1960 for synchronous motors (rotating measurement)

Determined data	Data that are accepted (p1960 = 1)
r1934 q inductance identified	-
r1935 q inductance identification current	-
Note: The q inductance characteristic can be used as basis to manually determine the data for the current controller adaptation (p0391, p0392 and p0393).	
r1937 torque constant identified	p0316 motor torque constant
r1938 voltage constant identified	p0317 motor voltage constant
r1939 reluctance torque constant identified	p0328 motor reluctance torque constant
r1947 optimum load angle identified	p0327 optimum motor load angle
r1969 moment of inertia identified	p0341 motor moment of inertia * p0342 ratio between the total moment of inertia and that of the motor + p1498 load moment of inertia
r1973 encoder pulse number identified	-
Note: The encoder pulse number is only determined with a very high degree of inaccuracy (p0407/p0408) and is only suitable for making rough checks. The sign is negative if inversion is required (p0410.0).	
r1984 Pole position identification angular difference	p0431 Angular commutation offset
Note: r1984 indicates the difference of the angular commutation offset before being transferred into p0431.	

For linear motors (p0300 = 4xx), p1959 is pre-set so that only the q inductance, the angular commutation offset and the high inertia mass are measured (p1959.05 = 1 and p1959.10 = 1), as generally the travel limits do not permit longer traversing distances in one direction.

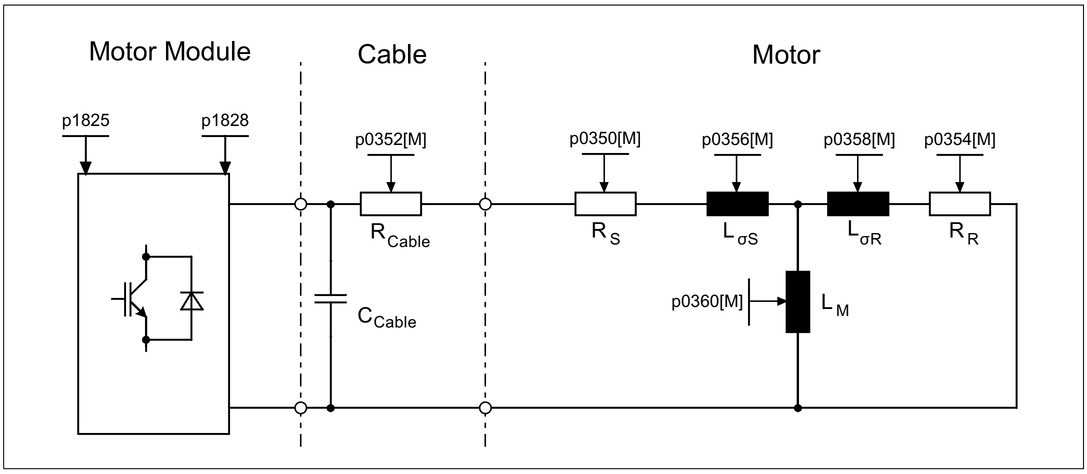


Figure 3-18 Equivalent circuit diagram for induction motor and cable

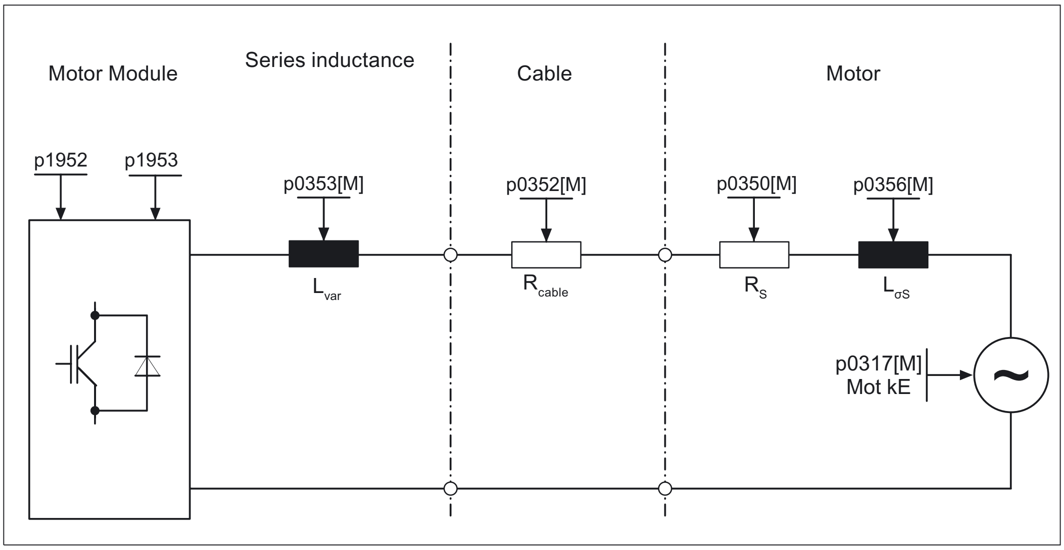


Figure 3-19 Equivalent circuit diagram for synchronous motor and cable

Overview of key parameters (see SINAMICS S List Manual)

- r0047 Status identification

Standstill measurement

- p1909 Motor data identification control word
- p1910 Motor data identification, stationary

Rotating measurement

- p1958 Motor data identification ramp-up/ramp-down times
- p1959 Rotating measurement configuration
- p1960 Rotating measurement selection

3.13 Pole position identification

Description

For synchronous motors, the pole position identification determines its electrical pole position, that is required for the field-oriented control. Generally, the electrical pole position is provided from a mechanically adjusted encoder with absolute information. In this case, pole position identification is not required. For the following encoder properties, pole position identification is not required:

- Absolute encoder (e.g. EnDat)
- Encoder with C/D track and pole pair number ≤ 8

- Hall sensor
- Resolver with a multiple integer ratio between the motor pole pair number and the encoder pole pair number
- Incremental encoder with a multiple integer ratio between the motor pole pair number and the encoder pulse number

The pole position identification is used for:

- Determining the pole position (p1982 = 1)
- Determining the angular commutation offset during commissioning (p1990 = 1)
- Plausibility check for encoders with absolute information (p1982 = 2)

⚠ WARNING
When the motors are not braked, the motor rotates or moves as a result of the current impressed during the measurement. The magnitude of the motion depends on the magnitude of the current and the moment of inertia of the motor and load.

Notes regarding pole position identification

The relevant technique can be selected using parameter P1980. The following techniques are available for a pole position identification routine:

- Saturation-based 1st+ 2nd harmonics (p1980 = 0)
- Saturation-based 1st harmonics (p1980 = 1)
- Saturation-based, two-stage (p1980 = 4)
- Saturation-based (p1980 = 10)

The following limitations/constraints apply for the saturation-based motion technique:

- This technique can be used for both braked and non-braked motors.
- It can only be used for a speed setpoint = 0 or from standstill.
- The specified current magnitudes (p0325, p0329) must be sufficient to provide a significant measuring result.
- For motors without iron, the pole position cannot be identified using the saturation-based technique.
- For 1FN3 motors, no traversing with the 2nd harmonic should take place (p1980 = 0,4).
- With 1FK7 motors, two-stage procedures must not be used (p1980 = 4). The value in p0329, which is set automatically, must not be reduced.

For the motion-based technique, the following constraints apply:

- The motor must be free to move and it may not be subject to external forces (no hanging/suspended axes)
- It can only be used for a speed setpoint = 0 or from standstill.
- If there is a motor brake, then this must be open (p1215 = 2).
- The specified current magnitude (p1993) must move the motor by a sufficient amount.

⚠ WARNING
Before using the pole position identification routine, the control sense of the speed control loop must be corrected (p0410.0). For linear motors, refer to the Commissioning Manual. For rotating motors, in sensorless operation with a small positive speed setpoint (e.g. 10 RPM), the speed actual value (r0061) and the speed setpoint (r1438) must have the same sign.

CAUTION
If more than one 1FN3 linear motor is using saturation-based pole position identification for commutation (p1980 <= 4 and p1982 = 1), this can reduce accuracy when the commutation angle is determined. If a high level of accuracy is essential, (e.g. when p404.15 = 0 or the commutation angle offset is determined with p1990 = 1), the pole position identification runs should be carried out consecutively. This can be achieved by staggering the time at which the individual drives are enabled.

Pole position determination with zero marks

The pole position identification routine provides coarse synchronization. If zero marks exist, the pole position can be automatically compared with the zero mark position once the zero mark(s) have been passed (fine synchronization). The zero mark position must be either mechanically or electrically (p0431) calibrated. If the encoder system permits this, then we recommend fine synchronization (p0404.15 = 1). This is because it avoids measurement spread and allows the determined pole position to be additionally checked.

Suitable zero marks are:

- One zero mark in the complete traversing range
- Equidistant zero marks whose relevant position to the commutation are identical
- Distance-coded zero marks

Determining a suitable technique for the pole position identification routine

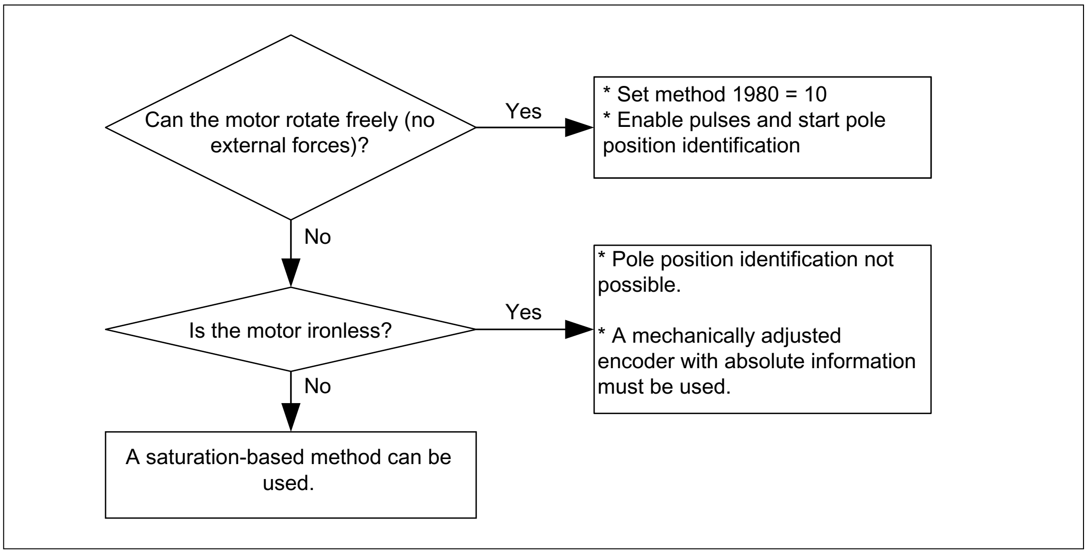


Figure 3-20 Selecting the appropriate technique

Overview of key parameters

- p0325[0...n] Motor pole position identification current 1st phase
- p0329[0...n] Motor pole position identification current
- p0404.15 Commutation with zero mark
- p0431 Angular commutation offset
- p1980[0...n] Pole position identification procedure
- p1981[0...n] Pole position identification maximum movement
- p1982[0...n] Pole position identification selection
- p1983 Pole position identification test
- r1984 Pole position identification angular difference
- r1985 Pole position identification saturation curve
- r1987 Pole position identification trigger curve
- p1990 Pole position identification commutation angle offset commissioning
- r1992 Pole position identification diagnostics
- p1993 Pole position identification current, motion based
- p1994 Pole position identification rise time motion based
- p1995 Pole position identification motion based P gain
- p1996 Pole position identification motion based integral action time
- p1997 Pole position identification motion based smoothing time

Angular commutation offset commissioning support (p1990)

The function for determining the commutation angle offset is activated via p1990=1. The commutation angle offset is entered in p0431. This function can be used in the following cases:

- Single calibration of the pole position for encoders with absolute information (exception: The Hall sensor must always be mechanically adjusted.)
- Calibrating the zero mark position for fine synchronization

Table 3-15 Mode of operation of p0431

	Incremental without zero mark	Incremental with one zero mark	Incremental with distance-coded zero marks	EnDat absolute encoder
C/D track	p0431 shifts the commutation with respect to the C/D track	p0431 shifts the commutation with respect to the C/D track and zero mark	Currently not available	Not permitted
Hall sensor	p0431 does not influence the Hall sensor. The Hall sensor must be mechanically adjusted.	p0431 does not influence the Hall sensor. p0431 shifts the commutation with respect to the zero mark	p0431 does not influence the Hall sensor. p0431 shifts the commutation with respect to the absolute position (after two zero marks have been passed)	Not permitted
Pole position identification	p0431 no effect	p0431 shifts the commutation with respect to the zero mark	p0431 shifts the commutation with respect to the absolute position (after two zero marks have been passed)	p0431 shifts the commutation with respect to the EnDat absolute position

Note

When fault F07414 occurs, p1990 is automatically started; if p1980 is not equal to 99 and p0301 does not refer to a catalog motor with an encoder that is adjusted in the factory.

3.14 Vdc control

Description

Vdc control can be activated if overvoltage or undervoltage is present in the DC link line-up. In the line-up, one or more drives can be used to relieve the DC link. This prevents a fault from occurring due to the DC link voltage and ensures that the drives are always ready to use

This function is activated by means of the configuration parameter (p1240). It can be activated if an overvoltage or undervoltage is present. The torque limits of the motors at which the Vdc controller is active can be affected if discrepancies in the DC link voltage are significant enough. The motors may no longer be able to maintain their setpoint speed or the acceleration/braking phases are prolonged.

The Vdc controller is an automatic P controller that influences the torque limits. It only intervenes when the DC link voltage approaches the "upper threshold" (p1244) or "lower threshold" (p1248) and the corresponding controller is activated via the configuration parameter (p1240).

The recommended setting for the P gain is
p1250 = 0.5*DC link capacitance [mF].

Once the DC link has been identified (p3410), the DC link capacitance can be read in parameter p3422 in the Infeed Module.

Note

To ensure that the drives remain active if the Line Module has failed, the response to fault F07841 must be changed to "none" or the operation message from the Infeed Module must be permanently set to "1" with p0864.

The Vdc controller can be used, for example, when a Line Module without energy feedback (Vdc_max controller) is used and as a safety measure in the event of a power failure (Vdc_min and Vdc_max controller). To ensure that critical drives can be operated for as long as possible, parameterizable faults exist that switch off individual drives if there is a problem with the DC link.

Description of Vdc_min control (p1240 = 2, 3)

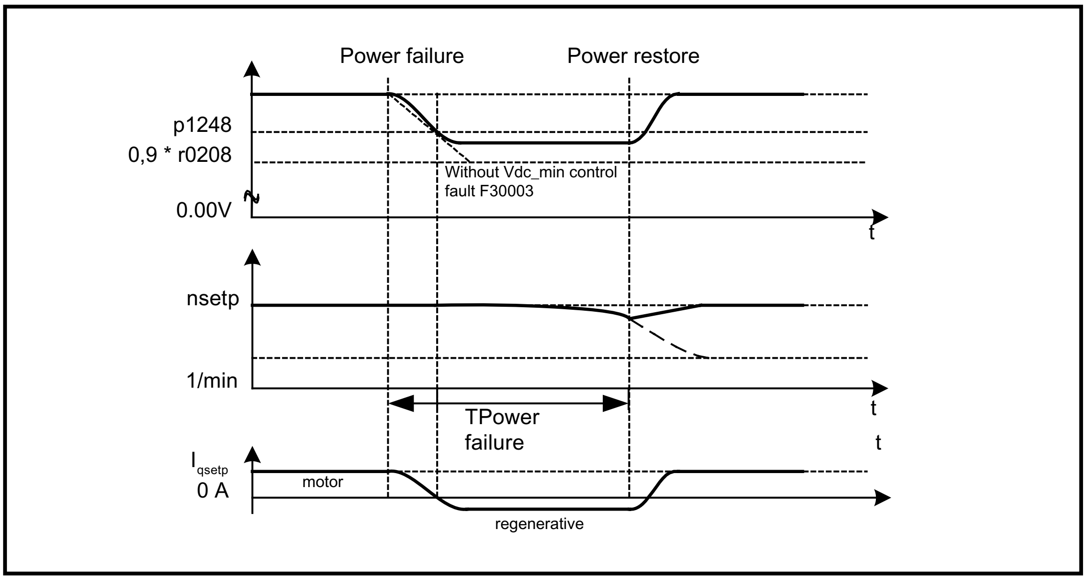


Figure 3-21 Switching Vdc_min control on/off (kinetic buffering)

In the event of a power failure, the Line Module can no longer supply the DC link voltage, particularly if the Motor Modules in the DC link line-up are drawing active power. To maintain the DC link voltage in the event of a power failure (e.g. for a controlled emergency retraction), the Vdc_min controller can be activated for one or more drives. If the voltage threshold set in p1248 is undershot, these drives are decelerated so that their kinetic energy can be used to maintain the DC link voltage. The threshold should be considerably higher than the shutdown threshold of the Motor Modules (recommendation: 50 V below the DC link voltage). When the power supply is reestablished, the Vdc controller is automatically deactivated and the drives approach the speed setpoint again. If the power supply cannot be reestablished, the DC link voltage collapses if the kinetic energy of the drives is exhausted with an active Vdc_min controller.

Note

You must make sure that the converter is not disconnected from the power supply. It could become disconnected, for example, if the line contactor drops out. The line contactor should have an uninterruptible power supply (UPS), for example.

Description of Vdc_min control without braking (p1240 = 8, 9)

As with p1240 = 2, 3, however, active motor braking can be prevented by reducing the DC link voltage. The effective upper torque limit must not be less than the torque limit offset (p1532). The motor does not switch to regenerative mode and no longer draws any active power from the DC link.

Description of Vdc_max control (p1240 = 1, 3)

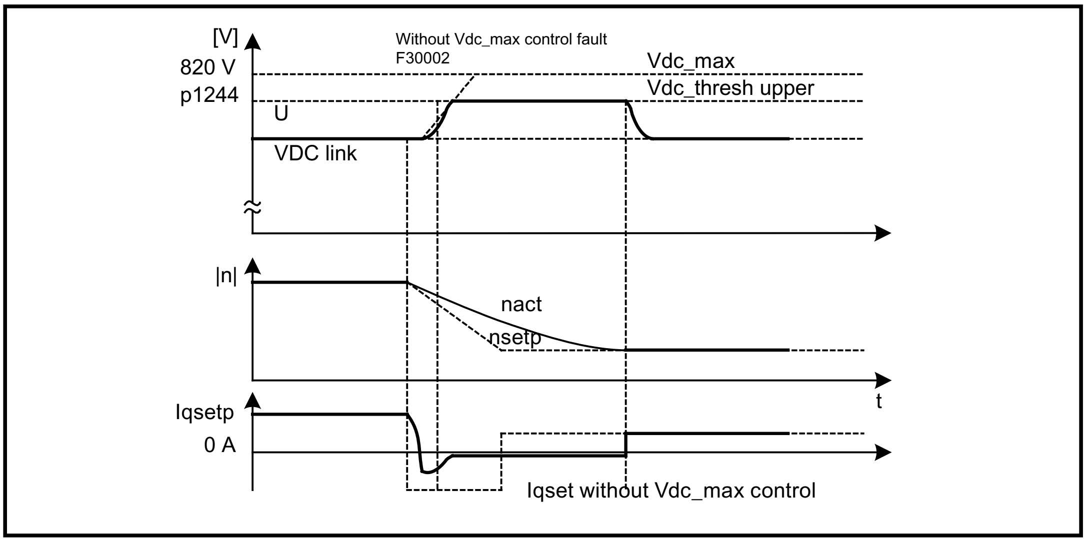


Figure 3-22 Switching-in/switching-out the Vdc_max control

With Infeed Modules without feedback or in the event of a power failure, the DC link voltage can increase until it reaches the shutdown threshold when drives in the DC link line-up are decelerated. To prevent the system from shutting down due to a DC link overvoltage, the Vdc_max controller can be activated for one or more drives. The Vdc_max controller is normally activated for drives that have to decelerate/accelerate high levels of kinetic energy themselves. When the overvoltage threshold in p1244 is reached (recommended setting: 50 V higher than the DC link voltage), the braking torque of the drives with an active Vdc_max controller is reduced by shifting the torque limit. In this way, the drives feed back the same amount of energy that is used as a result of losses or consumers in the DC link, thereby minimizing the braking time. If other drives for which the Vdc_max controller is not active feed energy back, the drives with an active Vdc_max controller can even be accelerated to absorb the braking energy and, in turn, relieve the DC link.

Description of Vdc_max control without acceleration (p1240 = 7, 9)

As with p1240 = 1, 3, if the drive must not be accelerated by means of feedback from other drives in the DC link, acceleration can be prevented by the setting p1240 = 7, 9. The effective lower torque limit must not be greater than the torque limit offset (p1532).

Description of Vdc controller monitoring functions (p1240 = 4, 5, 6)

In the event of a power failure, the Line Module can no longer supply the DC link voltage, particularly if the Motor Modules in the DC link line-up are drawing active power. To ensure that the DC link voltage is not burdened with uncritical drives in the event of a power failure, these drives can be switched off by a fault (F30003) with a parameterizable voltage threshold (p1248). This is carried out by activating the Vdc_min monitoring function (p1240 = 5, 6).

In the event of a power failure, the DC link voltage can increase until it reaches the shutdown threshold when drives are decelerated. To ensure that the DC link voltage is not burdened with uncritical drives in the event of a power failure, these drives can be switched off by a fault (F30002) with a parameterizable voltage threshold (p1244). This is carried out by activating the Vdc_max monitoring function (p1240 = 4, 6).

Function diagrams (see SINAMICS S List Manual)

- 5650 Vdc_max controller and Vdc_min controller

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p1240 Vdc controller or Vdc monitoring configuration
- p1244 DC link voltage threshold, upper
- p1248 DC link voltage threshold, lower
- p1250 Vdc controller proportional gain

Display parameters

- r0056.14 Vdc_max controller active
- r0056.15 Vdc_min controller active

3.15 Dynamic Servo Control (DSC)

Description

The function Dynamic Servo Control" (DSC) is a closed-loop control structure which is computed in a fast speed controller clock cycle and is supplied with setpoints by the control in the position controller clock cycle.

This allows higher position controller gain factors to be achieved.

The following prerequisites are necessary to use the "Dynamic Servo Control" function:

- n-set mode
- Isochronous PROFIBUS DP or PROFINET IO with IRT
- The position controller gain factor (KPC) and the system deviation (XERR) must be included in the PROFIBUS-DP setpoint telegram or PROFINET IO with IRT (refer to P0915).
- The position actual value must be transferred to the master in the actual value telegram of PROFIBUS-DP or PROFINET IO via the encoder interface Gx_XIST1.
- When DSC is activated, the speed setpoint N_SOLL_B from the PROFIBUS DP or PROFINET IO with IRT telegram is used as speed pre-control value.
- The internal quasi position controller uses the position actual value from the motor measuring system (G1_XIST1) or the position actual value from the additional encoder system (telegrams 06, 106, 116 or free telegrams).

The following PROFIdrive telegrams support DSC:

- Standard telegrams 5 and 6,
- SIEMENS telegrams 105, 106 ,116.

Further PZD data telegram types can be used with the telegram extension. It must then be ensured that SERVO supports a maximum of 16 PZD setpoints and 19 PZD actual values.

Note

Synchronization is required on the control side and on the drive side for the operation of DSC.

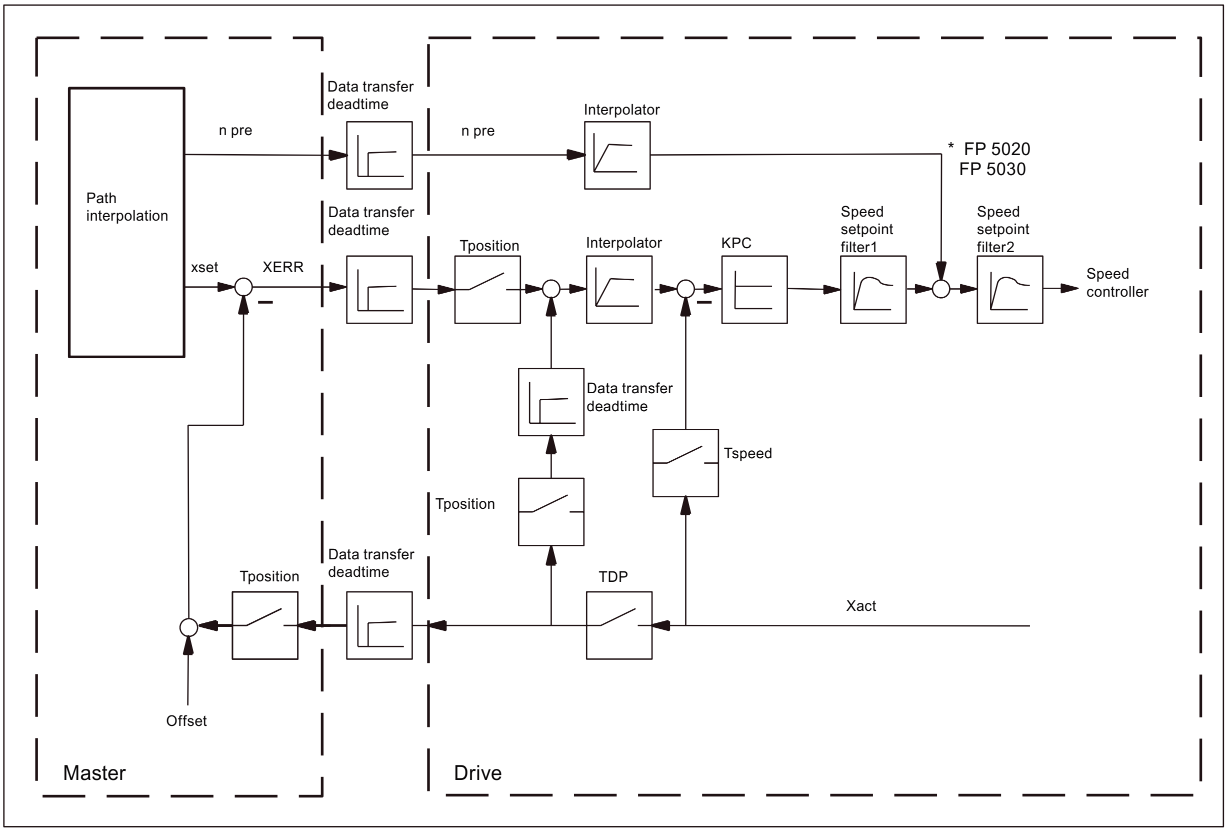


Figure 3-23 Control principle using DSC

Activating

If the prerequisites for DSC are met, the DSC structure is activated through a logical combination of the parameters p1190 "DSC position deviation XERR" and p1191 "DSC position controller gain KPC" through a selected suitable PROFIdrive telegram.
If KPC = 0 is issued, only speed control with the speed pre-control value (p1430, typically N_SOLL_B) can be used. Position controlled operation requires a transfer of KPC > 0.

When DSC is activated, it is recommended to use a new setting for the position controller gain KPC in the master.

When DSC is activated, the channels p1155 and p1160 for the position setpoint values as well as the channel for the extended setpoint value are not used.

The p1430 value for speed pre-control is still taken into account.

Deactivating

If both KPC = 0 (p1191=0) and XERR = 0 (p1190 = 0) are set, the DSC structure is dissolved and the "DSC" function is deactivated. In this case, only the value from p1430 from speed pre-control is taken into account.

Since it is possible to set higher gain factors using DSC, the control loop can become unstable when DSC is disabled. For this reason, before deactivating DSC, the value for KPC in the master must be reduced.

Speed setpoint filter

A speed setpoint filter to smoothen the speed setpoint steps is no longer required when DSC is active.

When using the "DSC" function, it only makes sense to use speed setpoint filter 1 to support the position controller, e.g. to suppress resonance effects.

External encoder systems (except motor encoder)

If, with DSC active, an external encoder is to be used, this requires the selection of a telegram with additional encoder actual values: Telegram 06,106,116 or free telegrams.

For optimum control in DSC mode, the same encoders must be used for the controller (Master) and the drive via the parameter p1192 "DSC encoder selection".

Since the motor encoder is no longer used in this case, the adaptation factor for the conversion of the selected encoder system into the motor encoder system is determined using parameter p1193 "DCS encoder adaptation factor". The factor represents the ratio of the pulse difference between the motor encoder and the used encoder for the same reference distance.

The effect of the parameters p1192 and p1193 is illustrated in function diagram 3090.

Diagnostics

Via the parameter r1407.4 = 1 it can be indicated whether the speed setpoint of DSC is used.

Preconditions for the indication:

- p1190 and p1191 must be connected to a signal source with a value of > 0 (DSC structure activated).
- OFF1, OFF3 und HALT2 must not be active.
- The motor data identification must not be active.
- Master control must not be active.

The "DSC" function cannot be active under the following conditions:

- Isochronous mode has not been selected (r2054 not equal to 4)
- PROFIBUS is not isochronous (r2064[0] not equal to 1)
- On the control side, DSC is not active, which causes the value of KPC =0 to be transmitted to p1191.

Function diagrams (see SINAMICS S List Manual)

- 2420 PROFIdrive standard telegrams and process data
- 2422 Vendor-specific telegrams and process data
- 3090 Dynamic Servo Control (DSC)
- 5020 Speed setpoint filter and speed pre-control
- 5030 Reference model

Overview of key parameters (see SINAMICS S List Manual)

- p1190 CI: DSC position deviation XERR
- p1191 CI: DSC position controller gain KPC
- p1192[DDS] DSC encoder selection
- p1193[DDS] DSC encoder adaptation factor
- r1407.4 CO/BO: Status word, velocity controller

3.16 Travel to fixed stop

Description

This function can be used to move a motor to a fixed stop at a specified torque without a fault being signaled. When the stop is reached, the specified torque is built up and remains applied.

The desired torque derating is brought about by scaling the upper/motor-mode torque limit and the lower/regenerative-mode torque limit.

Application examples

- Screwing parts together with a defined torque.
- Moving to a mechanical reference point.

Signals

When PROFIBUS telegrams 2 to 6 are used, the following are automatically interconnected:

- Control word 2, bit 8
- Status word 2, bit 8

Also with PROFIdrive telegrams 102 to 106:

- Message word, bit 1
- Process data M_red to the scaling of the torque limit

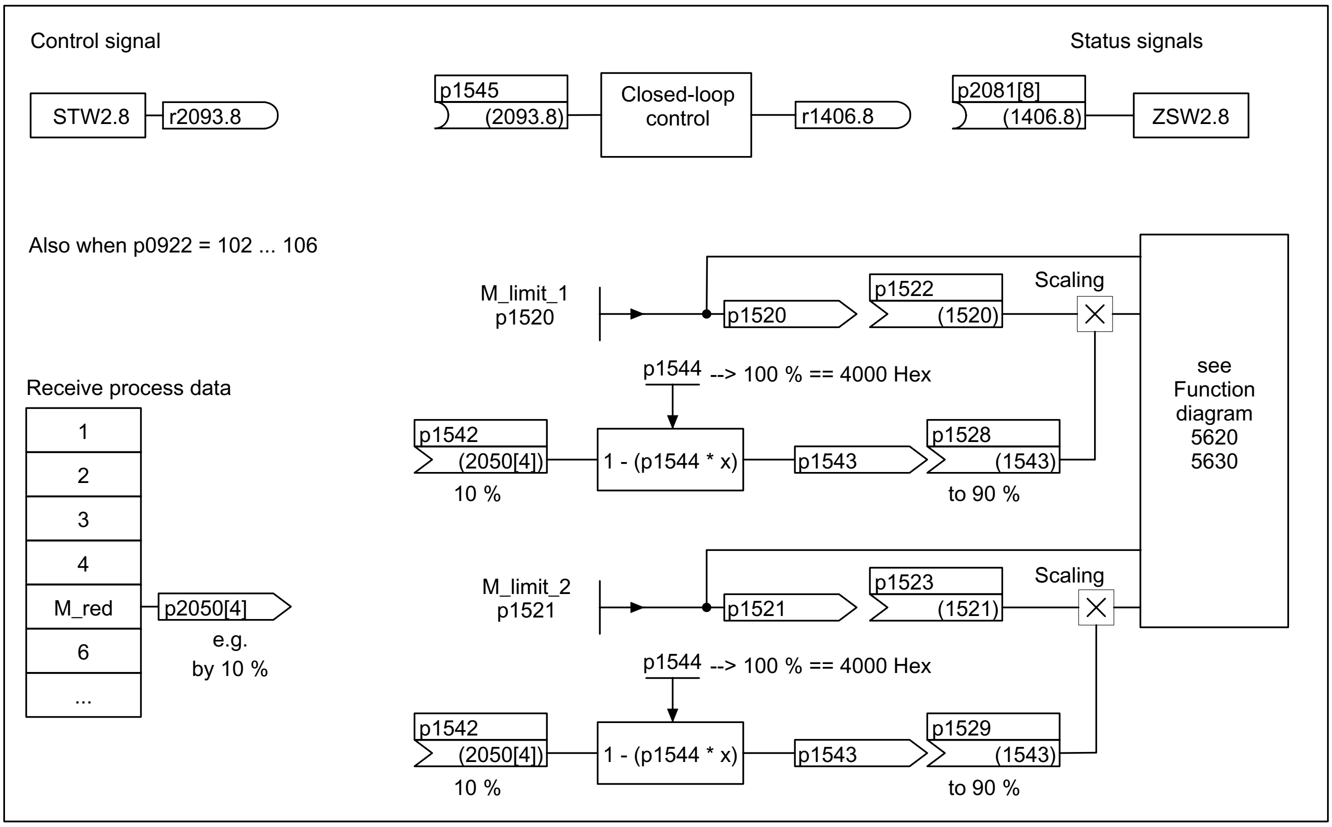


Figure 3-24 Signals for "Travel to fixed stop"

When PROFIdrive telegrams 2 to 6 are used, no torque reduction is transferred. When the "Travel to fixed stop" function is activated, the motor ramps up to the torque limits specified in p1520 and p1521. If the torque has to be reduced, protocols 102 to 106, for example, can be used to transfer it. Another option would be to enter a fixed value in p2900 and interconnect it to the torque limits p1528 and p1529.

Signal chart

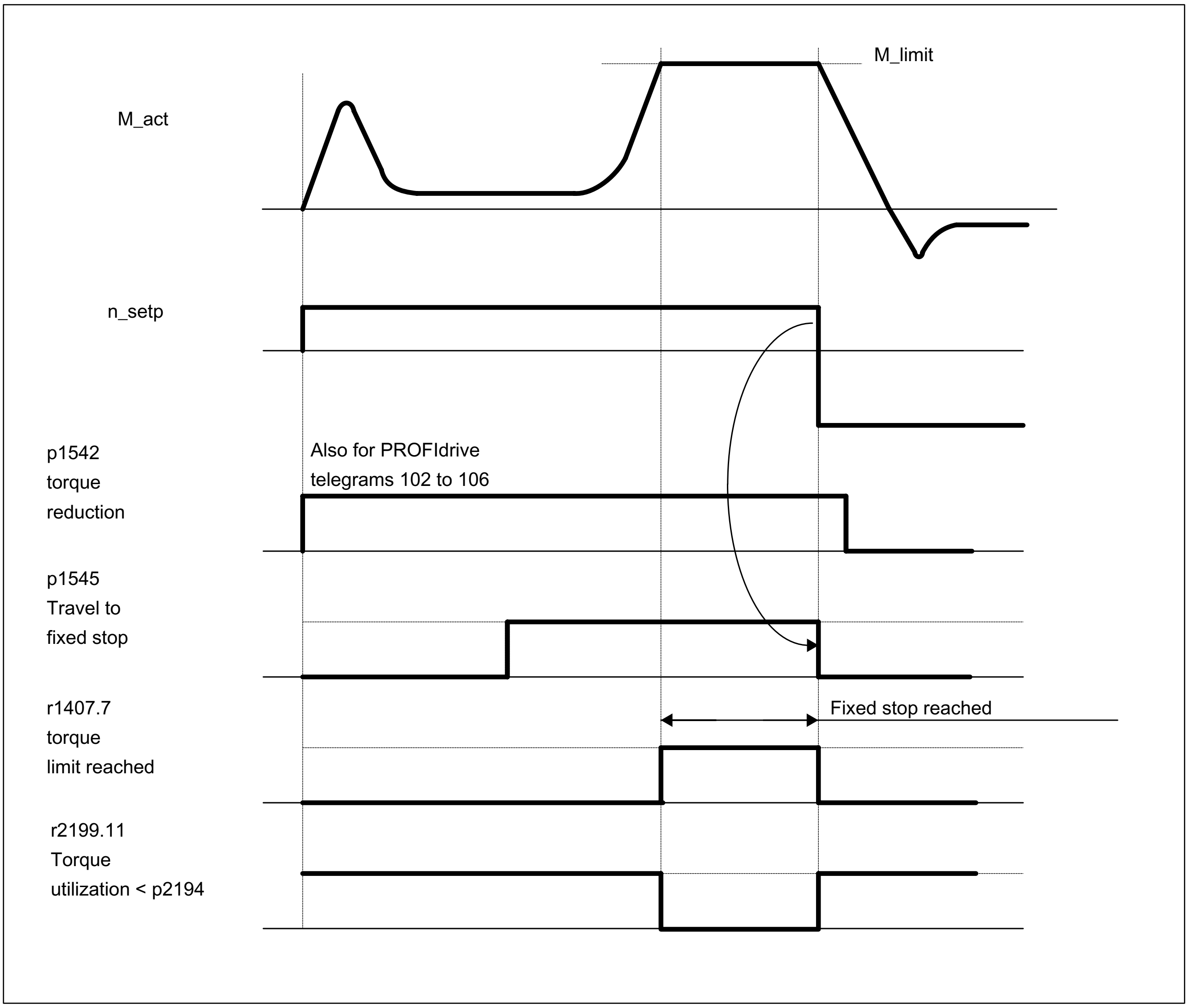


Figure 3-25 Signal chart for "Travel to fixed stop"

Commissioning for PROFIdrive telegrams 2 to 6

1. Activate travel to fixed stop.
   Set p1545 = "1".
2. Set the required torque limit.

   Example:
   p1400.4 = "0" —> upper or lower torque limit
   p1520 = 100 Nm —> effective in upper positive torque direction
   p1521 = –1500 Nm —> effective in lower negative torque direction
3. Run motor to fixed stop.

The motor runs at the set torque until it reaches the stop and continues to work against the stop until the torque limit has been reached, this status being indicated in status bit r1407.7 "Torque limit reached".

Control and status messages

Table 3-16 Control: Travel to fixed stop

Signal name	Internal control word STW n_ctrl	Binector input	PROFIdrive p0922 and/or p2079
Activates travel to fixed stop	8	p1545 Activates travel to fixed stop	STW2.8

Table 3-17 Status message: Travel to fixed stop

Signal name	Internal status word	Parameter	PROFIdrive p0922 and/or p2079
Travel to fixed stop active	-	r1406.8	ZSW2.8
Torque limits reached	ZSW n_ctrl.7	r1407.7	ZSW1.11 (inverted)
Torque utilization < torque threshold value 2	ZSW monitoring functions 3.11	r2199.11	MESSAGEW.1

Function diagrams (see SINAMICS S List Manual)

- 5610 Torque limiting/reduction/interpolator
- 5620 Motor/generator torque limit
- 5630 Upper/lower torque limit
- 8012 Torque messages, motor blocked/stalled

Overview of key parameters (see SINAMICS S List Manual)

- p1400[0...n] Speed control configuration
- r1407.7 BO: Torque limit reached
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[0...n] CI: Torque limit, upper/motoring
- p1523[0...n] CI: Torque limit, lower/regenerative
- r1526 Torque limit, upper/motoring without offset
- r1527 Torque limit, lower/regenerative without offset
- p1532[0...n] Torque limit offset
- p1542[0...n] CI: Travel to fixed stop, torque reduction
- r1543 CO: Travel to fixed stop, torque scaling
- p1544 Travel to fixed stop, evaluate torque reduction

- p1545[0...n] BI: Activates travel to fixed stop
- p2194[0...n] Torque threshold 2
- p2199.11 BO: Torque utilization < torque threshold value 2

3.17 Vertical axes

Description

With a vertical axis without mechanical weight compensation, electronic weight compensation can be set by offsetting the torque limits (p1532). The torque limits specified in p1520 and p1521 are shifted by this offset value.

The offset value can be read in r0031 and transferred in p1532.

To reduce compensation once the brake has been released, the torque offset can be interconnected as a supplementary torque setpoint (p1513). In this way, the holding torque is set as soon as the brake has been released.

Function diagrams (see SINAMICS S List Manual)

- 5060 Torque setpoint, control type switchover
- 5620 Motor/generator torque limit
- 5630 Upper/lower torque limit

Overview of key parameters (see SINAMICS S List Manual)

- r0031 Actual torque smoothed
- p1513 CI: Supplementary torque 2
- p1520 CO: Torque limit, upper/motoring
- p1521 CO: Torque limit, lower/regenerative
- p1532 CO: Torque limit, offset

4 Vector control

Compared with vector V/f control, vector control offers the following benefits:

- Stability vis-à-vis load and setpoint changes
- Short rise times with setpoint changes (–> better command behavior)
- Short settling times with load changes (–> better disturbance characteristic)
- Acceleration and braking are possible with maximum available torque
- Motor protection due to variable torque limitation in motor and regenerative mode
- Drive and braking torque controlled independently of the speed
- Maximum breakaway torque possible at speed 0

Vector control can be used with or without an encoder.

The following criteria indicate when an encoder is required:

- High speed accuracy is required
- High dynamic response requirements
  - Better command behavior
  - Better disturbance characteristic
- Torque control is required in a control range greater than 1:10
- Allows a defined and/or variable torque for speeds below approx. 10% of the rated motor frequency (p0310) to be maintained.

With regard to setpoint input, vector control is divided into:

- Speed control
- Torque/current control (in short: torque control)

4.1 Sensorless vector control (SLVC)

In sensorless vector control (SLVC), the position of the flux and actual speed must be determined via the electric motor model. The model is buffered by the incoming currents and voltages. At low frequencies (approx. 0 Hz), the model cannot determine the speed. For this reason and due to uncertainties in the model parameters or inaccurate measurements, the system is switched from closed-loop to open-loop operation in this range.

The changeover between closed-loop/open-loop controlled operation is controlled using time and frequency conditions (p1755, p1756, p1758 - only for induction motors). The system does not wait for the time condition to elapse when the setpoint frequency at the ramp-function generator input and the actual frequency are below p1755 * (1 - (p1756/100%)) simultaneously.

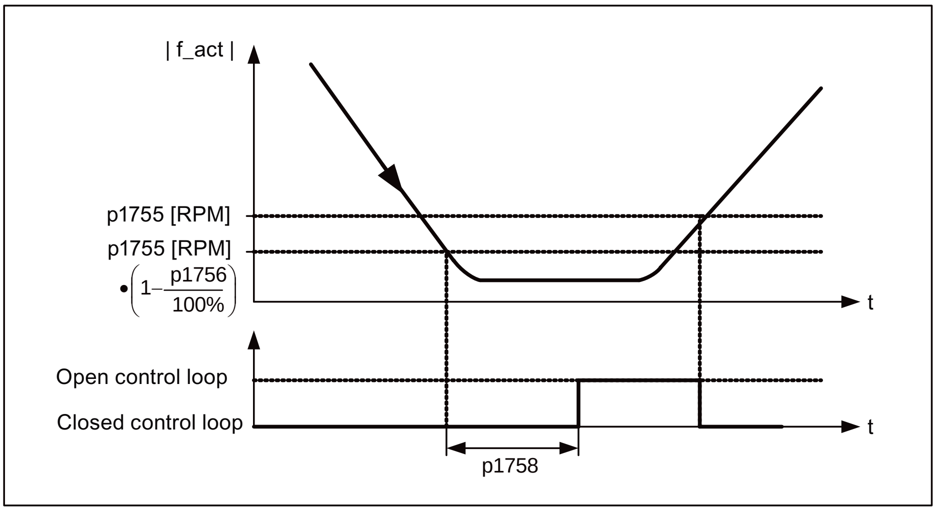


Figure 4-1 Switchover conditions for SLVC

In open-loop operation, the calculated actual speed value is the same as the setpoint value. For vertical loads and acceleration processes, parameters p1610 (constant torque boost) and p1611 (acceleration torque boost) must be modified in order to generate the static or dynamic load torque of the drive. If, for induction motors (ASM), p1610 is set to 0%, only the magnetizing current r0331 is injected; when the value is 100%, the rated motor current p0305 is injected. For permanent-magnet synchronous motors (PEM), for p1610 = 0%, a pre-control absolute value, derived from the supplementary torque r1515, remains instead of the magnetizing current for ASM. To ensure that the drive does not stall during acceleration, p1611 can be increased or acceleration pre-control for the speed controller can be used. This is also advisable to ensure that the motor is not subject to thermal overload at low speeds.

Vector control without a speed sensor has the following characteristics at low frequencies:

- Closed-loop operation up to approx. 1 Hz output frequency
- Starting in closed-loop controlled operation (directly after the drive has been energized) (only ASM)

Note

In this case, the speed setpoint upstream of the ramp-function generator must be greater than (p1755).

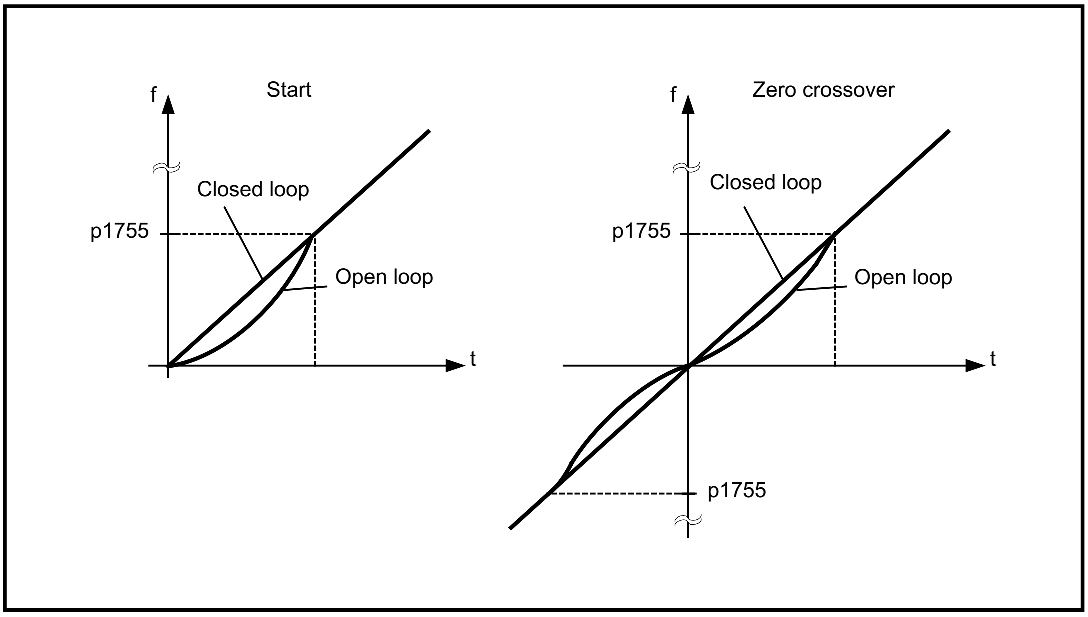


Figure 4-2 Start-up and passing through 0 Hz in closed-loop operation

Closed-loop operation up to approx. 1 Hz (settable via parameter p1755) and the ability to start or reverse at 0 Hz directly in closed-loop operation (settable via parameter p1750) result in the following benefits:

- No switchover required within closed-loop control (smooth operation, no dips in frequency).
- Steady-state speed-torque control is possible up to approx. 1 Hz.

Note

When the motor is started or reversed in closed-loop control at 0 Hz, it is important to take into account that a switchover is made from closed-loop to open-loop control automatically if the system remains in the 0 Hz range for too long (> 2 s or > p1758).

Permanent-magnet synchronous motors (PEM) are always started and reversed in open-loop operation. The changeover speeds are set to 10% or 5% of the rated motor speed. Changeover is not subject to any time condition (p1758 is not evaluated). Prevailing load torques (motor or regenerative) are adapted in open-loop operation, facilitating constant-torque crossover to closed-loop operation even under high static loads. Whenever the pulses are enabled, the rotor position is identified.

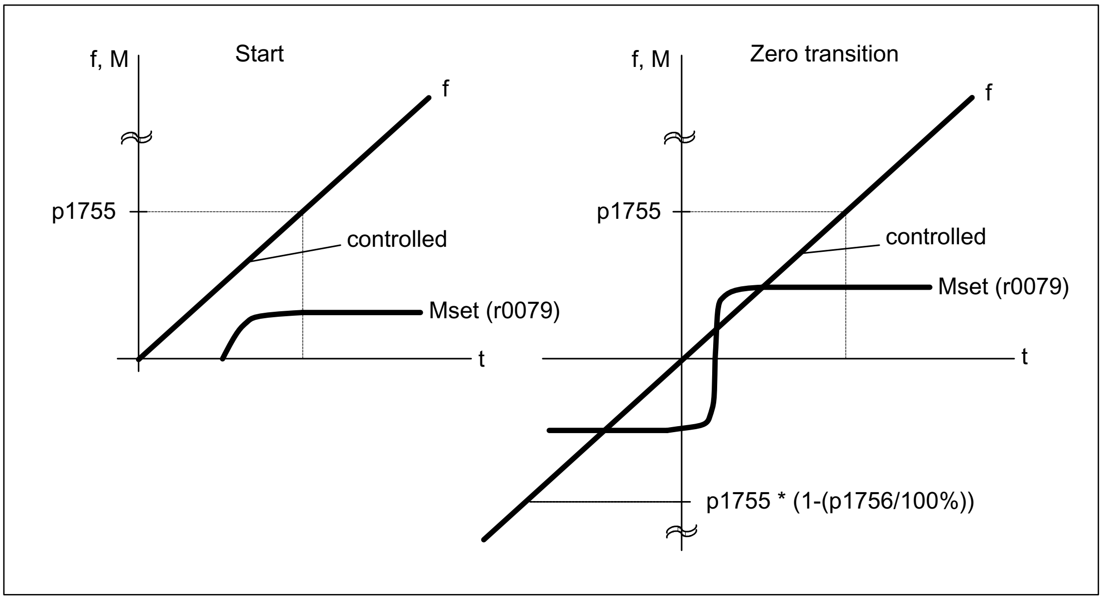


Figure 4-3 Zero crossover for permanent-magnet synchronous motors

Function diagrams (see SINAMICS S List Manual)

- 6730 Interface with Motor Module for induction motor (p0300 = 1)
- 6731 Interface to the Motor Module (PEM, p0300 = 2)

Overview of key parameters (see SINAMICS S List Manual)

- p0305[0...n] Rated motor current
- r0331[0...n] Motor magnetizing current/short-circuit current (actual)
- p1610[0...n] Torque setpoint static (SLVC)
- p1611[0...n] Supplementary accelerating torque (SLVC)
- p1750[0...n] Motor model configuration
- p1755[0...n] Motor model changeover speed sensorless operation
- p1756 Motor model changeover speed hysteresis
- p1758[0...n] Motor model changeover delay time, open/closed-loop control

4.2 Vector control with encoder

Benefits of vector control with an encoder:

- The speed can be controlled right down to 0 Hz (standstill)
- Constant torque in the rated speed range

- Compared with speed control without an encoder, the dynamic response of drives with an encoder is significantly better because the speed is measured directly and integrated in the model created for the current components.
- Higher speed accuracy

Motor model change

A model change takes place between the current model and the observer model within the speed range p1752*(100%-p1756) and p1752. In the current model range (i.e at lower speeds), torque accuracy depends on whether thermal tracking of the rotor resistance is carried out correctly. In the observer model range and at speeds of less than approx. 20% of the rated speed, torque accuracy depends primarily on whether thermal tracking of the stator resistance is carried out correctly. If the resistance of the supply cable is greater than 20% to 30% of the total resistance, this should be entered in p0352 before motor data identification is carried out (p1900/p1910).

To deactivate thermal adaptation, set p0620 = 0. This may be necessary if adaptation cannot function accurately enough due to the following general conditions: for example, if a KTY sensor is not used for recording the temperature and the ambient temperatures fluctuate significantly or the overtemperatures of the motor (p0626 ... p0628) deviate significantly from the default settings due to the design of the motor.

4.3 Speed controller

Both closed-loop control procedures with and without an encoder (VC, SLVC) have the same speed controller structure, which contains the following components:

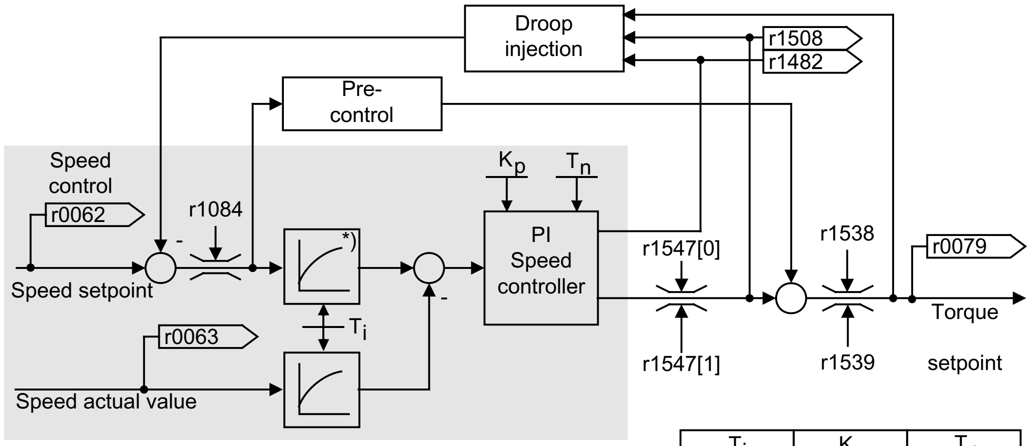
- PI controller
- Speed controller pre-control
- Droop

The total of the output variables result in the torque setpoint, which is reduced to the permissible magnitude by means of the torque setpoint limitation.

Speed controller

The speed controller receives its setpoint (r0062) from the setpoint channel and its actual value (r0063) either directly from the speed sensor (control with sensor (VC)) or indirectly via the motor model (control without sensor (SLVC)). The system deviation is increased by the PI controller and, in conjunction with the pre-control, results in the torque setpoint.

When the load torque increases, the speed setpoint is reduced proportionately when droop is active, which means that the single drive within a group (two or more mechanically connected motors) is relieved when the torque becomes too great.



*) only active if pre-control is active (p1496 > 0)

	T_i	K_p	T_n
SLVC:	p1452	p1470	p1472
VC:	p1442	p1460	p1462

Figure 4-4 Speed controller

The optimum speed controller setting can be determined via the automatic speed controller optimization function (p1900 = 1, rotating measurement).

If the inertia load has been specified, the speed controller (Kp, Tn) can be calculated by means of automatic parameterization (p0340 = 4). The controller parameters are defined in accordance with the symmetrical optimum as follows:

Tn = 4 * Ts

Kp = 0.5 * r0345 / Ts = 2 * r0345 / Tn

Ts = total of the short delay times (contains p1442 and p1452)

If vibrations occur with these settings, the speed controller gain Kp must be reduced manually. Actual-speed-value smoothing can also be increased (standard procedure for gearless or high-frequency torsion vibrations) and the controller calculation performed again because this value is also used to calculate Kp and Tn.

The following relationships apply for optimization:

- If Kp is increased, the controller becomes faster, although overshoot is reduced. Signal ripples and vibrations in the speed control loop, however, increase.
- If Tn is decreased, the controller still becomes faster, although overshoot is increased.

When speed control is set manually, it is easiest to define the possible dynamic response via Kp (and actual speed value smoothing) first before reducing the integral time as much as possible. When doing so, closed-loop control must also remain stable in the field-weakening range.

To suppress any vibrations that occur in the speed controller, it is usually only necessary to increase the smoothing time in p1452 for operation with an encoder or p1442 for operation without an encoder or reduce the controller gain.

The integral output of the speed controller can be monitored via r1482 and the limited controller output via r1508 (torque setpoint).

Note

In comparison with speed control with an encoder, the dynamic response of drives without an encoder is significantly reduced. The actual speed is derived by means of a model calculation from the converter output variables for current and voltage that have a corresponding interference level. To this end, the actual speed must be adjusted by means of filter algorithms in the software.

Function diagrams (see SINAMICS S List Manual)

- 6040 Speed controller with/without encoder

Overview of key parameters (see SINAMICS S List Manual)

- p0340[0...n] Automatic calculation of control parameters
- p1442[0...n] Speed actual value smoothing time
- p1452[0...n] Speed actual value smoothing time (SLVC)
- p1460[0...n] Speed controller P gain lower adaptation speed
- p1462[0...n] Speed controller integral time lower adaptation speed
- p1470[0...n] Speed controller sensorless operation P gain
- p1472[0...n] Speed controller sensorless operation integral time
- p1960 Speed controller optimization selection
- r0062 CO: Speed setpoint after the filter
- r0063[0...1] CO: Speed actual value
- r0345[0...n] Nominal motor starting time
- r1482 CO: Speed controller I torque output
- r1508 CO: Torque setpoint before supplementary torque

4.4 Speed controller adaptation

Description

Two adaptation methods are available, namely free Kp_n adaptation and speed-dependent Kp_n/Tn_n adaptation.

Free Kp_n adaptation can also also be activated in "operation without encoder" mode and is used in "operation with encoder" mode as an additional factor for speed-dependent Kp_n adaptation.

The speed-dependent Kp_n/Tn_n-adaptation is only active during "operation with encoder".

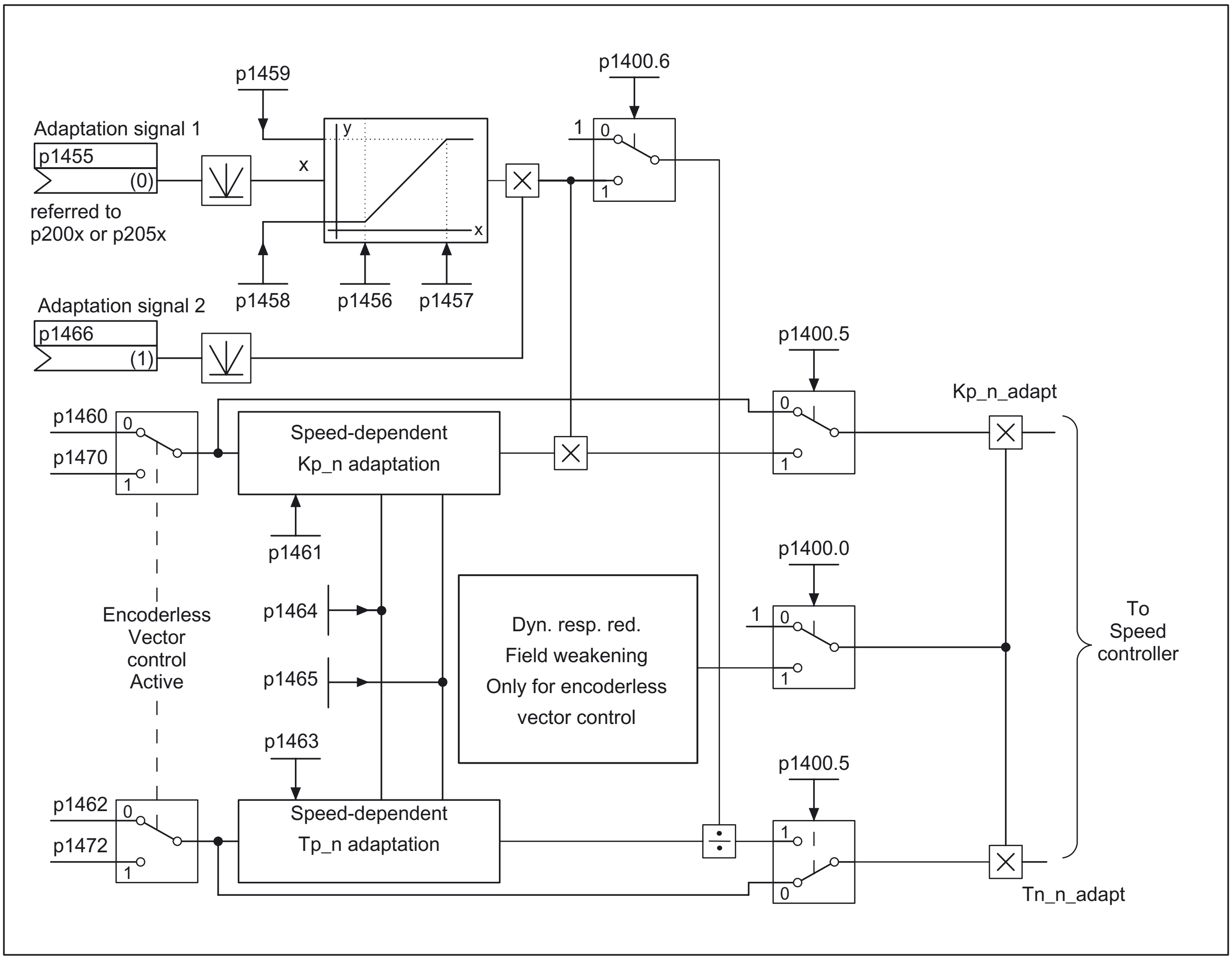


Figure 4-5 Kp_n-/Tn_n adaptation

Dynamic response reduction in the field-weakening range can be activated (p1400.0) with sensorless operation. This is activated when the speed controller is optimized in order to achieve a greater dynamic response in the basic speed range.

Example of speed-dependent adaptation

Note

This type of adaptation is only active in "operation with encoder" mode.

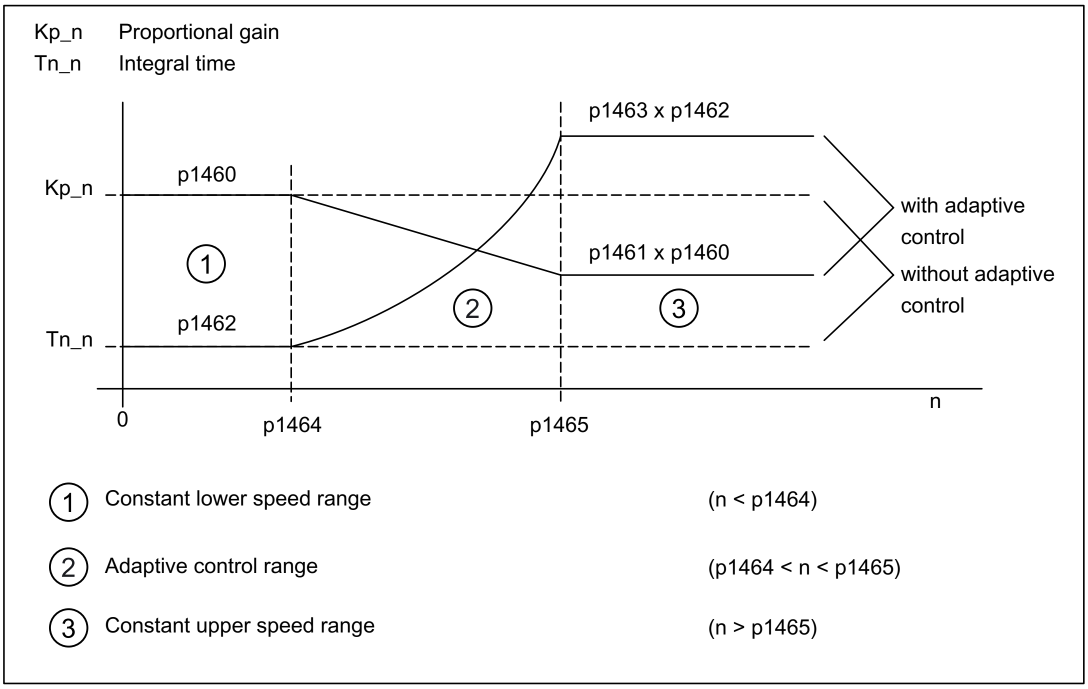


Figure 4-6 Speed controller Kp_n/Tn_n adaptation

Parameterization

The "speed controller" parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

Figure 4-7 STARTER icon for "speed controller"

Function diagrams (see SINAMICS S List Manual)

- 6050 Kp_n and Tn_n adaptation

Overview of key parameters (see SINAMICS S List Manual)

- p1400.5 speed control configuration: Kp/Tn adaptation active
- p1470 Speed controller sensorless operation P-gain
- p1472 Speed controller sensorless operation integral-action time

Free Kp_n adaptation

- p1455 CI: Speed controller P gain adaptation signal
- p1456 Speed controller P gain adaptation lower starting point
- p1457 Speed amplifier, P gain adaptation upper starting point
- p1458 adaptation factor lower

- p1459 adaptation factor upper
- p1466 CI: Speed controller P gain scaling

Speed-dependent Kp_n/Tn_n adaptation (VC only)

- p1460 Speed controller P gain adaptation speed, lower
- p1461 Speed controller P gain adaptation speed, upper
- p1462 Speed controller integral action time adaptation speed, lower
- p1463 Speed controller integral action time adaptation speed, upper
- p1464 Speed controller adaptation speed, lower
- p1465 Speed controller adaptation speed, upper

Dynamic response reduction field weakening (SLVC only)

- p1400.0 Speed control configuration: Automatic Kp/Tn adaptation active

4.5 Speed controller pre-control and reference model

The command behavior of the speed control loop can be improved by calculating the accelerating torque from the speed setpoint and connecting it on the line side of the speed controller. This torque setpoint (mv) is calculated as follows:

$$mv = p1496 \cdot J \cdot \frac{dn}{dt} = p1496 \cdot p0341 \cdot p0342 \cdot \frac{dn}{dt}$$

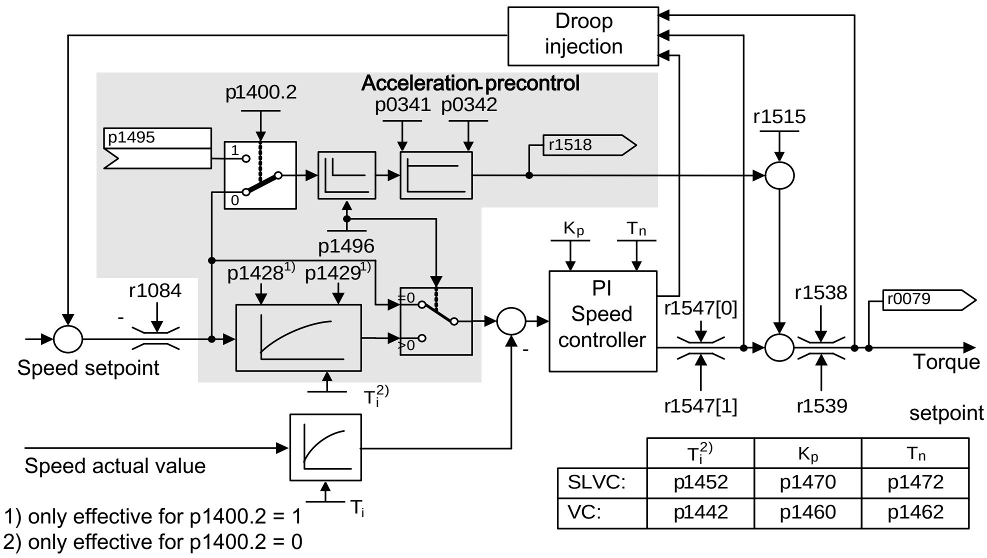
The torque setpoint is switched/pre-controlled directly to the current controller via adaptors as supplementary command variables (enabled via p1496).

The motor moment of inertia p0341 is calculated directly during commissioning or when the entire set of parameters is calculated (p0340 = 1). The factor p0342 between the total moment of inertia J and the motor moment of inertia must be determined manually or by means of speed controller optimization. The acceleration is calculated from the speed difference over the time dn/dt.

Note

When speed controller optimization is carried out, the ratio between the total moment of inertia and that of the motor (p0342) is determined and acceleration pre-control scaling (p1496) is set to 100%.

When p1400.2 = p1400.3 = 0, pre-control balancing is set automatically.



	T_i 2)	K_p	T_n
SLVC:	p1452	p1470	p1472
VC:	p1442	p1460	p1462

Figure 4-8 Speed controller with pre-control

If the speed controller has been correctly adjusted, it only has to compensate for disturbance variables in its own control loop, which can be achieved by means of a relatively small change to the correcting variables. Speed setpoint changes, on the other hand, are carried out without involving the speed controller and are, therefore, performed more quickly.

The effect of the pre-control variable can be adapted according to the application via the evaluation factor p1496. If p1496 = 100 %, pre-control is calculated in accordance with the motor and load moment of inertia (p0341, p0342). A balancing filter is used automatically to prevent the speed controller from acting against the injected torque setpoint. The time constant of the balancing filter corresponds to the equivalent delay time of the speed control loop. Speed controller pre-control is correctly set (p1496 = 100%, calibration via p0342) when the I component of the speed controller (r1482) does not change during a ramp-up or ramp-down in the range n > 20% x p0310. Thus, the pre-control allows a new speed setpoint to be approached without overshoot (prerequisite: the torque limiting does not act and the moment of inertia remains constant).

If the speed controller is pre-controlled through injection, the speed setpoint (r0062) is delayed with the same smoothing time (p1442 or p1452) as the actual value (r1445). This ensures that no target/actual difference (r0064) occurs at the controller input during acceleration, which would be attributable solely to the signal propagation time.

When speed pre-control is activated, the speed setpoint must be specified continuously or without a higher interference level (avoids sudden torque changes). An appropriate signal can be generated by smoothing the speed setpoint or activating the ramp function generator rounding p1130 – p1131.

The starting time r0345 (T_{start}) is a measure for the total moment of inertia J of the machine and describes the time during which the unloaded drive can be accelerated with the rated motor torque r0333 ($M_{mot,rated}$) from standstill to the rated motor speed p0311 ($n_{mot,rated}$).

$$r0345 = T_{Anlauf} = J \bullet \frac{(2\pi \bullet n_{Mot,nenn})}{(60 \bullet M_{Mot,nenn})} = p0341 \bullet p0342 \bullet \frac{(2\pi \bullet p0311)}{(60 \bullet r0333)}$$

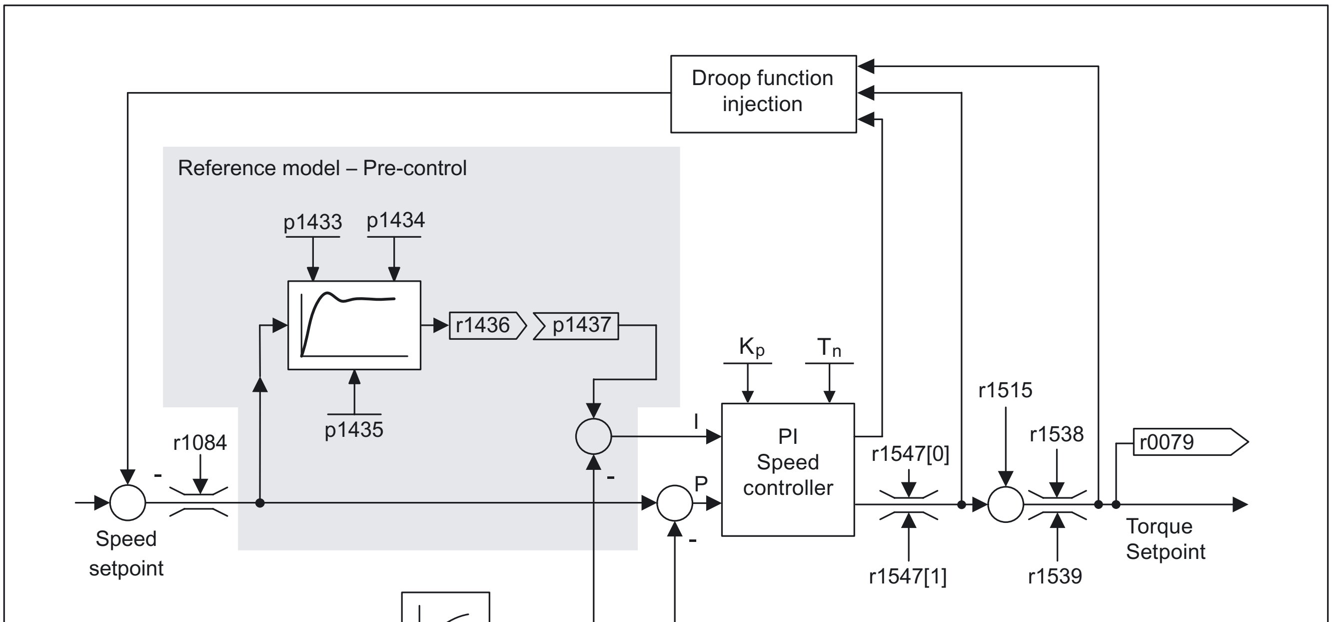
If these basic conditions are in line with the application, the starting time can be used as the lowest value for the ramp-up or ramp-down time.

Note

The ramp-up and ramp-down times (p1120; p1121) of the ramp function generator in the setpoint channel should be set accordingly so that the motor speed can track the setpoint during acceleration and braking. This ensures that speed controller pre-control is functioning optimally.

The acceleration pre-control using a connector input (p1495) is activated by the parameter settings p1400.2 = 1 and p1400.3 = 0. p1428 (dead time) and p1429 (time constant) can be set for balancing purposes.

Reference model



	T_i	K_p	T_n
SLVC:	p1452	p1470	p1472
VC:	p1442	p1460	p1462

Figure 4-9 Reference model

The reference model is activated when p1400.3 = 1 and p1400.2 = 0.

The reference model is used to emulate the path of the speed control loop with a P speed controller.

The path emulation can be set in p1433 to p1435. It is activated when p1437 is connected to the output of model r1436.

The reference model delays the setpoint-actual deviation for the integral component of the speed controller so that transient conditions can be suppressed.

The reference model can also be emulated externally and its output signal injected via p1437.

Function diagrams (see SINAMICS S List Manual)

- 6031 Pre-control balancing for reference/acceleration model
- 6040 Speed controller

Overview of key parameters (see SINAMICS S List Manual)

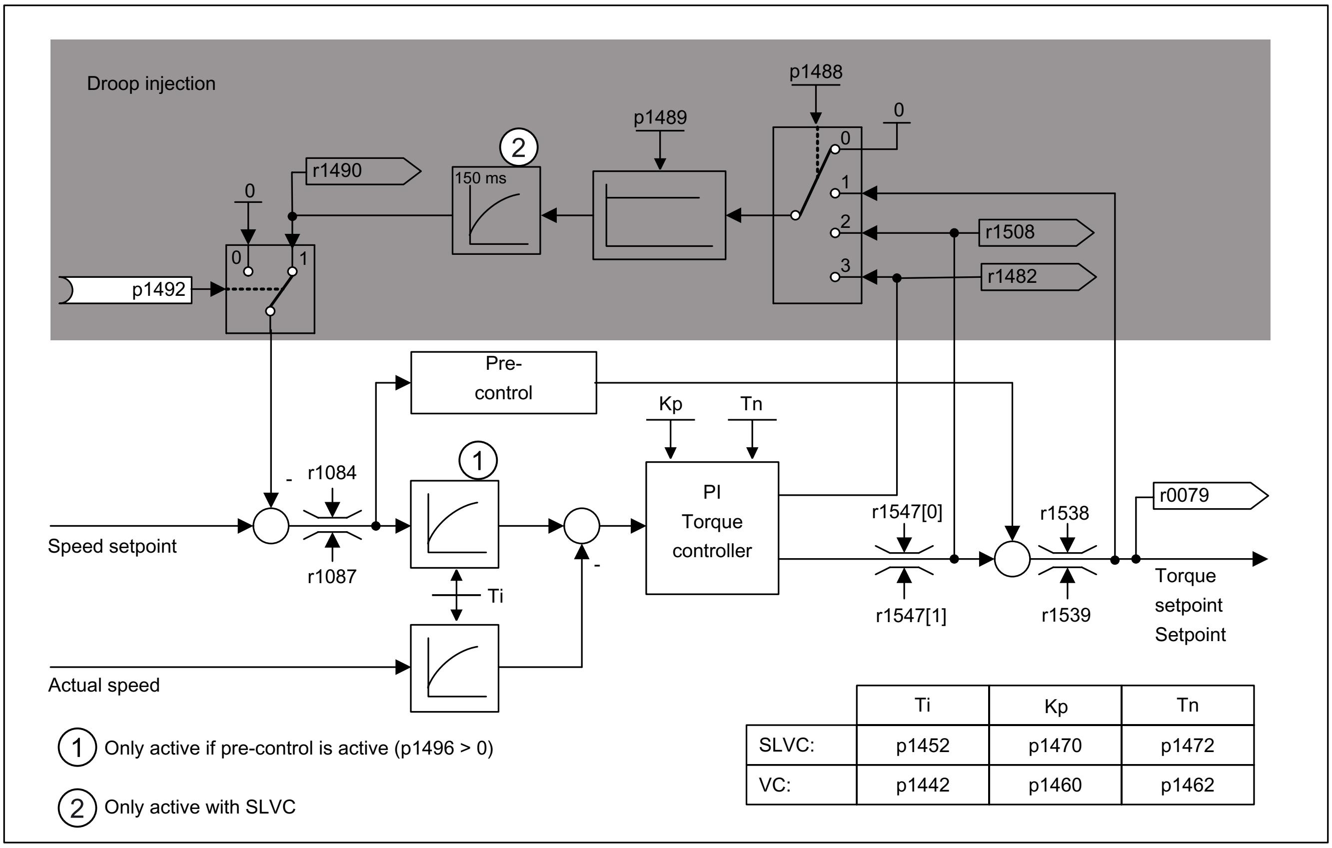
- p0311[0...n] Rated motor speed
- r0333[0...n] Rated motor torque
- p0341[0...n] Motor moment of inertia
- p0342[0...n] Ratio between the total moment of inertia and that of the motor
- r0345[0...n] Nominal motor starting time
- p1400.2[0...n] Acceleration pre-control source
- p1428[0...n] Speed precontrol deadtime for balancing pre-control speed
- p1429[0...n] Speed pre-control time constant for balancing
- p1496[0...n] Acceleration precontrol scaling
- r1518 CO: Accelerating torque

For reference model

- p1400.3[0...n] Reference model speed setpoint I component
- p1433[0...n] Speed controller reference model natural frequency
- p1434[0...n] Speed controller reference model damping
- p1435[0...n] Speed controller reference model deadtime
- r1436 CO: Speed controller reference model speed setpoint output
- p1437[0...n] CI: Speed controller reference model I component input

4.6 Droop

Droop (enabled via p1492) ensures that the speed setpoint is reduced proportionally as the load torque increases.



	Ti	Kp	Tn
SLVC:	p1452	p1470	p1472
VC:	p1442	p1460	p1462

Figure 4-10 Speed controller with droop

The droop function has a torque limiting effect on a drive that is mechanically coupled to a different speed (e.g. guide roller on a goods train). In this way, a very effective load distribution can also be realized in connection with the torque setpoint of a leading speed-controlled drive. In contrast to torque control or load distribution with overriding and limitation, with the appropriate setting, such a load distribution controls even a smooth mechanical connection or the case of slipping.

This method is only suitable to a limited extent for drives that are accelerated and braked with significant changes in speed.

The droop feedback is used, for example, in applications in which two or more motors are connected mechanically or operate with a common shaft and fulfill the above requirements. It limits the torque differences that can occur as a result of the mechanical connection between the motors by modifying the speeds of the individual motors (drive is relieved when the torque becomes too great).

Prerequisites

- All connected drives must be operated with vector control and speed control (with or without an encoder).
- Only a single common ramp function generator may be used for mechanically coupled drives.

Function diagrams (see SINAMICS S List Manual)

- 6030 Speed setpoint, droop, acceleration model

Overview of key parameters (see SINAMICS S List Manual)

- p1488[0...n] Droop input source
- p1489[0...n] Droop feedback scaling
- p1492[0...n] BI: Droop feedback enable
- r1482 CO: Speed controller I torque output
- r1490 CO: Droop feedback speed reduction

4.7 Torque control

With sensorless speed control SLVC (p1300 = 20) or speed control with sensor VC (p1300 = 21), a switchover can be made to torque control (slave drive) via BICO parameter p1501. A switchover cannot be made between speed and torque control if torque control is selected directly with p1300 = 22 or 23. The torque setpoint and/or supplementary setpoint can be entered using BICO parameter p1503 (CI: torque setpoint) or p1511 (CI: supplementary torque setpoint). The supplementary torque is active both with torque and speed control. This particular feature with the supplementary torque setpoint allows a pre-control torque to be applied for speed control.

Note

For safety reasons, connecting to fixed torque setpoints is currently not possible.

Regenerative energy may accumulate, and this must be either fed back into the supply system or converted into heat using a braking resistor.

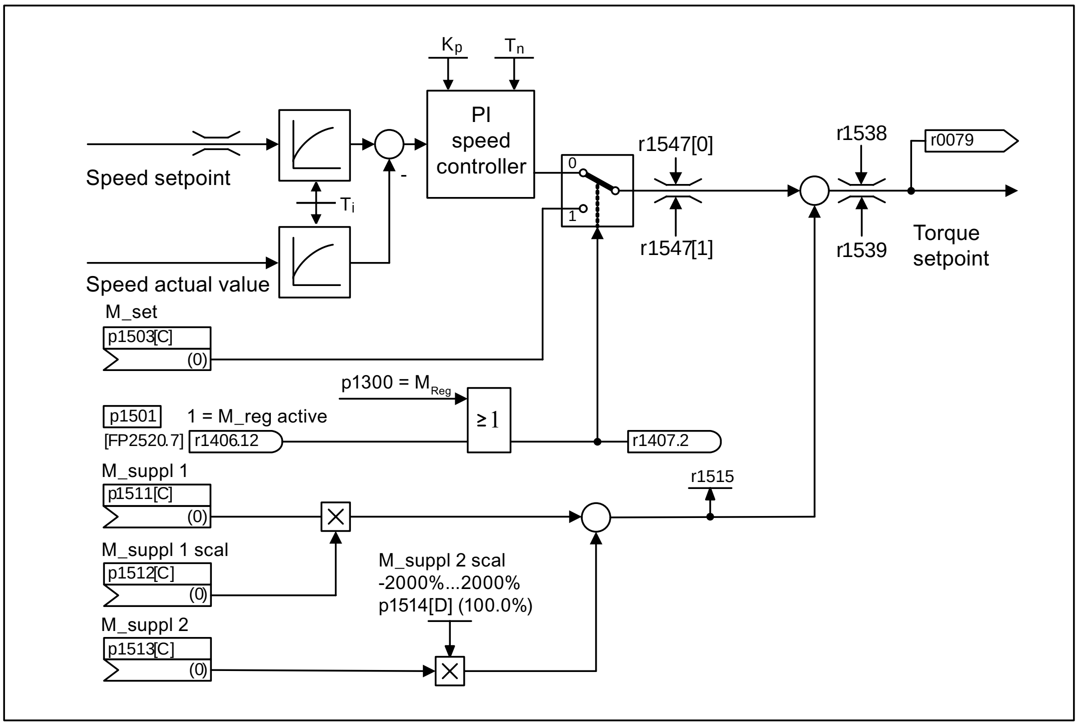


Figure 4-11 Closed-loop speed/torque control

The total of the two torque setpoints is limited in the same way as the speed control torque setpoint. Above the maximum speed (p1082), a speed limiting controller reduces the torque limits in order to prevent the drive from accelerating any further.

True torque control (with self-adjusting speed) is only possible in closed-loop but not open-loop control for sensorless vector control (SLVC). In open-loop control, the torque setpoint adjusts the setpoint speed via a ramp function generator (integration time ~ p1499 x p0341 x p0342). For this reason, sensorless torque control at standstill is only suitable for applications that require an accelerating torque but no load torque (e.g. traction drives). This restriction does not apply to torque control with sensor.

OFF responses

- OFF1 and p1300 = 22, 23
  - Reaction as for OFF2
- OFF1, p1501 = "1" signal and p1300 ≠ 22, 23
  - No separate braking response; the braking response takes place by a drive that specifies the torque.
  - The pulses are suppressed when the brake application time (p1217) expires. Standstill is detected when the actual speed value is less than the speed threshold (p1226) or when the monitoring time (p1227) that started when speed setpoint ≤ speed threshold (p1226) has expired.
  - Power-on disable is activated.

- OFF2
  - Immediate pulse suppression, the drive coasts to standstill.
  - The motor brake (if parameterized) is closed immediately.
  - Power-on disable is activated.
- OFF3
  - Switch to speed-controlled operation
  - n_set = 0 is input immediately to brake the drive along the OFF3 deceleration ramp (p1135).
  - When zero speed is detected, the motor brake (if parameterized) is closed.
  - The pulses are suppressed when the motor brake application time (p1217) has elapsed. Standstill is detected when the actual speed value is less than the speed threshold (p1226) or when the monitoring time (p1227) that started when speed setpoint ≤ speed threshold (p1226) has expired.
  - Power-on disable is activated.

Function diagrams (see SINAMICS S List Manual)

- 6060 Torque setpoint

Overview of key parameters (see SINAMICS S List Manual)

- p0341 motor moment of inertia
- p0342 Ratio between the total moment of inertia and that of the motor
- p1300 Open-loop/closed-loop control operating mode
- p1499 Accelerating for torque control, scaling
- p1501 BI: Change over between closed-loop speed/torque control
- p1503 CI: Torque setpoint
- p1511 CI: Supplementary torque 1
- p1512 CI: Supplementary torque 1 scaling
- p1513 CI: Supplementary torque 2
- p1514 Supplementary torque 2 scaling
- r1515 Supplementary torque total

4.8 Torque limiting

Description

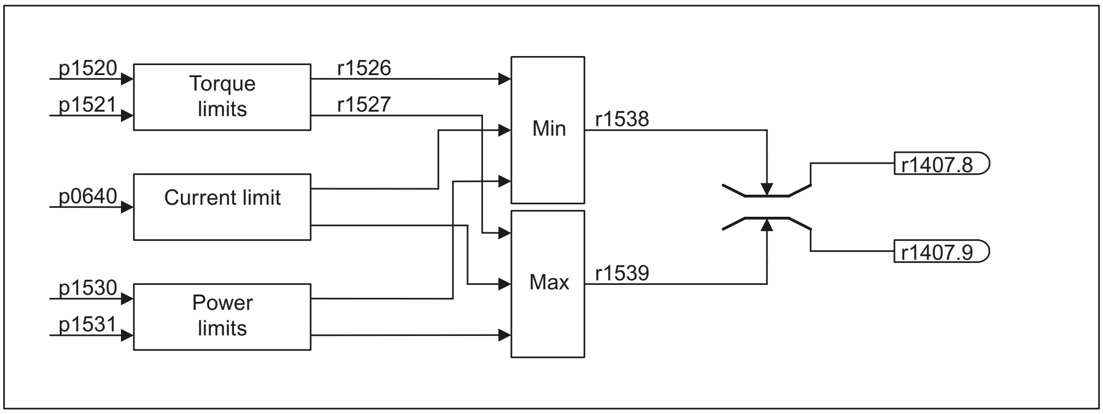


Figure 4-12 Torque limiting

The value specifies the maximum permissible torque whereby different limits can be parameterized for motor and regenerative mode.

- p0640[0...n] Current limit
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[0...n] CI: Torque limit, upper/motoring
- p1523[0...n] CI: Torque limit, lower/regenerative
- p1524[0...n] CO: Torque limit, upper/motoring, scaling
- p1525[0...n] CO: Torque limit, lower/regenerating scaling
- p1530[0...n] Motor mode power limit
- p1531[0...n] Regenerative mode power limit

The current active torque limit values are displayed in the following parameters:

- r0067 Maximum drive output current
- r1526 Torque limit, upper/motoring without offset
- r1527 Torque limit, lower/regenerative without offset

The following limits all apply to the torque setpoint, which is present either at the speed controller output in the case of speed control, or at the torque input in the case of torque control. The minimum/maximum value of the different limits is used in each case. The minimum value is calculated cyclically and displayed in parameters r1538 and r1539.

- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit

  These cyclical values therefore limit the torque setpoint at the speed controller output/torque input or indicate the instantaneous max. possible torque. If the torque setpoint is limited in the Motor Module, this is indicated via the following diagnostic parameters:

- r1407.8 Upper torque limit active
- r1407.9 Lower torque limit active

indicated.

Function diagrams (see SINAMICS S List Manual)

- 6060 Torque setpoint
- 6630 Upper/lower torque limit
- 6640 Current/power/torque limits

4.9 Vdc control

Description

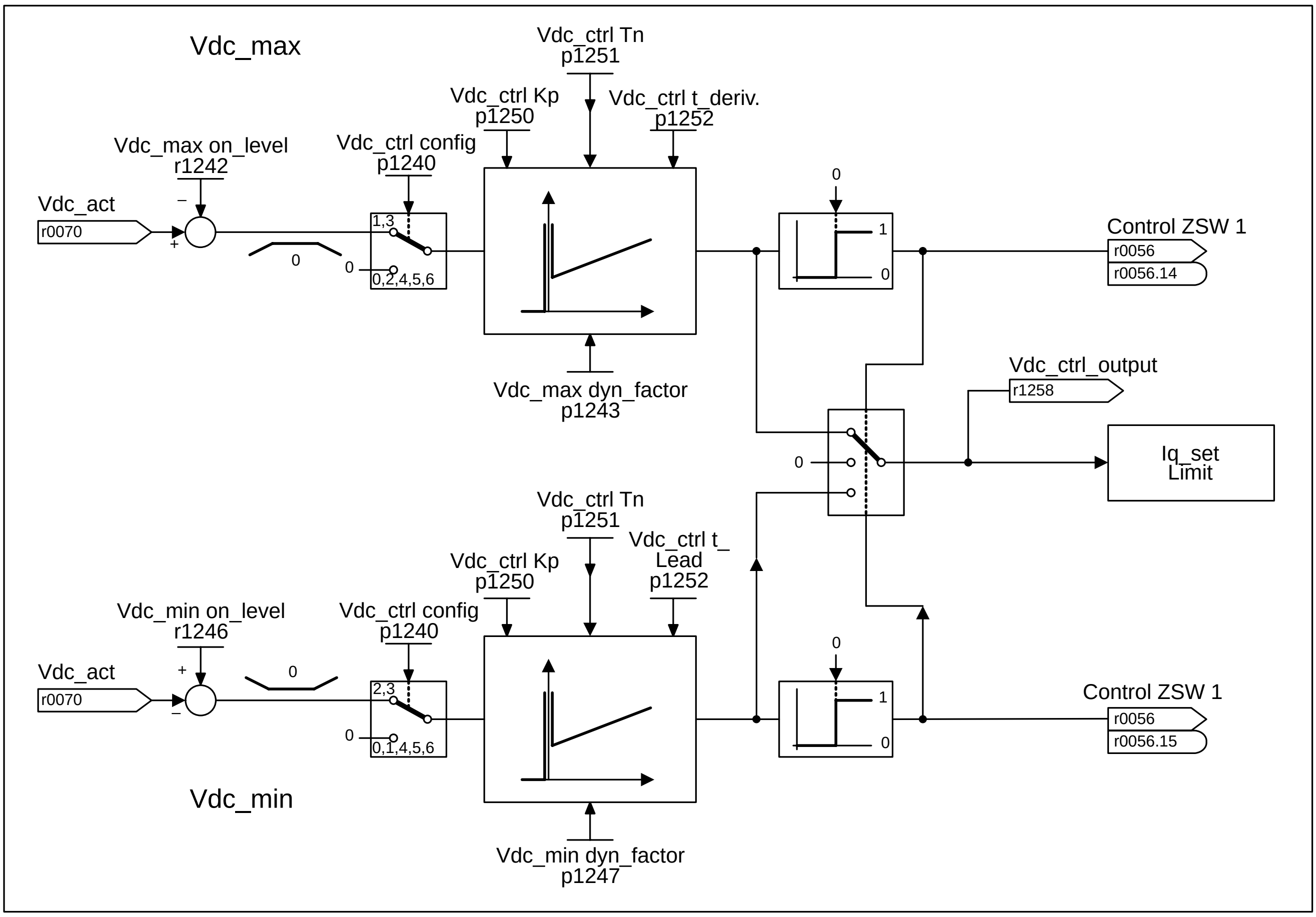


Figure 4-13 Vdc control vector

The "Vdc control" function can be activated using the appropriate measures if an overvoltage or undervoltage is present in the DC link.

- Overvoltage in the DC link
  - Typical cause

    The drive is operating in regenerative mode and is supplying too much energy to the DC link.
  - Remedy

    Reduce the regenerative torque to maintain the DC link voltage within permissible limits. With the Vdc controller activated, the converter may automatically extend the ramp down time of a drive if the shutdown supplies too much energy to the DC link.
- Undervoltage in the DC link
  - Typical cause

    Failure of the supply voltage or supply for the DC link.
  - Remedy

    Specify a regenerative torque for the rotating drive to compensate the existing losses, thereby stabilizing the voltage in the DC link (kinetic buffering).

Properties

- Vdc control
  - This comprises Vdc_max control and Vdc_min control (kinetic buffering), which are independent of each other.
  - Joint PI controller. The dynamic factor is used to set Vdc_min and Vdc_max control independently of each other.
- Vdc_max control
  - This function can be used to control momentary regenerative load without shutdown using “overvoltage in the DC link“.
  - Vdc_max control is only recommended with a supply without active closed-loop control for the DC link and without feedback.
- Vdc_min control (kinetic buffering)
  - With this function, the kinetic energy of the motor is used for buffering the DC link voltage in the event of a momentary power failure, thereby delaying the drive.

Description of Vdc_min control

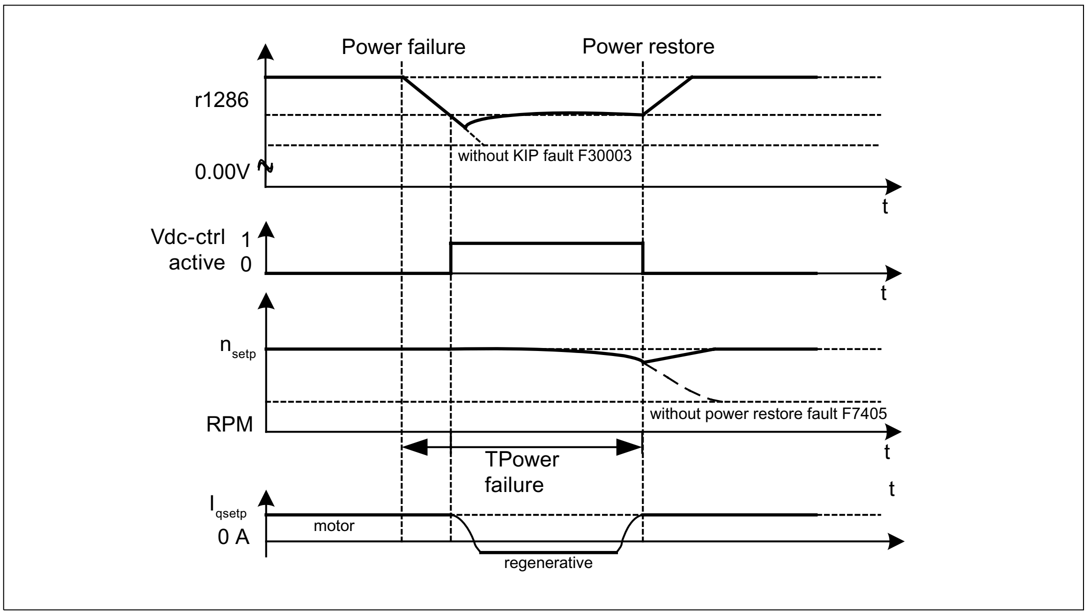


Figure 4-14 Switching Vdc_min control on/off (kinetic buffering)

In the event of a power failure, Vdc_min control is activated when the Vdc_min switch-in level is undershot. This controls the DC link voltage and maintains it at a constant level. The motor speed is reduced.

When the power supply is restored, the DC link voltage increases again and Vdc_min control is deactivated at 5 % above the Vdc_min switch-on level. The motor continues operating normally.

If the power supply is not reestablished, the motor speed continues to drop. When the threshold in p1257 is reached, this results in a response in accordance with p1256.

Once the time threshold (p1255) has elapsed without the line voltage being reestablished, a fault is triggered (F07406), which can be parameterized as required (factory setting: OFF3).

The Vdc_min controller can be activated for a drive. Other drives can participate in supporting the DC link, by transferring a scaling of their speed setpoint from the controlling drive via BICO interconnection.

Note

You must make sure that the converter is not disconnected from the power supply. It could become disconnected, for example, if the line contactor drops out. The line contactor should have an uninterruptible power supply (UPS), for example.

Description of Vdc_max control

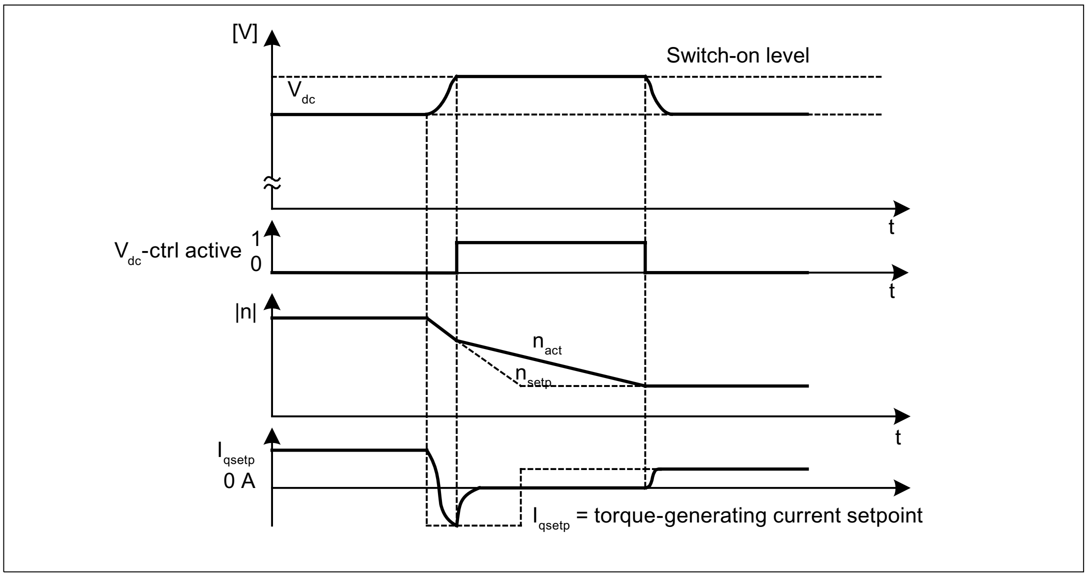


Figure 4-15 Switching Vdc_max control on/off

The switch-in level for Vdc_max control (r1242) is calculated as follows:

- When the function for automatically detecting the switch-on level is switched off (p1254 = 0)
  r1242 = 1.15 * p0210 (device connection voltage, DC link).
- When the function for automatically detecting the switch-on level is switched on (p1254 = 1)
  r1242 = Vdc_max - 50 V (Vdc_max: overvoltage threshold of the Motor Module)

Function diagrams (see SINAMICS S List Manual)

- 6220 Vdc_max controller and Vdc_min controller

Overview of key parameters (see SINAMICS S List Manual)

- p1240[0...n] Vdc controller or Vdc monitoring configuration
- r1242 Vdc_max controller switch-in level
- p1243[0...n] Vdc_max controller dynamic factor (control)
- p1245[0...n] Vdc_min controller switch-in level (kinetic buffering) (control)
- r1246 Vdc_min controller switch-in level (kinetic buffering) (control)
- p1247[0...n] Vdc_min controller dynamic factor (kinetic buffering) (control)
- p1250[0...n] Vdc controller proportional gain (control)
- p1251[0...n] Vdc controller integral time (control)
- p1252[0...n] Vdc controller derivative-action time (control)
- p1254 Vdc_max controller automatic detection ON level (control)

- p1256[0...n] Vdc_min controller response (kinetic buffering) (control)
- p1257[0...n] Vdc_min controller speed threshold (controller)
- r1258 CO: Vdc controller output (control)

4.10 Current setpoint filter

Description

The two current setpoint filters connected in series can be parameterized as follows:

- Low-pass 2nd order (PT2): -40 dB/decade
- General 2nd-order filter

  STARTER converts band-stop and low-pass with reduction in the parameters of the general 2nd order filter.

  – Bandstop
  – Low-pass with reduction by a constant value

    The phase frequency curve is shown alongside the amplitude log frequency curve. A phase shift results in a control system delay and should be kept to a minimum.

Function diagrams (see SINAMICS S List Manual)

- 6710 Current setpoint filters

Overview of key parameters (see SINAMICS S List Manual)

- p1655 CI: Current setpoint filter natural frequency tuning
- ...
- p1666 Current setpoint filter 2 numerator damping

4.11 Current controller adaptation

Description

Current controller adaptation can be used to adapt the P gain of the current controller and the dynamic pre-control of the Iq current controller depending on the current. Current controller adaptation can be deactivated with the setting p1402.2 = 0.

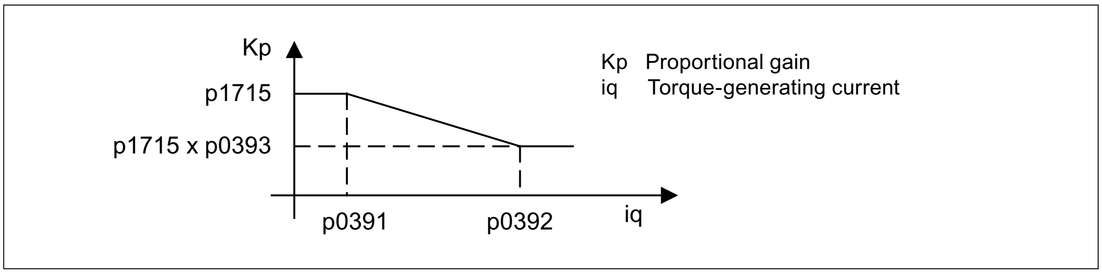


Figure 4-16 Current controller adaptation for p0393 < 1, with p0391 < p0392

or (e.g for the ASM) when the iq points are swapped

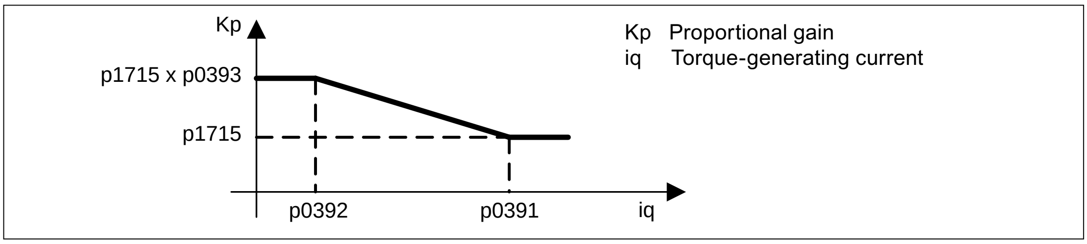


Figure 4-17 Current controller adaptation with swapped iq interpolation points for p0393 > 1, with p0392 < p0391

Function diagrams (see SINAMICS S List Manual)

- 6710 Current setpoint filters
- 6714 Iq and Id controller

Overview of key parameters (see SINAMICS S List Manual)

- p0391 Current controller adaptation starting point KP
- p0392 Current controller adaptation starting point KP adapted
- p0393 Current controller adaptation P gain scaling
- p1703 Isq current controller pre-control scaling
- p1715 Current controller P gain
- p1717 Current controller integral time

4.12 Motor data identification and rotating measurement

Description

Two motor identification options, which are based on each other, are available:

- Motor identification with p1910 (standstill measurement)
- Rotating measurement with p1960

Note

For both types of motor identification the following applies:
If there is a motor brake, then this must be open (p1215 = 2).

These can be selected more easily via p1900. p1900 = 2 selects the standstill measurement (motor not rotating). The setting p1900 = 1 also activates the rotating measurement, i.e. with the setting of p1900 = 1 and p1960 depending on the current control mode (p1300).

If a permanent-magnet synchronous motor is being used (p0300 = 2), then with p1900 > 1, the encoder adjustment (p1990 = 1) is automatically activated. The technique used can be set in p1980.

Parameter p1960 is set depending on p1300:

- p1960 = 1, when p1300 = 20 or 22 (without encoder)
- p1960 = 2, when p1300 = 21 or 23 (with encoder)

The measurements, parameterized using p1900 are started in the following sequence after the drive has been enabled:

- Standstill (static) measurement - after the measurement has been completed, the pulses are inhibited and parameter p1910 is reset to 0.
- Encoder adjustment - after the measurement has been completed, the pulses are inhibited and parameter p1990 is reset to 0.
- Rotating measurement - after the measurement has been completed, the pulses are inhibited and parameter p1960 is reset to 0.
- After all of the measurements, activated using p1900 have been successfully completed, then this is set to 0.

Note

To set the new controller setting permanently, the data must be saved in a non-volatile memory (see also "Parameters").

Completion of the individual identification runs can be read via parameters r3925 to r3928.

The identification runs influence only the current valid motor data set (MDS).

⚠ DANGER

During motor identification, the drive may cause the motor to move.

The emergency STOP functions must be fully operational during commissioning. To protect the machines and personnel, the relevant safety regulations must be observed.

Motor identification (p1910)

Motor identification with p1910 is used for determining the motor parameters at standstill (see also p1960: speed controller optimization):

- Equivalent circuit diagram data p1910 = 1
- Magnetization characteristic p1910 = 3

For control engineering reasons, you are strongly advised to carry out motor identification because the equivalent circuit diagram data, motor cable resistance, IGBT on-state voltage, and compensation for the IGBT lockout time can only be estimated if the data on the type plate is used. For this reason, the stator resistance for the stability of sensorless vector control or for the voltage boost in the V/f curve is very important. Motor data identification is essential if long supply cables or third-party motors are used. When motor data identification is started for the first time, the following data is determined with p1910 on the basis of the data on the type plate (rated data):

Table 4-1 Data determined using p1910

	Induction motor	Permanent-magnet synchronous motor
p1910 = 1	• Stator resistance (p0350) • Rotor resistance (p0354) • Stator leakage inductance (p0356) • Rotor leakage inductance (p0358) • Magnetizing inductance (p0360) • Drive converter valve threshold voltage (p1825) • Drive converter valve interlocking times (p1828 ... p1830)	• Stator resistance (p0350) • Stator resistance q axis (p0356) • Stator inductance d axis (p0357) • Drive converter valve threshold voltage (p1825) • Converter valve interlocking times (p1828 ... p1830)
p1910 = 3	• Saturation characteristics (p0362 ... p0366)	Not recommended Notice: When encoder adjustment is complete, the motor is automatically rotated approx. one revolution in order to determine the zero marker of the encoder.

Since the type plate data contains the initialization values for identification, you must ensure that it is entered correctly and consistently (taking into account the connection type (star/delta)) so that the above data can be determined.

If the resistance of the motor supply cable is known, you are advised to enter this value before the standstill measurement (p0352) so that it can be subtracted from the total measured resistance when the stator resistance (p0350) is calculated.

Entering the cable resistance improves the accuracy of thermal resistance adaptation, particularly when long supply cables are used. This governs behavior at low speeds, particularly during sensorless vector control.

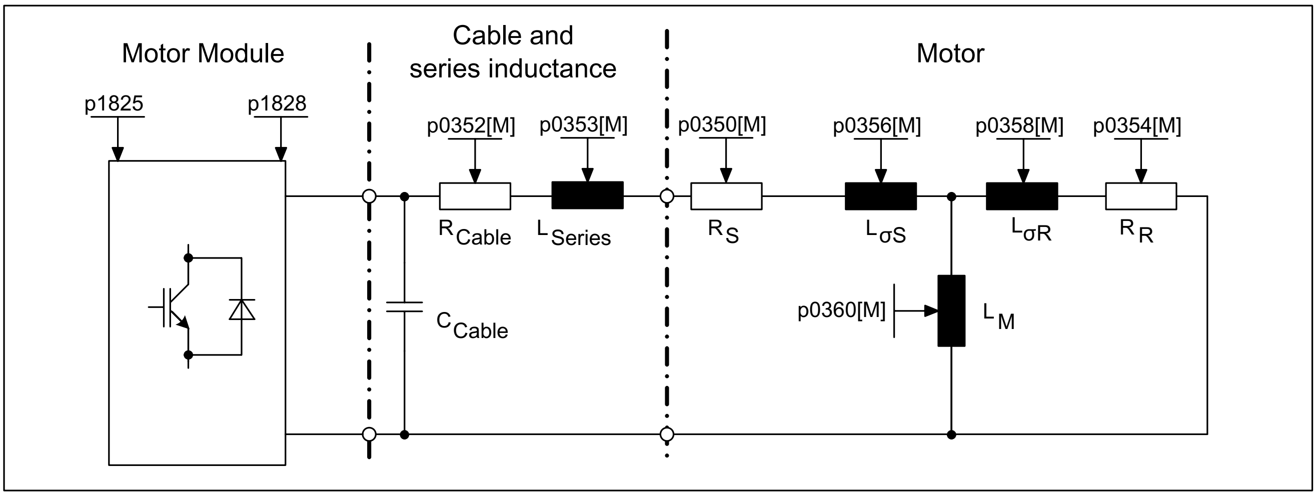


Figure 4-18 Equivalent circuit diagram for induction motor and cable

If an output filter (see p0230) or series inductance (p0353) is used, the data for this must also be entered before the standstill measurement is carried out.

The inductance value is then subtracted from the total measured value of the leakage. With sinusoidal filters, only the stator resistance, valve threshold voltage, and valve interlocking time are measured.

Note

With diffusion of more than 35% to 40% of the motor nominal impedance, the dynamic response of the speed and current control is restricted to the area of the voltage limit and to field weakening mode.

Note

The standstill measurement must be carried out when the motor is cold. In p0625, enter the estimated ambient temperature of the motor during the measurement (with KTY sensor: set p0600, p0601 and read r0035). This is the reference point for the thermal motor model and thermal R_S/R_R adaptation.

In addition to the equivalent circuit diagram data, motor data identification (p1910 = 3) can be used for induction motors to determine the magnetization characteristic of the motor. Due to the higher accuracy, the magnetization characteristic should, if possible, be determined during the rotating measurement (without encoder: p1960 = 1, 3; with encoder: p1960 = 2, 4). If the drive is operated in the field-weakening range, this characteristic should be determined for vector control in particular. The magnetization characteristic can be used to calculate the field-generating current in the field-weakening range more accurately, thereby increasing torque accuracy.

Note

In comparison with the standstill measurement (p1910), for induction motors, the rotating measurement (p1960) allows the rated magnetization current and saturation characteristic to be determined more accurately.

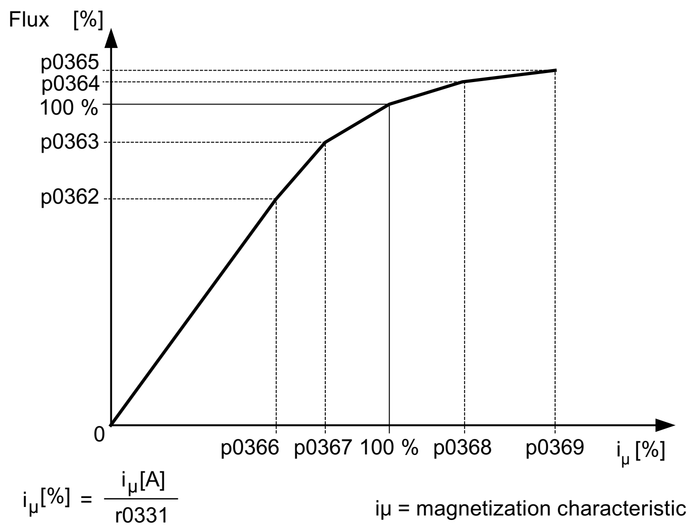


Figure 4-19 Magnetization characteristic

Note

To set the new controller setting permanently, the data must be saved in a non-volatile memory.

Carrying out motor identification

- Enter p1910 > 0. Alarm A07991 is displayed.
- Identification starts when the motor is switched on.
- p1910 resets itself to "0" (successful identification) or fault F07990 is output.
- r0047 displays the current status of the measurement.

Rotating measurement (p1960)

Rotating measurement can be activated via p1960 or p1900 = 1.

The main difference of rotating measurement is speed control optimization, with which the drive's moment of inertia is ascertained and speed controller is set. In addition, the saturation characteristic and rated magnetization current of induction motors are measured.

If the rotating measurement is not to be carried out using the speed set in p1965, this parameter can be changed before the measurement is started. Higher speeds are recommended.

The same applies to the speed in p1961 for which the saturation characteristic is determined and the encoder test is carried out.

The speed controller is set to the symmetrical optimum in accordance with dynamic factor p1967. p1967 must be set before the optimization run and only affects the calculation of the controller parameters.

If, during the measurement, it becomes clear that, with the specified dynamic factor, the drive cannot operate in a stable manner or the torque ripples are too large, the dynamic response is reduced automatically and the result displayed in r1968. The drive must also be checked to ensure that it is stable across the entire range. If necessary, the dynamic response may have to be reduced or Kp/Tn adaptation for the speed controller parameterized accordingly.

When commissioning induction machines, you are advised to proceed as follows:

- Before connecting the load, a complete "rotating measurement" (without encoder: p1960 = 1; with encoder: p1960 = 2) should be carried-out. Since the induction machine is idling, you can expect highly accurate results regarding the saturation characteristic and the rated magnetization current.
- When the load is connected, speed controller optimization should be repeated because the total inertia load has changed. This is realized by selecting parameter p1960 (without encoder: p1960 = 3; with encoder: p1960 = 4).

When permanent-magnet synchronous motors are commissioned, with the load connected, the speed controller should be optimized (p1960 = 2/4).

Carrying out the rotating measurement (p1960 > 0)

The following measurements are carried out when the enable signals are set and a switch-on command is issued in accordance with the settings in p1959 and p1960.

- Encoder test

  If a speed encoder is used, the direction of rotation and the pulse number are checked.
- Only for induction motors:
  - Measurement of the saturation characteristic (p0362 to p0369)
  - Measurement of the magnetization current (p0320) and determination of the offset voltage of the converter for offset compensation
  - Measurement of the saturation of the leakage inductance, for induction motors, and setting of the current controller adaptation (p0391…p0393)

    This is automatically activated with 1LA1 and 1LA8 motors (p0300 = 11, 18) (see p1959.5).
- Speed controller optimization
  - p1470 and p1472, when p1960 = 1 (operation without encoder)
  - p1460 and p1462, when p1960 = 2 (operation with encoder)
  - Kp adaptation switch-off
- Acceleration pre-control setting (p1496)
- Setting for ratio between the total moment of inertia and that of the motor (p0342)

Note

To set the new controller setting permanently, the data must be saved in a non-volatile memory. Refer to Chapter "Parameters"

⚠ DANGER

During speed controller optimization, the drive triggers movements in the motor that can reach the maximum motor speed. The emergency STOP functions must be fully operational during commissioning. To protect the machines and personnel, the relevant safety regulations must be observed.

Note

If speed control optimization is used for operation with encoder, then the control operating mode is automatically reset to speed control without encoder, so that the encoder test can be carried out.

Overview of key parameters (see SINAMICS S List Manual)

- r0047 Status identification
- p1300[0...n] Open-loop/closed-loop control operating mode
- p1900 Motor data identification and rotating measurement
- r3925 Identification completion display
- r3927 MotId control word
- r3928 Rotating measurement configuration

Rotating measurement

- p0391 Current controller adaptation starting point Kp
- p0392 Current controller adaptation starting point Kp adapted
- p0393 Current controller adaptation P gain scaling
- p1959 Speed controller optimization configuration
- p1960 Rotating measurement selection
- p1961 Saturation characteristic speed for calculation
- p1965 Speed controller optimization speed
- p1967 Speed controller optimization dynamics factor
- r1968 Speed controller optimization dynamic factor current
- r1969 Speed controller optimization inertia identified
- r1973 Speed controller optimization encoder test pulse number determined
- p1980 Pole position identification technique
- p1990 Encoder adjustment selection

Motor data identification at standstill

- p1909[0...n] Motor data identification control word
- p1910 Motor data identification selection

4.13 Efficiency optimization

Description

The following can be achieved when optimizing the efficiency using p1580:

- Lower motor losses in the partial load range
- Noise in the motor is minimized

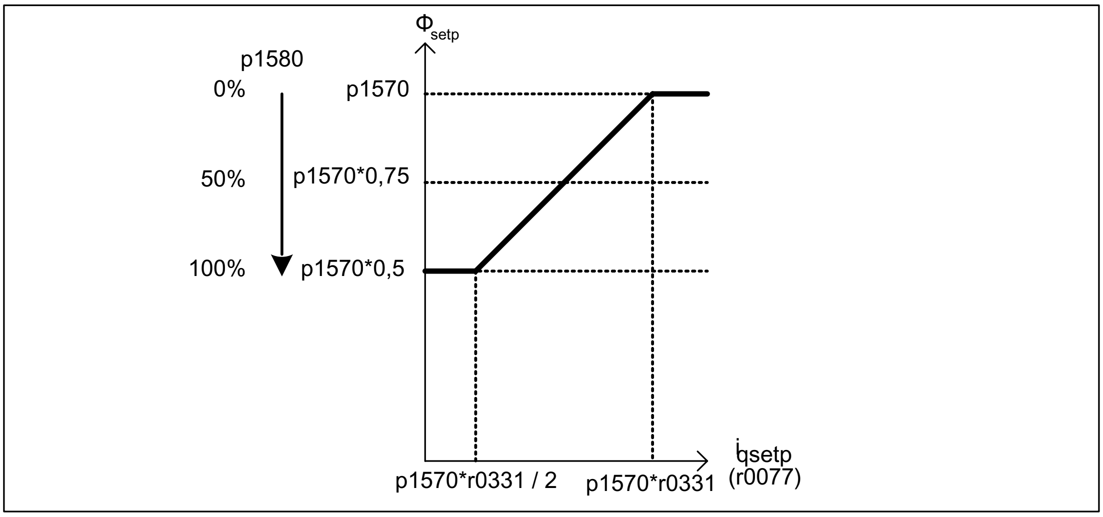


Figure 4-20 Efficiency optimization

It only makes sense to activate this function if the dynamic response requirements of the speed controller are low (e.g., pump and fan applications).

For p1580 = 100%, the flux in the motor under no-load operating conditions is reduced to half of the setpoint (reference flux) (p1570/2). As soon as load is connected to the drive, the setpoint (reference) flux linearly increases with the load and at approx. r0077 = r0331 * p1570 reaches the setpoint set in p1570.

In the field-weakening range, the final value is reduced by the actual degree of field weakening. The smoothing time (p1582) should be set to approx. 100 to 200 ms. Flux differentiation (see also p1401.1) is automatically deactivated internally following magnetization.

Function diagrams (see SINAMICS S List Manual)

- 6722 Field weakening characteristic, Id setpoint (ASM, p0300 = 1)
- 6723 Field weakening control, flux control for induction motors (p0300 = 1)

Overview of key parameters (see SINAMICS S List Manual)

- r0077 CO: Current setpoints, torque-generating
- r0331 Motor magnetizing current/short-circuit current (actual)
- p1570 CO: Flux setpoint
- p1580 Efficiency is optimization

4.14 Instructions for commissioning induction motors (ASM)

Equivalent circuit diagram for vector induction motor and cable

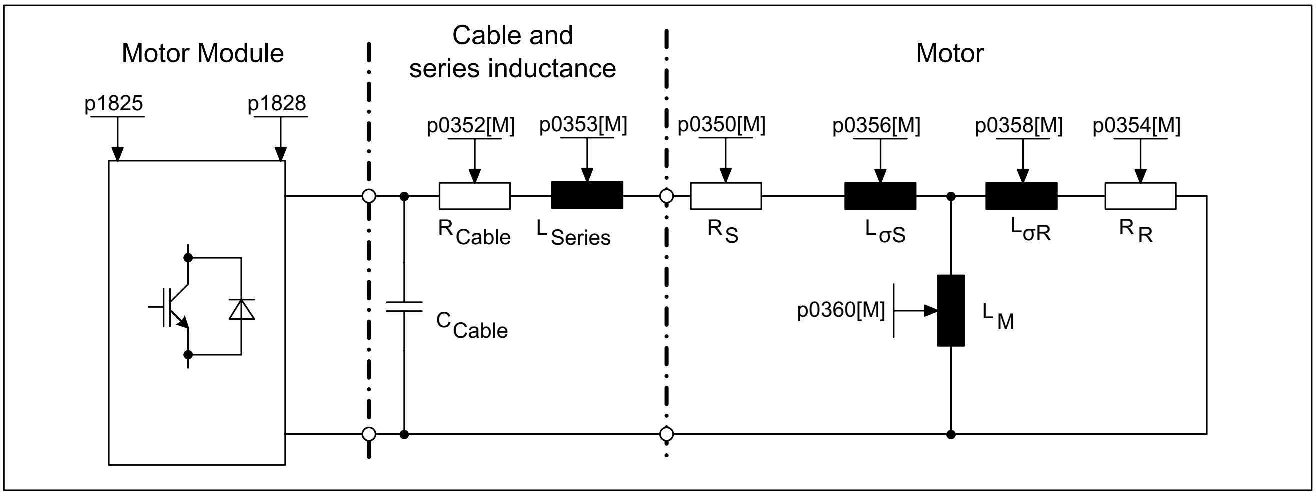


Figure 4-21 Equivalent circuit diagram for induction motor and cable

Induction motors, rotating

The following parameters can be entered in STARTER during the commissioning phase:

Table 4-2 Motor data type plate

Parameter	Description	Remark
p0304	Rated motor voltage	If this value is not known, a "0" can also be entered. Using this value, the stator leakage inductance can be more precisely calculated (p0356, p0357).
p0305	Rated motor current	-
p0307	Rated motor power	-
p0308	Rated motor power factor	-
p0310	Rated motor frequency	-
p0311	Motor rated speed	-
p0335	Motor cooling type	-

The following parameters can be optionally entered:

Table 4-3 Optional motor data

Parameter	Description	Remark
p0320	Motor rated magnetization current/short-circuit current	-
p0322	Maximum motor speed	-

Parameter	Description	Remark
p0341	Motor moment of inertia	-
p0342	Ratio between the total and motor moment of inertia	-
p0344	Motor weight	-
p0352	Cable resistance (component of the stator resistance)	-
p0353	Motor series inductance	-

Table 4-4 Equivalent circuit diagram for motor data

Parameter	Description	Remark
p0350	Motor stator resistance, cold	-
p0354	Motor rotor resistance, cold	-
p0356	Motor stator inductance	-
p0358	Motor rotor leakage inductance	-
p0360	Motor magnetizing inductance	-

Features

- Field weakening up to approx. 1.2 * rated speed (this depends on the drive converter supply voltage and the motor data, also refer to limitations/ constraints)
- Flying restart (for operation without encoder, only possible with additional VSM)
- Vector closed-loop speed and torque control
- Vector V/f control for diagnostics
- Motor identification
- Speed controller optimization (rotating measurement)
- Thermal protection via temperature sensor (PTC/KTY)
- All encoders that can be connected to an SMC10, SMC20 or SMC30 are supported.
- Operation with or without encoder is possible.

Supplementary conditions

Depending on the terminal voltage and load cycle, the maximum torque can be taken from the motor data sheets / project design instructions.

Commissioning

We recommend the following points when commissioning:

- Commissioning Wizard in STARTER

  The motor identification routine and the "rotating measurement" (p1900) can be activated from the commissioning Wizard in STARTER.

- Motor identification (standstill (static) measurement (p1910)
- Rotating measurement (p1960)

The following parameters can be entered in STARTER during the commissioning phase:

The optional motor data can be entered if it is known. Otherwise, they are estimated using the rating plate data or are determined using a motor identification routine or speed controller optimization.

4.15 Instructions for commissioning permanent-magnet synchronous motors

Equivalent circuit diagram for vector synchronous motor and cable

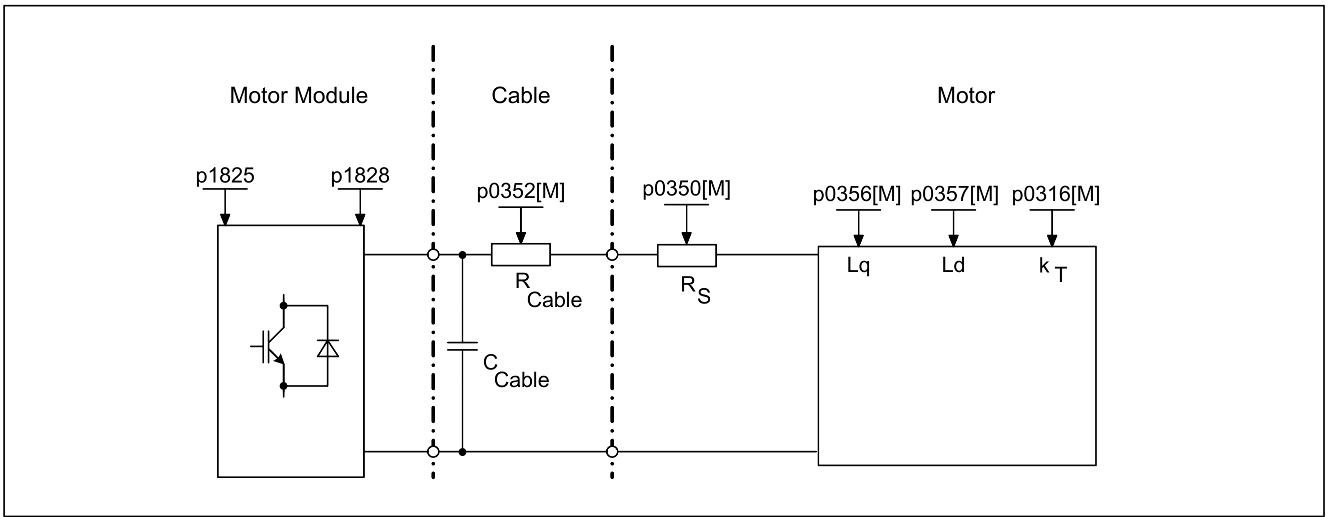


Figure 4-22 Equivalent circuit diagram for synchronous motor (vector)

Permanent-magnet synchronous motors, rotating

Permanent-magnet synchronous motors with or without encoder are supported.

The following encoder types are supported:

- Encoder with position information (e.g. without CD track or reference signal)
- Encoder without position information

For operation without encoders or with encoders without position information, a pole position identification must be carried out (see the chapter on pole position identification for further details).

Typical applications include direct drives with torque motors, which are characterized by high torque at low speeds. When these drives are used, gear units and mechanical parts subject to wear can be dispensed with if the application allows this.

Temperature protection can be implemented using a temperature sensor (KTY/PTC). In order to achieve a high torque accuracy, we recommend that a KTY temperature sensor is used.

Table 4-5 Motor data

Parameter	Description	Remark
p0304	Rated motor voltage	If this value is not known, a "0" can also be entered. Using this value, the stator leakage inductance can be more precisely calculated (p0356, p0357).
p0305	Rated motor current	-
p0307	Rated motor power	-
p0310	Rated motor frequency	-
p0311	Rated motor speed	-

If the torque constant k_T is not stamped on the rating plate or specified in the data sheet, you can calculate this value from the rated motor data or from the stall current I_o and stall torque M_o as follows:

$$kT_{nom.} = \frac{P_{Mot,nom}}{2\pi \cdot \frac{min}{60s} \cdot n_{nom.} \cdot I_{Mot,nom}}$$

Table 4-6 Optional data

Parameter	Description	Remark
p0314	Motor pole pair number	-
p0316	Motor torque constant	-
p0320	Motor rated magnetization current/short-circuit current	This is used for the field weakening characteristic
p0322	Maximum motor speed	Maximum mechanical speed
p0323	Maximum motor current	De-magnetization protection
p0325	Motor pole position information	-
p0327	Optimum motor load angle	-
p0328	PE spindle, reluctance torque constant	-
p0329	Motor pole position identification current	-
P0341	Motor moment of inertia	For speed controller pre-control
p0342	Ratio between the total motor moment of inertia	-

Table 4-7 Equivalent circuit diagram for motor data

Parameter	Description	Remark
p0350	Motor stator resistance, cold	-
p0356	Motor stator inductance	-
p0357	Motor stator inductance, d axis	-

WARNING

As soon as the motor starts to rotate, a voltage is generated. When work is carried out on the converter, the motor must be safely disconnected. If this is not possible, the motor must be locked by a holding brake, for example.

Features

- Field weakening up to approx. 1.2 * rated speed (this depends on the drive converter supply voltage and the motor data, also refer to limitations/ constraints)
- Flying restart (for operation without encoder, only possible with additional VSM)
- Vector closed-loop speed and torque control
- Vector V/f control for diagnostics
- Motor identification
- Automatic rotating encoder adjustment (the zero encoder position is calibrated)
- Speed controller optimization (rotating measurement)
- Thermal protection via temperature sensor (PTC/KTY)
- All encoders that can be connected to an SMC10, SMC20 or SMC30 are supported.
- Operation with or without encoder is possible.

Supplementary conditions

- Maximum speed or maximum torque depend on the converter output voltage available and the back EMF of the motor (calculation specifications: EMF must not exceed U_{rated} converter).
- Calculating the maximum speed:

$$n_{max} = n_{nom.} \cdot \sqrt{\frac{3}{2}} \cdot \frac{V_{DC,lim} \cdot I_{Mot,nom}}{P_{Mot,nom}}$$

or

$$n_{max} = \frac{60s}{min} \cdot \sqrt{\frac{3}{2}} \cdot \frac{V_{DC,lim}}{2\pi \cdot kT_{nom}}$$

$V_{DC,lim}$:
690 V devices: 1220 V
500 V devices: 1022 V
400 V devices: 820 V

Calculating k_T see "Commissioning".

Note

If pulse inhibition of the converter occurs (fault or OFF2), synchronous motors can generate high terminal voltages in the field weakening range, which could lead to overvoltage in the DC link. The following possibilities exist to protect the drive system from being destroyed due to overvoltage:

1. Restrict (p0643 = 0) maximum speed (p1082)

2. External voltage limiter or chopper or other measures appropriate to the application.

⚠ CAUTION

With p0643 = 1, it must be ensured that there is sufficiently high and suitable overvoltage protection. If necessary, system-side precautions should be taken.

- Depending on the terminal voltage and load cycle, the maximum torque can be taken from the motor data sheets / project design instructions.

Commissioning

We recommend the following points when commissioning:

- Commissioning Wizard in STARTER

  The motor identification routine and the "rotating measurement" (p1900) can be activated from the commissioning Wizard in STARTER. The encoder adjustment (p1990) is automatically activated together with the motor identification routine.
- Motor identification (standstill (static) measurement (p1910)
- Encoder adjustment (p1990)

⚠ WARNING

During initial commissioning and when the encoder is replaced, the encoder must be adjusted (p1990).

- Rotating measurement (p1960)

The following parameters can be entered in STARTER during the commissioning phase:

The optional motor data can be entered if it is known. Otherwise, they are estimated using the rating plate data or are determined using a motor identification routine or speed controller optimization.

4.15.1 Automatic encoder adjustment

Description

The pole wheel-oriented closed-loop control of the synchronous motor requires information about the pole wheel position angle. Automatic encoder adjustment must be used if the pole wheel position encoders are not mechanically adjusted and after a motor encoder has been replaced.

Automatic encoder adjustment only makes sense for encoders with absolute position information and/or zero mark. The following encoders are supported:

- Sin/Cos encoder with A/B-, R-track as well as with A/B-, C/D-, R-track
- Resolver
- Absolute encoder (e.g. EnDat, SSI)
- Incremental encoder with zero mark

Encoder adjustment using a zero mark

If an incremental encoder with zero mark is being used, after the zero mark has been passed, the position of the zero mark can be calibrated. Commutation with the zero mark is activated via p0404.15.

Commissioning

Automatic encoder adjustment is activated with p1990 = 1. When the pulses are enabled the next time, the measurement is carried-out and the angular difference determined (p1984) is entered into p0431. For p1990 = 2 the determined angular difference (p1984) is not entered into p0431 and has not effect on the closed-loop motor control. Using this function, the angular difference - entered into p0431 - can be checked. For extremely high moments of inertia, the run time can be scaled higher using p1999.

⚠ WARNING
The measurement causes the motor to rotate. The motor turns through a minimum of one complete revolution.

Integration

Automatic encoder adjustment is integrated into the system in the following way:

Overview of key parameters (see SINAMICS S List Manual)

- p0404.15 Commutation with zero mark
- p0431 Angular commutation offset
- p1990 Encoder adjustment selection
- p1999 Angular commutation offset calibration, scaling

4.15.2 Pole position identification

Description

The pole position identification routine is used to determine rotor position at start up. This is required when no pole position information is available. If, for example, incremental encoders are used or operation without encoder is employed, then pole position identification is started automatically. For operation with encoder, pole position identification can be started via p1982 = "1", or via p1780.6 = "1", for operation without encoder .

If possible, pole position identification should be carried out in decoupled state. If there is no large moment of inertia and there is negligible friction, then the identification can also be carried out in coupled state.

If there is negligible friction and high moment of inertia, then the dynamic response for the speed encoder can be adjusted to the moment of inertia by increasing p1999.

If there is high friction torque or an active load, then an adjustment is only possible in decoupled state.

Three pole position identification techniques can be selected:

- p1980 = 1, voltage pulsing, first harmonic

  This technique also functions for magnetically isotropic motors if adequate iron saturation can be achieved.

- p1980 = 4, voltage pulsing, two-stage

  This technique functions with motors that are magnetically anisotropic. During the measurement, the motor must be at a standstill. The measurement is carried-out the next time that the pulses are enabled.

  Note

  Using this type of identification, the motor can emit a significant amount of noise.

- p1980 = 10, DC current impression

  This technique functions for all motors; however, it takes more time than the measurement selected using p1980 = 4. During the measurement, the motor must be able to rotate. The measurement is carried-out the next time that the pulses are enabled. For extremely high moments of inertia, the run time can be scaled higher using p1999.

⚠ WARNING
The measurement can electrically trigger a rotation or movement of the motor, by up to a half rotation.

Integration

The pole position identification is integrated into the system as follows:

Overview of key parameters (see SINAMICS S List Manual)

- p0325 Motor pole position identification current 1st phase
- p0329 Motor pole position identification current
- p1780.6 Selects pole position identification PEM without an encoder (sensorless)
- p1980 Pole position identification technique
- p1982 Pole position identification technique
- r1984 Pole position identification angular difference
- r1985 Pole position identification saturation curve
- r1987 Pole position identification trigger curve
- p1999 Angular commutation offset calibration, scaling

4.16 Flying restart

Description

After power ON, the "flying restart" function switches automatically to a Motor Module that may be coasting.

The "Flying restart" function should be activated via p1200 for an overrunning load. This prevents sudden loads in the entire mechanics.

With an induction motor, the system waits for a demagnetization time to elapse before the search is carried out. An internal demagnetization time is calculated. A time can also be entered in p0347. The system waits for the longer of the two times to elapse.

In operation without an encoder, a search is carried out initially for the current speed. The search starts at the maximum speed plus 25%. A Voltage Sensing Module (VSM) is required for permanent-magnet synchronous motors for additional information, refer to the Equipment Manual.

When operated with an encoder (speed actual value is sensed), the search phase is eliminated.

For an induction motor, immediately after the speed has been determined, magnetization starts (p0346).

The current speed setpoint in the ramp function generator is then set to the current actual speed value.

The ramp-up to the final speed setpoint starts with this value.

Application example: After a power failure, a fan drive can be quickly reconnected to the running fan motor by means of the flying restart function.

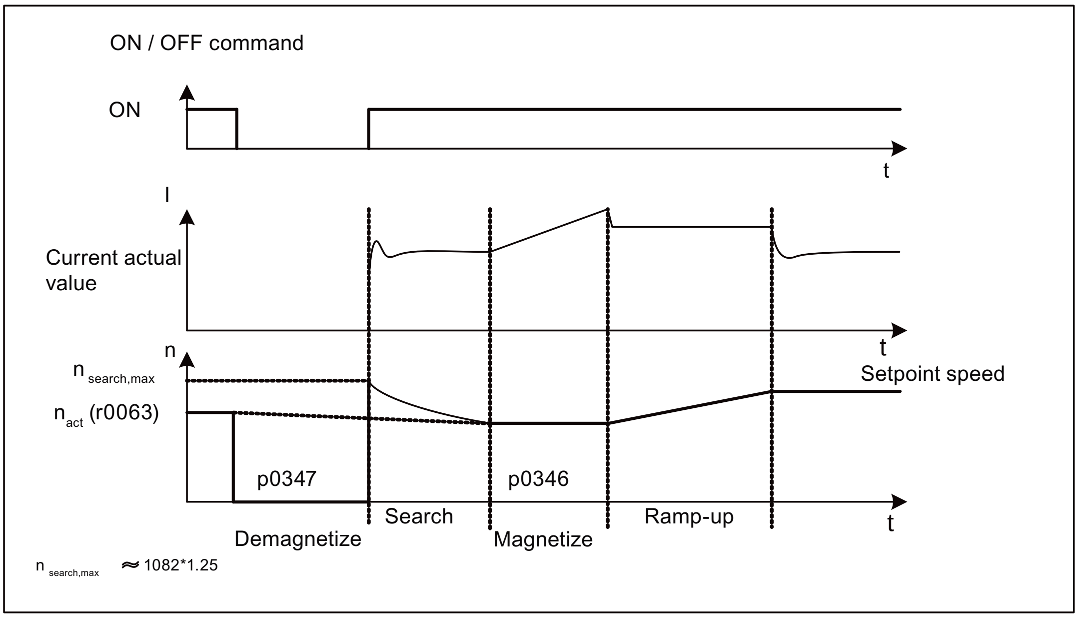


Figure 4-23 Flying restart, example of induction motor without encoder

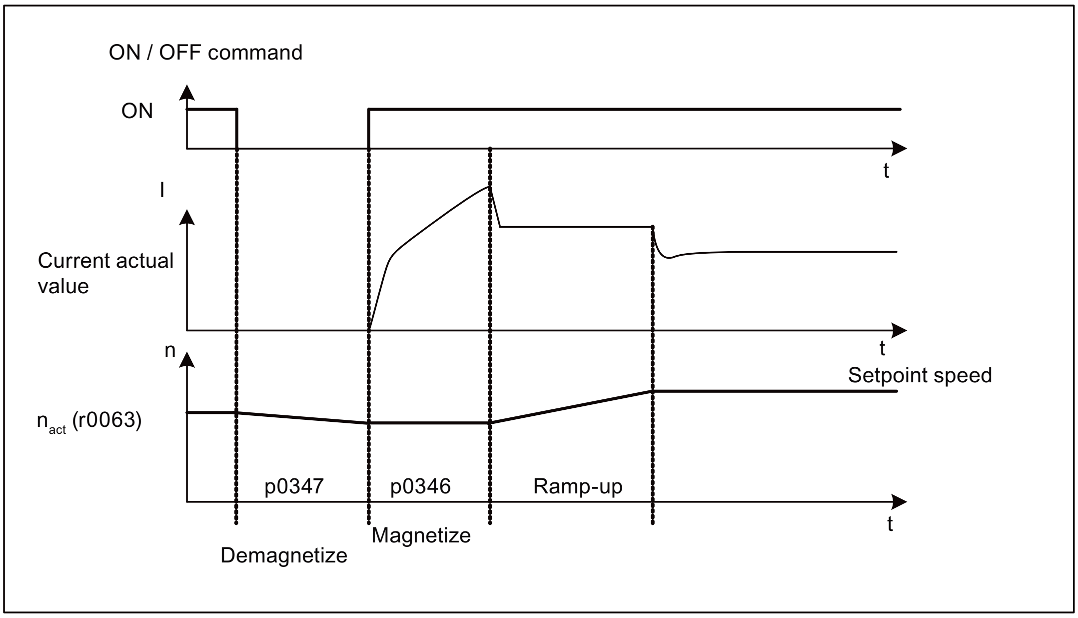


Figure 4-24 Flying restart, example of induction motor with encoder

⚠ WARNING

When the flying restart (p1200) function is active, the drive may still be accelerated by the detection current despite the fact that it is at standstill and the setpoint is 0!

For this reason, entering the area around the drive when it is in this condition can cause death, serious injury, or considerable material damage.

Note

With induction motors, the demagnetization time must elapse before the flying restart function is activated to allow the voltage at the motor terminals to decrease otherwise high equalizing currents can occur when the pulses are enabled due to a phase short-circuit.

Overview of key parameters (see SINAMICS S List Manual)

- p1082 Maximum speed
- p1200 Flying restart operating mode
  - 0: Flying restart inactive
  - 1: Flying restart is always active (start in the setpoint direction).
  - 2: Flying restart is active after: power-on, fault, OFF2 (start in the setpoint direction).
  - 3: Flying restart is active after: fault, OFF2. (start in the setpoint direction).
  - 4: Flying restart is always active Start in setpoint direction **only.**
  - 5: Flying restart is active after: power-on, fault, OFF2 Start in setpoint direction **only.**
  - 6: Flying restart is active after: fault, OFF2, start in setpoint direction **only.**
- p1202 Flying restart search current
- p1203 Flying restart search rate factor
- r1204 CO/BO: Flying restart, V/f control status
- r1205 CO/BO: Flying restart, vector control status

4.17 Synchronization

Features

- For the vector mode
- For induction motors without encoder
- Line supply sensing using the Voltage Sensing Module (VSM10) connected to the infeed or vector (p3801)
- Connector inputs for the actual voltage sensing of the motor via VSM10 (p3661, r3662)
- Setting a phase difference (p3809)
- Can be activated by parameter (p3802)

Description

With the synchronization function, synchronization to the infeed line is possible, in order to switch-over (bypass) directly to the line. An additional application is to temporarily operate the motor from the line supply in order to be able to carry out maintenance work on the drive converter without incurring any down times.

Synchronizing is activated using parameter p3800 and either internal or external actual voltage sensing is selected. For the internal actual voltage sensing (p3800 = 1), the voltage setpoints of the electrical motor model are used for synchronizing. For the external actual voltage sensing (p3800 = 2), the voltage is sensed using a VSM, this is connected between the Motor Module and Motor. The voltage values must be transferred to the synchronization via connectors r3661 and r3662.

Prerequisite

- Firmware release 2.4
- Drive object, vector/infeed with connected VSM10
- Induction motor without encoder
- Vector control

Function diagrams (see SINAMICS S List Manual)

- 7020 Synchronization

Overview of key parameters (see SINAMICS S List Manual)

- p3800 Sync-line-drive activation
- p3801 Sync-line-drive object number
- p3802 BI: Sync-line-drive enable
- r3803 CO/BO: Sync-line-drive control word
- r3804 CO: Sync-line-drive target frequency
- r3805 CO: Sync-line-drive frequency difference
- r3819 CO/BO: Status word, synchronizing

4.18 Simulation operation

4.18.1 Description

Simulation mode allows you to simulate the drive without a connected motor and without the DC link voltage. In this case, it should be noted that the simulation mode can only be activated under an actual DC link voltage of 40 V. If the voltage is higher, simulation mode is reset and fault message F07826 is output.

Simulation mode enables you to test communication with a higher-level automation system. If the drive is also to return actual values, note that it must be switched over to sensorless operation during simulation mode. This means that large parts of the SINAMICS software (e.g. setpoint channel, sequence control, communication, technology function, etc.) can be tested in advance without requiring a motor.

For units with outputs of > 75 W it is recommended to test the activation of the power semiconductors after repairs. To do so, a DC voltage < 40 V is applied to the DC link, and the possible pulse patterns must be tested by the control software.

The software must allow enabling of the pulses and the output of various frequencies. This is implemented using V/f control or sensorless closed-loop speed control.

Note

Simulation mode cannot be activated without a power unit. A power unit must be connected via DRIVE-CLiQ.

4.18.2 Features

- Automatic deactivation with a DC link voltage greater than 40 V (measurement tolerance ± 4 V) with fault message F07826 and immediate pulse inhibit (OFF2)
- Can be activated via parameter p1272
- Deactivation of line contactor activation during simulation mode
- Activation of power semi-conductor with low DC link voltage and with motor (for test purposes).
- Power unit and closed-loop control can be simulated without a connected motor.

4.18.3 Commissioning

Simulation mode can be activated via p1272 =1. The following prerequisites must be fulfilled:

- Initial commissioning must be complete (default: Standard induction motors).
- The DC link voltage must be below 40 V (observe the tolerance of the DC link voltage sensing).

4.19 Redundance operation power units

Features

- Redundance for up to 4 chassis power units
- Power unit can be de-activated via parameter (p0125)
- Power unit can be de-activated via binector input (p0895)

Description

Redundant operation can be used so that operation can be continued in spite of the failure of one power unit connected in parallel. In order that the failed power unit can be replaced, DRIVE-CLiQ cables must be connected in a star-type configuration - it may be necessary to use a DRIVE-CLiQ HUB Module (DMC20). The failed power unit must be deactivated via p0125 or via the binector input p0895, before it is removed. When a replacement power unit has been installed it must be activated accordingly.

Prerequisites

- Parallel connection only works with equivalent (order number) chassis power units.
- Maximum number of parallel power units is 4
- Minimum firmware release 2.4
- Parallel connection of power units with suitable power reserves
- DRIVE-CLiQ star topology (possibly a DMC20, refer to the Equipment Manual)
- Motor with one single-winding system (p7003 = 0)
- No safe standstill

Integration

The boot function with partial topologies is integrated in the system as follows.

- p0125 Activate/de-activate power unit component
- r0126 Power unit component active/inactive
- p0895 BI: Activate/deactivate power unit component
- p7003 Par_circuit winding system

4.20 Bypass

Features

- Available for the vector mode
- Available for induction motors without encoder

Description

The bypass function controls two contactors via digital outputs of the drive converter and evaluates the feedback signals of the contactors via digital inputs (e.g. via TM31). This circuit allows the motor to either be fed from the drive converter or connected directly to the supply line. The drive converter controls the contactors; the feedback signals for the contactor states must be fed back to the drive converter.

This bypass circuit can be implemented in two ways:

- Without synchronizing the motor to the line supply and

- Synchronizing the motor to the line supply.

For all bypass versions, the following applies:

- The bypass is always switched-out when one of the control word signals "OFF2" or "OFF3" is withdrawn.
- Exception:
  When required, the bypass switch can be interlocked by a higher-level control so that the drive converter can be completely powered-down (i.e. including the control electronics) while the motor is operated from the line supply. The contactor interlocking should be implemented on the plant/system side.
- When the drive converter restarts after POWER OFF, the state of the bypass contactors is evaluated. After powering up, the converter can thereby change straight into "Ready to start and bypass" status. This is only possible if the bypass is activated via a control signal, the control signal (p1266) is still present once the system has been ramped up, and the automatic restart function (p1200 = 4) is active.
- Changing the converter into "Ready to start and bypass" status after powering up, is of a higher priority than switching back on automatically.
- Monitoring of the motor temperatures using temperature sensors is active while the converter is in one of two statuses "Ready to start and bypass" or "Ready to operate and bypass".
- The two motor contactors must be designed for switching under load.

Note

The examples contained in the following descriptions are only basic circuits designed to explain the basic function. The dimensions of specific circuit configurations (contactors, protective equipment) must be calculated for specific systems.

Prerequisite

The bypass function is only possible for sensorless closed-loop speed control (p1300 = 20) or V/f control (p1300 = 0...19) and when an induction motor is used.

Commissioning the bypass function

The bypass function is part of the function module "technology controller" that can be activated when using the commissioning Wizard. Parameter r0108.16 indicates whether it has been activated.

4.20.1 Bypass with synchronization with overlap (p1260 = 1)

Description

When "bypass with synchronization with overlap (p1260 = 1)" is activated, then motor is transferred, synchronized to the line supply and is also retrieved again. During the changeover, the two contactors K1 and K2 are simultaneously closed for a time (phase lock synchronization).

A reactor is used to de-couple the drive converter from the line supply - the uk value for the reactor is 10% +/- 2%.

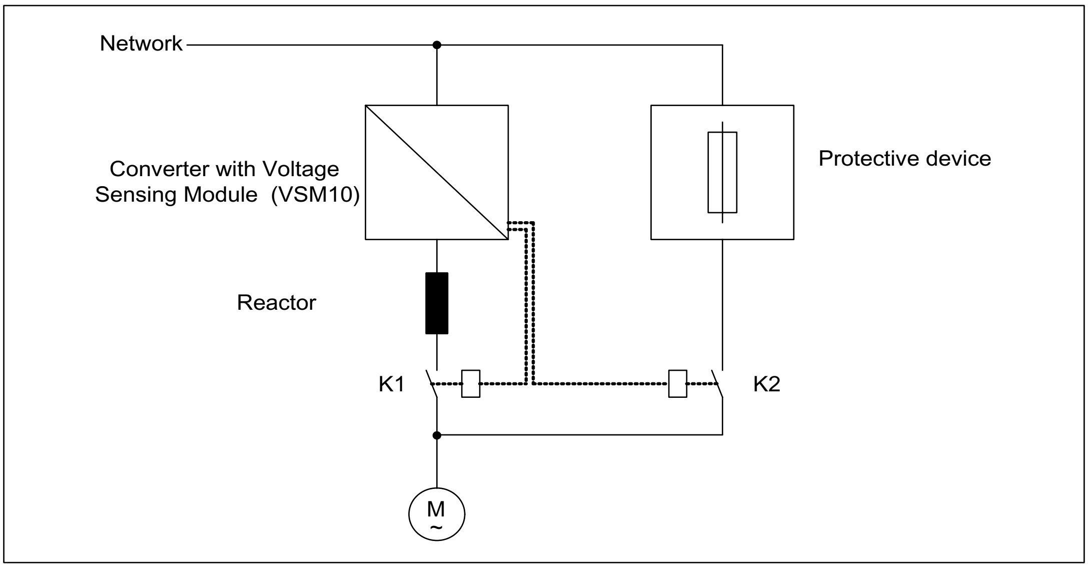


Figure 4-25 Circuit example: Bypass with synchronization with overlap

Activating

The bypass function with synchronization with overlap (p1260 = 1) can only be activated using a control signal. It cannot be activated using a speed threshold or a fault.

Example

The following parameters must be set after the bypass function with synchronization with overlap (p1260 = 1) has been activated.

Table 4-8 Parameter setting for bypass function with synchronization with overlap

Parameter	Description
p1266 =	Control signal setting when p1267.0 = 1
p1267.0 = 1 p1267.1 = 0	Bypass function is initiated by the control signal
P1269[0] =	Signal source to provide the feedback signal of contactor K1
P1269[1] =	Signal source for contactor K2 feedback
p3800 = 1	For synchronization, the internal voltages are used.
p3802 = r1261.2	Synchronizer activation is triggered by the bypass function.

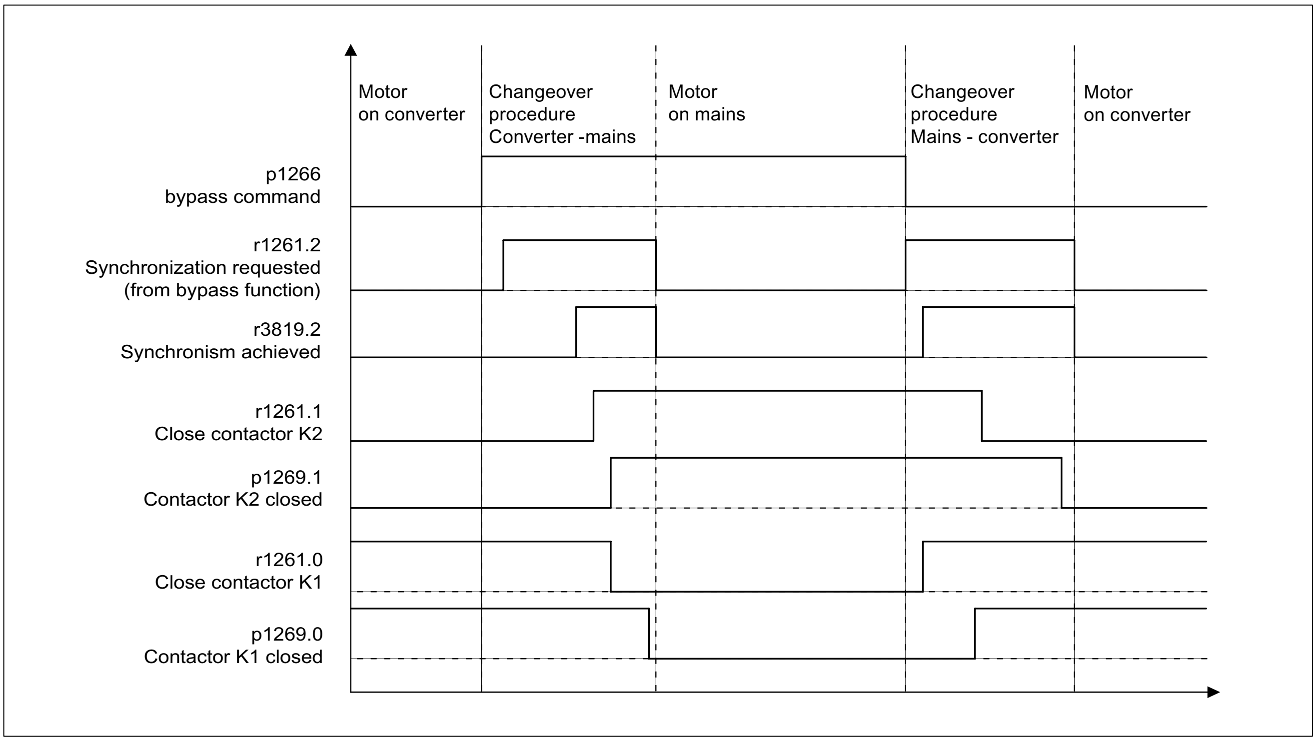


Figure 4-26 Signal diagram, bypass with synchronization with overlap

The motor is transferred to the line supply
(the drive converter controls contactors K1 and K2):

- The initial state is as follows: Contactor K1 is closed, contactor K2 is open and the motor is fed from the drive converter.
- The control bit "bypass command" (p1266) is set (e.g. from the higher-level automation).
- The bypass function sets the control word bit "synchronizing" (r1261.2).
- Since the bit is set while the converter is running, the "Transfer motor to supply" synchronization process is started.
- After the motor has been synchronized to the line frequency, line voltage and line phase, the synchronizing algorithm reports this status (r3819.2).
- The bypass mechanism evaluates this signal and closes contactor K2 (r1261.1 = 1). The signal is internally evaluated - BICO wiring is not required.
- After contactor K2 has signaled back the "closed" state (r1269[1] = 1), contactor K1 is opened and the drive converter inhibits the pulses. The drive converter is in the "hot standby" state.
- If the on command is withdrawn in this phase, the drive converter changes into the basic standby state. If the appropriate contactors are being used, the drive converter is isolated from the line supply and the DC link is discharged.

Retrieving the motor from supply mode functions the same but in reverse:
At the start of the process, contactor K2 is closed and contactor K1 is opened.

- The "Command bypass" control bit is canceled (e.g. by the higher-level automation).
- The bypass function sets the control word bit "synchronizing".

- Pulses are enabled. Since "Synchronize" is set before "Pulse enable", the converter interprets this as a command to retrieve a motor from the supply and to take it over.
- After the motor has been synchronized to the line frequency, line voltage and line phase, the synchronizing algorithm reports this status.
- The bypass mechanism evaluates this signal and closes contactor K1. The signal is internally evaluated - BICO wiring is not required.
- Once contactor K1 has reported "closed" status, contactor K2 is opened and the motor is operated again on the converter.

4.20.2 Bypass with synchronization, without overlap (p1260 = 2)

Description

When "bypass with synchronization without overlap (p1260 = 2)" is activated, contactor K2 to be closed is only closed when contactor K1 has opened (anticipatory type synchronization). Phasing of the motor voltage before synchronization must be set such that there is an "initial jump" upstream of the supply to which synchronization should be carried out. This is done by setting the synchronization setpoint (p3809). As a result of the motor braking in the short time during which, both contactors are open, when closing contactor K2, a phase and frequency difference of approximately zero is obtained.

Sufficiently large moment of inertia is a precondition for sound functioning.

It is no longer necessary to use the de-coupling reactor after having determined the synchronizing setpoint (p3809).

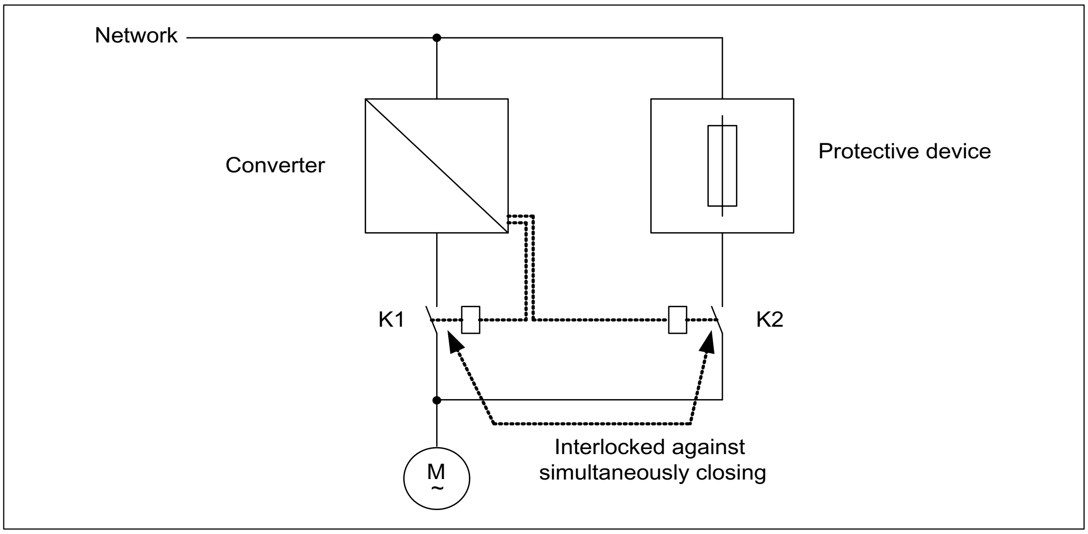


Figure 4-27 Circuit example, bypass with synchronization without overlap

Activating

The bypass function with synchronization without overlap (p1260 = 2) can only be activated using a control signal. It cannot be activated using a speed threshold or a fault.

Example

The following parameters must be set after the bypass function with synchronization without overlap (p1260 = 2) has been activated.

Table 4-9 Parameter settings for bypass function with synchronization without overlap

Parameter	Description
p1266 =	Control signal setting when p1267.0 = 1
p1267.0 = 1 p1267.1 = 0	Bypass function is initiated by the control signal.
P1269[0] =	Signal source to provide the feedback signal of contactor K1
P1269[1] =	Signal source for contactor K2 feedback
p3800 = 1	The internal voltages are used for synchronization.
p3802 = r1261.2	Synchronizer activation is triggered by the bypass function.

4.20.3 Bypass without synchronization (p1260 = 3)

Description

When the motor is transferred to the line supply, contactor K1 is opened (after the drive converter pulses have been inhibited); the system then waits for the motor de-excitation time and then contactor K2 is closed so that the motor is directly connected to the line supply.

When the motor is switched on in a non-synchronized manner, an equalizing current flows that must be taken into account when the protective equipment is designed.

When the converter retrieves the motor from the line supply, initially contactor K2 is opened, and after the excitation time has expired, contactor K1 is closed. The drive converter then connects to the rotating motor and the motor is fed from the drive converter.

In this case, contactor K2 must be designed/selected to be able to switch inductive loads.

Contactors K1 and K2 must be interlocked so that they cannot simultaneously close.

The "flying restart" function must be activated (p1200).

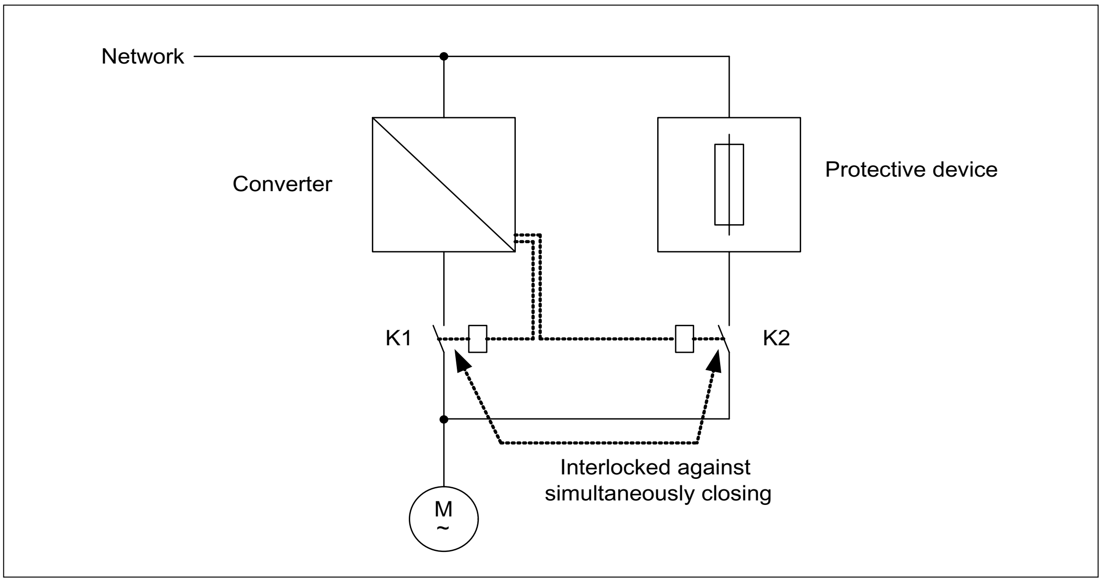


Figure 4-28 Circuit example, bypass without synchronization

Activating

The bypass without synchronization (p1260 = 3) can be triggered by the following signals (p1267):

- Bypass by means of control signal (p1267.0 = 1):
  The bypass can be activated by means of a digital signal (p1266) (e.g. from a higher-level automation system). If the digital signal is withdrawn again after the debypass delay time has expired (p1263), then a changeover is made to drive converter operation.
- Bypass at speed threshold (p1267.1 = 1):
  Once a certain speed is reached, the system switches to bypass (i.e. the converter is used as a start-up converter). The bypass cannot be connected until the speed setpoint is greater than the bypass speed threshold (p1265).
  The system reverts to converter mode when the setpoint (on the input of the ramp function generator, r1119) falls below the bypass speed threshold (p1265). The setpoint > comparison value condition prevents the bypass from being reactivated straight away if the actual speed is still above the bypass speed threshold (p1265) after switching back to converter operations.

The bypass time, debypass time, bypass speed variables and the command source for changing over are set using parameters.

The following signal diagram shows the timing when the bypass switch is on when activating "bypass for fault".

Example

After activating the bypass function without synchronization (p1260 = 3) the following parameters still have to be set:

Table 4-10 Parameter setting for bypass function with synchronization with overlap

Parameter	Description
p1262 =	Bypass dead time setting
p1263 =	Debypass dead time setting
p1264 =	Bypass delay time setting
p1265 =	Speed threshold setting when p1267.1 = 1
p1266 =	Control signal setting when p1267.0 = 1
p1267.0 = p1267.1 = p1267.2 =	Trigger signal setting for bypass function
P1269[0] =	Signal source to provide the feedback signal of contactor K1
P1269[1] =	Signal source for contactor K2 feedback
p3800 = 1	The internal voltages are used for synchronization.
p3802 = r1261.2	Synchronizer activation is triggered by the bypass function.

Function diagrams (see SINAMICS S List Manual)

- 7020 Synchronization

Overview of key parameters (see SINAMICS S List Manual)

Bypass function

- p1260 Bypass configuration
- r1261 CO/BO: Bypass control/status word
- p1262 Bypass deadtime
- p1263 Debypass delay time
- p1264 Bypass delay time
- p1265 Bypass speed threshold
- p1266 BI: Bypass control signal
- p1267 Bypass source configuration
- p1268 BI: Bypass control signal
- p1269 BI: Bypass switch feedback signal source

Synchronization

- p3800 Sync-line-drive activation
- p3801 Sync-line-drive object number
- p3802 BI: Sync-line-drive enable
- r3803 CO/BO: Sync-line-drive control word
- r3804 CO: Sync-line-drive target frequency

- r3805 CO: Sync-line-drive frequency difference
- p3806 Sync-line-drive frequency difference threshold value
- r3808 CO: Sync-line-drive phase difference
- p3809 Sync-line-drive phase setpoint
- p3811 Sync-line-drive frequency limiting
- r3812 CO: Sync line drive correction frequency
- p3813 Sync line-drive phase synchronism, threshold value
- r3814 CO: Sync line drive voltage difference
- p3815 Sync line-drive voltage difference, threshold value
- p3816 CI: Sync line-drive voltage actual value U12 = U1 – U2
- p3817 CI: Sync line-drive voltage actual value U23 = U2 – U3
- r3819 CO/BO: Sync-line-drive status word

Vector V/f control (r0108.2 = 0) 5

5.1 Introduction

The simplest solution for a control procedure is the V/f curve, whereby the stator voltage for the induction motor or synchronous motor is controlled proportionately to the stator frequency. This method has proved successful in a wide range of applications with low dynamic requirements, such as:

- Pumps and fans
- Belt drives

and other similar processes.

V/f control aims to maintain a constant flux Φ in the motor. whereby the flux is proportional to the magnetization current (Iμ) or the ratio of voltage (U) to frequency (f).

Φ ~ Iμ ~ V/f

The torque (M) generated by the induction motors is, in turn, proportional to the product (or, more precisely, the vector product (Φ x I)) of the flux and current.

M ~ Φ x I

To generate as much torque as possible with a given current, the motor must function using the greatest possible constant flux. To maintain a constant flux (Φ), therefore, the voltage (V) must be changed in proportion to the frequency (f) to ensure a constant magnetization current (Iμ). V/f characteristic control is derived from these basic premises.

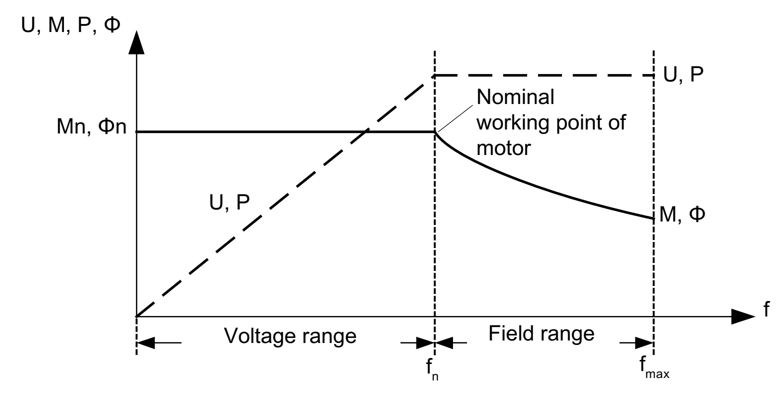
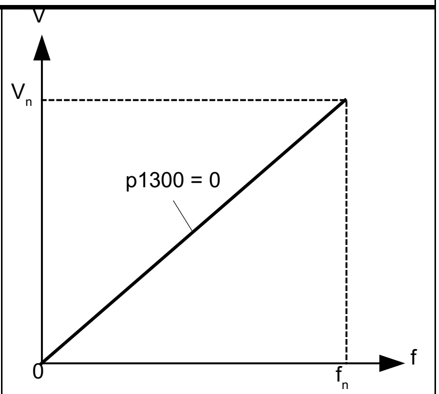
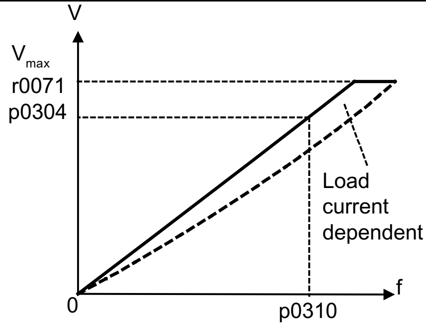
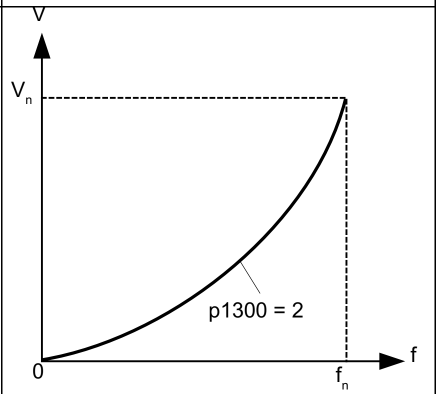
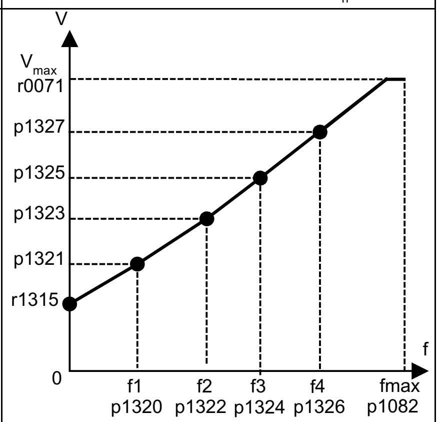


Figure 5-1 Operating areas and characteristic curves for the induction motor with converter supply

Several variations of the V/f characteristic exist, which are shown in the following table:

Table 5-1 V/f characteristic (p1300)

<table>
<tr><th>Parameter values</th><th>Meaning</th><th colspan="2">Application / property</th></tr>
<tr><td>0</td><td>Linear characteristic</td><td>Standard (w/o voltage boost)</td><td>
</td></tr>
<tr><td>1</td><td>Linear characteristic with flux current control (FCC)</td><td>Characteristic that compensates for voltage losses in the stator resistance for static / dynamic loads (flux current control FCC).
This is particularly useful for small motors, since they have a relatively high stator resistance.</td><td>
</td></tr>
<tr><td>2</td><td>Parabolic characteristic</td><td>Characteristic that takes into account the motor torque curve (e.g. fan/pump).
a) Quadratic characteristic (f^2 characteristic)
b) Energy saving because the low voltage also results in small currents and drops.</td><td>
</td></tr>
<tr><td>3</td><td>Programmable characteristic</td><td>Characteristic that takes into account motor/machine torque curve (e.g. synchronous motor).</td><td>
</td></tr>
</table>

Parameter values	Meaning	Application / property
5	Precise frequency drives	Characteristic that takes into account the technological particularity of an application (e.g. textile applications): a) whereby the current limitation (Imax controller) only affects the output voltage and not the output frequency, or b) by disabling slip compensation
6	Precise frequency drives with flux current control (FCC)	Characteristic that takes into account the technological particularity of an application (e.g. textile applications): a) whereby the current limitation (Imax controller) only affects the output voltage and not the output frequency, or b) by disabling slip compensation Voltage losses in the stator resistance for static / dynamic loads are also compensated (flux current control FCC). This is particularly useful for small motors, since they have a relatively high stator resistance.
19	Independent voltage setpoint	The user can define the output voltage of the Motor Module independently of the frequency using BICO parameter p1330 via the interfaces (e.g. analog input AI0 of Terminal Board 30 –> p1330 = r4055[0]).

5.2 Voltage boost

With an output frequency of 0 Hz, the V/f characteristics yield an output voltage of 0 V. The voltage boost must be entered to:

- Magnetize the induction motor.
- Maintain the load.
- Compensate for the losses (ohmic losses in the winding resistors) in the system
- Generate a breakaway/acceleration/braking torque.

The voltage boost can be increased permanently (p1310) or during acceleration (p1311).

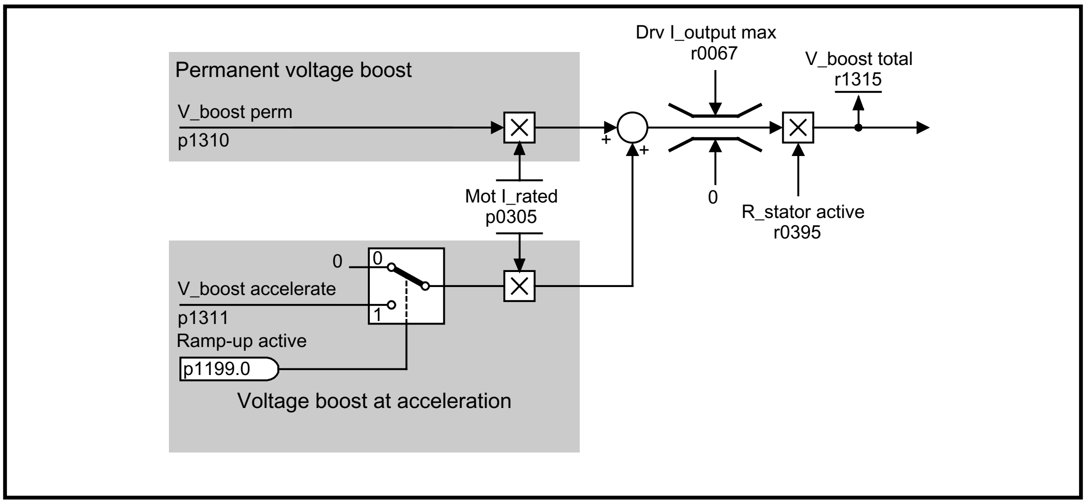


Figure 5-2 Voltage boost total

Note

The voltage boost affects all V/f characteristics (p1300).

NOTICE
If the voltage boost value is too high, this can result in a thermal overload of the motor winding.

Permanent voltage boost (p1310)

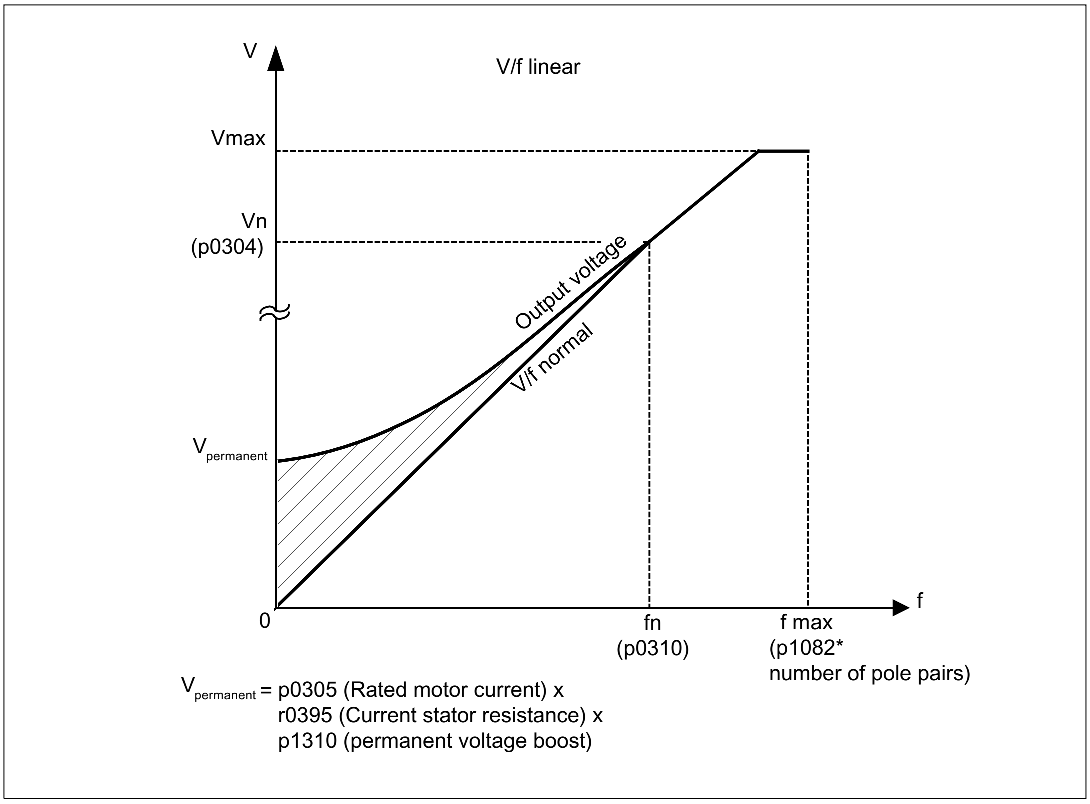


Figure 5-3 Permanent voltage boost (example: p1300 = 0 and p1310 > 0)

Voltage boost at acceleration (p1311)

Voltage boost at acceleration is effective if the ramp function generators provide the feedback signal "ramp-up active" (r1199.0 = 1).

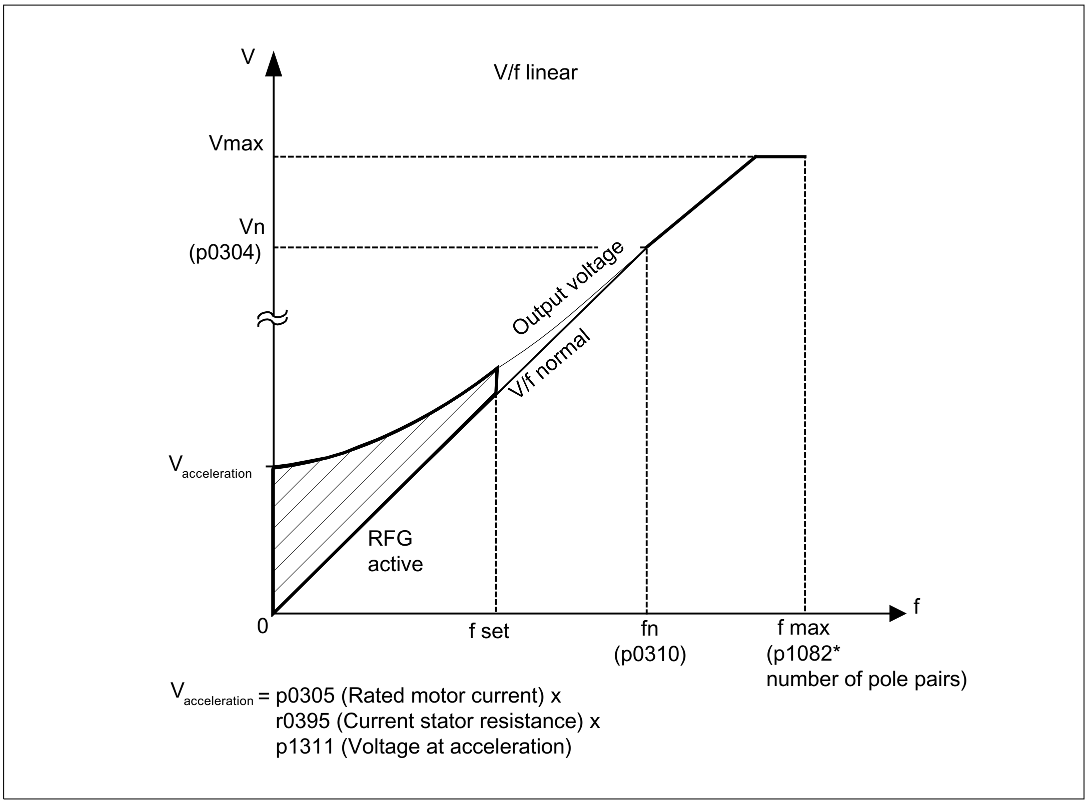


Figure 5-4 Voltage boost at acceleration (example: p1300 = 0 and p1311 > 0)

Function diagrams (see SINAMICS S List Manual)

- 6300 V/f characteristic and voltage boost

Overview of key parameters (see SINAMICS S List Manual)

- p0304[0...n] Rated motor voltage
- p0305[0...n] Rated motor current
- r0395[0...n] Stator resistance current
- p1310[0...n] Voltage boost permanent
- p1311[0...n] Voltage boost at acceleration
- r1315 Voltage boost total

5.3 Slip compensation

Description

Slip compensation is an additional V/f control function. It ensures that the setpoint speed n_{set} of induction motors is maintained at a constant level irrespective of the load (torque M_1 or M_2).

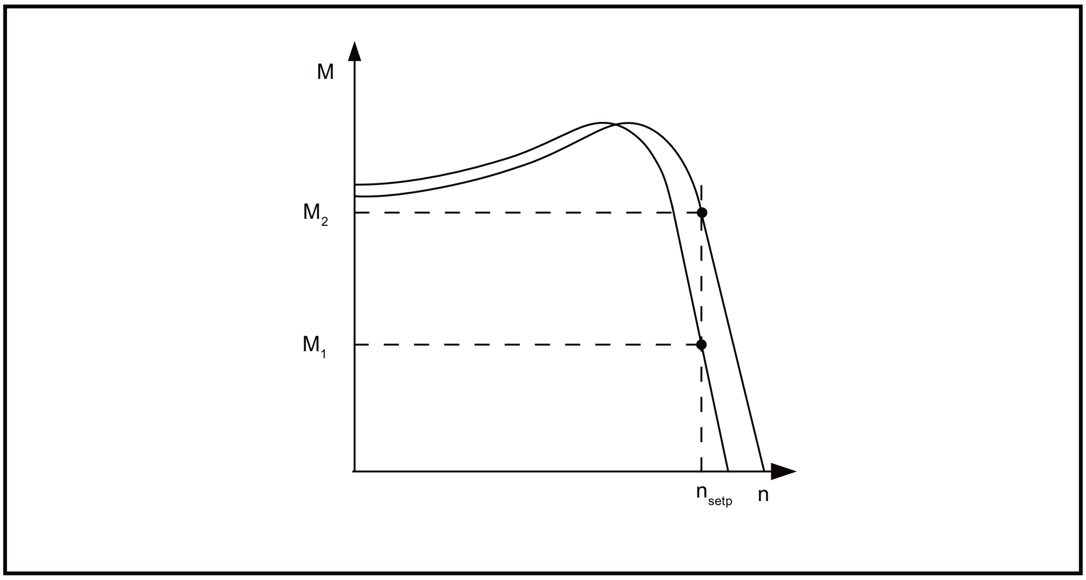


Figure 5-5 Slip compensation

Overview of key parameters (see SINAMICS S List Manual)

- p1335[0...n] Slip compensation
  - p1335 = 0.0 %: slip compensation is deactivated.
  - p1335 = 100.0 %: slip is fully compensated.
- p1336[0...n] Slip compensation limit value
- r1337[0...n] Slip compensation actual value

5.4 Vdc control

Description

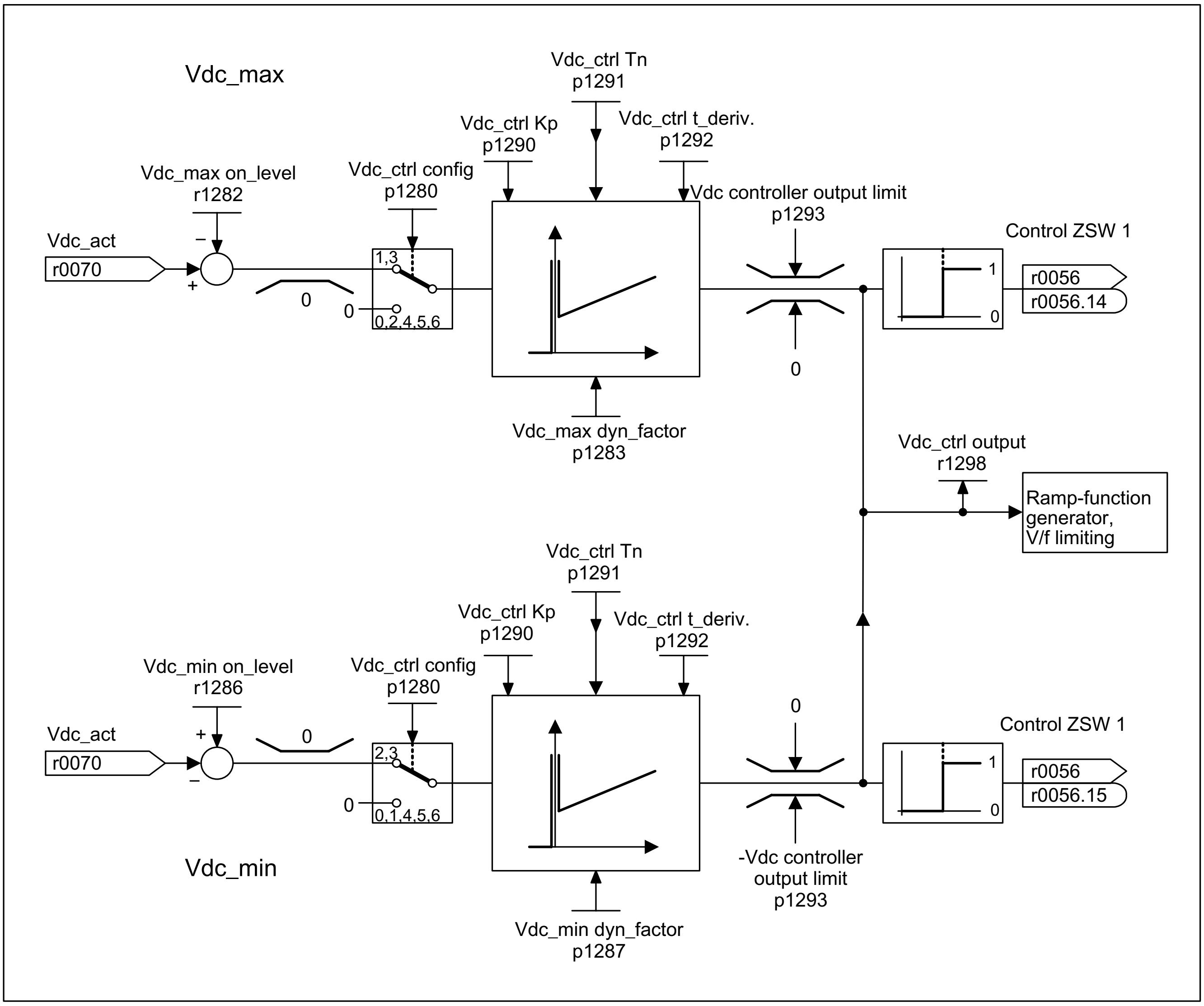


Figure 5-6 Vdc control V/f

The "Vdc control" function can be activated using the appropriate measures if an overvoltage or undervoltage is present in the DC link.

- Overvoltage in the DC link
  - Typical cause

    The drive is operating in regenerative mode and is supplying too much energy to the DC link.
  - Remedy

Reduce the regenerative torque to maintain the DC link voltage within permissible limits.

- Undervoltage in the DC link
  - Typical cause

    Failure of the supply voltage or supply for the DC link.
  - Remedy

    Specify a regenerative torque for the rotating drive to compensate the existing losses, thereby stabilizing the voltage in the DC link (kinetic buffering).

Properties

- Vdc control
  - This comprises Vdc_max control and Vdc_min control (kinetic buffering), which are independent of each other.
  - Joint PI controllers. The dynamic factor is used to set Vdc_min and Vdc_max control to a smoother or harder setting independently of each other.
- Vdc_min control (kinetic buffering)
  - With this function, the kinetic energy of the motor is used for buffering the DC link voltage in the event of a momentary power failure, thereby delaying the drive.
- Vdc_max control
  - This function can be used to control momentary regenerative load without shutdown with “overvoltage in the DC link“.
  - Vdc_max control is only recommended with a supply without active closed-loop control for the DC link and without feedback.

Description of Vdc_min control

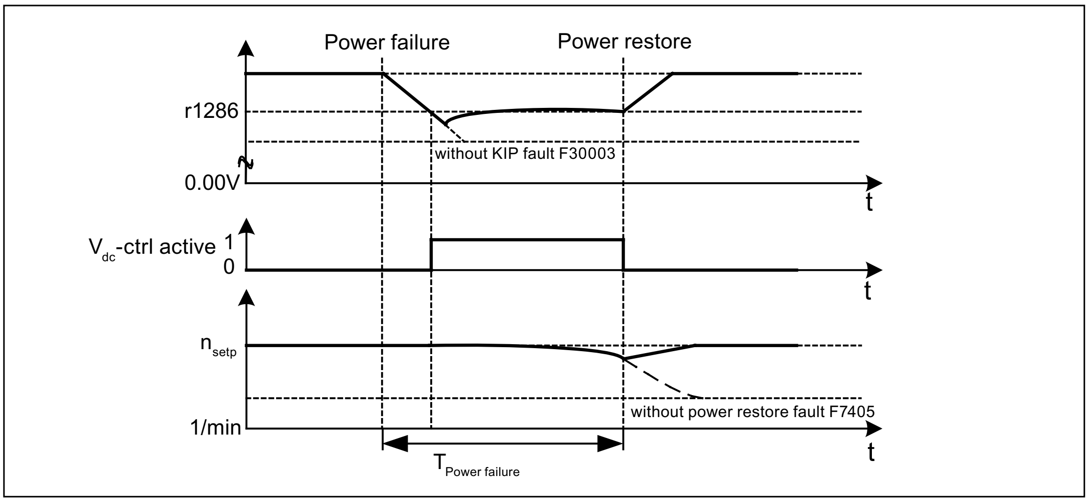


Figure 5-7 Switching Vdc_min control on/off (kinetic buffering)

In the event of a power failure, Vdc_min control is activated when the Vdc_min switch-in level is undershot. This controls the DC link voltage and maintains it at a constant level. The motor speed is reduced.

When the power supply is restored, the DC link voltage increases again and Vdc_min control is deactivated at 5 % above the Vdc_min switch-on level. The motor continues operating normally.

If the power supply is not reestablished, the motor speed continues to drop. When the threshold in p1297 is reached, this results in a response in accordance with p1296.

Once the time threshold (p1295) has elapsed without the line voltage being reestablished, a fault is triggered (F07406), which can be parameterized as required (factory setting: OFF3).

The Vdc_min controller can be activated for a drive. Other drives can participate in supporting the DC link, by transferring a scaling of their speed setpoint from the controlling drive via BICO interconnection.

Note

You must make sure that the converter is not disconnected from the power supply. It could become disconnected, for example, if the line contactor drops out. The line contactor should have an uninterruptible power supply (UPS), for example.

Description of Vdc_max control

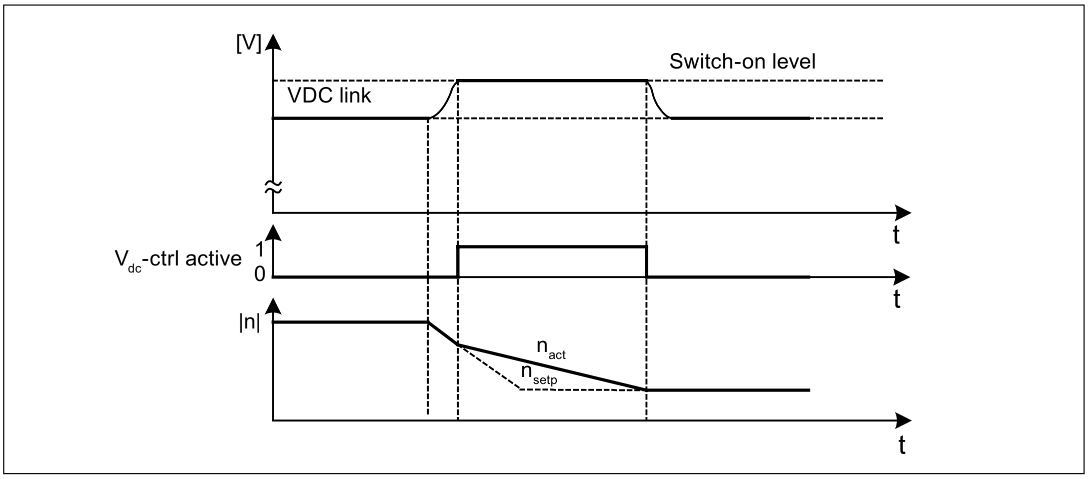


Figure 5-8 Switching Vdc_max control on/off

The switch-in level for Vdc_max control (r1282) is calculated as follows:

- When the function for automatically detecting the switch-on level is switched off (p1294 = 0)
  r1282 = 1.15 * p0210 (device connection voltage, DC link).
- When the function for automatically detecting the switch-on level is switched on (p1294 = 1)
  r1282 = Vdc_max - 50 V (Vdc_max: overvoltage threshold of the Motor Module)

Function diagrams (see SINAMICS S List Manual)

- 6320 Vdc_max controller and Vdc_min controller

Overview of key parameters (see SINAMICS S List Manual)

- p1280[0...n] Vdc controller configuration (V/f)
- r1282 Vdc_max controller switch-in level (V/f)
- p1283[0...n] Vdc_max controller dynamic factor (V/f)
- p1285[0...n] Vdc_min controller switch-in level (kinetic buffering) (V/f)
- r1286 Vdc_min controller switch-in level (kinetic buffering) (V/f)
- p1287[0...n] Vdc_min controller dynamic factor (kinetic buffering) (V/f)
- p1290[0...n] Vdc controller proportional gain (V/f)
- p1291[0...n] Vdc controller integral action time (V/f)
- p1292[0...n] Vdc controller derivative action time (V/f)
- p1293 Vdc controller output limit (V/f)
- p1294 Vdc_max controller automatic detection ON signal level (V/f)
- p1295 Vdc_min controller time threshold (V/f)
- p1296[0...n] Vdc_min controller response (kinetic buffering) (V/f)
- p1297[0...n] Vdc_min controller speed threshold (V/f)
- r1298[0...n] CO: Vdc controller output (V/f)

Basic functions 6

6.1 Changing over units

Description

By changing over the units, parameters and process quantities for input and output can be changed over to an appropriate system of units (US units or as per unit quantities (%)).

The following supplementary conditions apply when changing over units:

- Parameters of the type plate of the drive converter or the motor rating plate can be changed over between SI/US units; however, a per unit representation is not possible.
- After changing over the units parameter, all parameters that are assigned to one of the units group dependent on it, are all changed over to the new system of units.
- A parameter is available to select technological units (p0595) to represent technological quantities in the technology controller.
- If the units are converted to per unit quantities and the reference quantity changed, the percentage value entered in a parameter is not changed.
  Example:
  - A fixed speed of 80% corresponds, for a reference speed of 1500 RPM, to a value of 1200 RPM.
  - If the reference speed is changed to 3000 RPM, then the value of 80% is kept and now means 2400 RPM.

Restrictions

- When a unit changeover occurs, rounding to the decimal places is carried out. This can lead to the original value being changed by up to one decimal place.
- If a referenced form is selected and the reference parameters (e.g. p2000) are changed retrospectively, the referenced values of some of the control parameters are also adjusted to ensure that the control behavior is unaffected.
- If the reference values (p2000 to p2007) are changed offline in STARTER, it can lead to boundary violations of the parameter values, which cause error messages during loading to the drive.

Groups of units

Every parameter that can be changed over is assigned to a units group, that, depending on the group, can be changed over within certain limits.

This assignment and the unit groups can be read for each parameter in the parameter list in the SINAMICS S List Manual.

The unit groups can be individually switched using 4 parameters (p0100, p0349, p0505 and p0595).

Function in STARTER

To call up the function for converting units in STARTER, choose Drive object -> Configuration -> Units. The reference parameters can be found under Drive object -> Configuration -> Reference parameters

Overview of key parameters (see SINAMICS S List Manual)

- p0010 Commissioning parameter filter
- p0100 Motor Standard IEC/NEMA
- p0349 Selecting the system of units, motor equivalent circuit diagram data
- p0505 Selecting the system of units
- p0595 Selecting technological units
- p0596 Reference quantity, technological units
- p2000 CO: Reference frequency/speed
- p2001 CO: Reference voltage
- p2002 CO: Reference current
- p2003 CO: Reference torque
- r2004 CO: Reference power
- p2005 CO: Reference angle
- p2007 CO: Reference acceleration

6.2 Reference parameters/normalizations

Description

Reference values, corresponding to 100%, are required for the statement of units as percentages. These reference values are entered in parameters p2000 to p2007. They are computed during the calculation through p0340 = 1 or in STARTER during drive configuration. After calculation in the drive, these parameters are automatically protected via p0573 = 1 from boundary violation through a new calculation (p0340). This eliminates the need to adjust the references values in a PROFIdrive controller whenever a new calculation of the reference parameters via p0340 takes place.

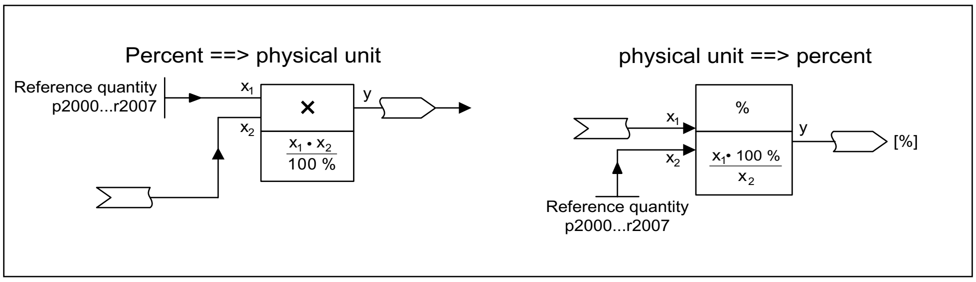


Figure 6-1 Illustration of conversion with reference values

Note

If a referenced form is selected and the reference parameters (e.g. p2000) are changed retrospectively, the referenced values of some of the control parameters are also adjusted to ensure that the control behavior is unaffected.

Using STARTER offline

Following offline drive configuration, the reference parameters are preset; they can be changed and protected under Drive -> Configuration -> "Disabled list" tab.

Note

If the reference values (p2000 to p2007) are changed offline in STARTER, it can lead to boundary violations of the parameter values, which cause error messages during loading to the drive.

Scaling for vector object

Table 6-1 Scaling for vector object

Size	Scaling parameter	Default at initial commissioning
Reference speed	100 % = p2000	p2000 = Maximum speed (p1082)
Reference voltage	100 % = p2001	p2001 = 1000 V
Reference current	100 % = p2002	p2002 = Current limit (p0640)
Reference torque	100 % = p2003	p2003 = 2 * rated motor torque (p0333)
Reference power	100 % = r2004	r2004 = p2003 * p2000 * 2π / 60
Reference angle	100% = p2005	90°
Reference acceleration	100% = p2007	0.01 $1/s^2$
Reference frequency	100 % = p2000/60	-
Reference modulation depth	100 % = Maximum output voltage without overload	-
Reference flux	100 % = Rated motor flux	-
Reference temperature	100% = 100°C	-
Reference electrical angle	100 % = 90°	-

Scaling for servo object

Table 6-2 Scaling for servo object

Size	Scaling parameter	Default at initial commissioning
Reference speed	100 % = p2000	Induction motor p2000 = Maximum motor speed (p0322) Synchronous motor p2000 = Rated motor speed (p0311)
Reference voltage	100 % = p2001	p2001 = 1000 V
Reference current	100 % = p2002	p2002 = Motor limit current (p0338); when p0338 = "0", 2 * rated motor current (p0305)
Reference torque	100 % = p2003	p2003 = p0338 * p0334; when "0", 2 * rated motor torque (p0333)
Reference power	100 % = r2004	r2004 = p2003 * p2000 * π / 30
Reference angle	100% = p2005	90°
Reference acceleration	100% = p2007	0.01 1/s²
Reference frequency	100 % = p2000/60	-
Reference modulation depth	100 % = Maximum output voltage without overload	-
Reference flux	100 % = Rated motor flux	-
Reference temperature	100% = 100°C	-
Reference electrical angle	100 % = 90°	-

Scaling for object A_Inf

Table 6-3 Scaling for object A_Inf

Size	Scaling parameter	Default at initial commissioning
Reference frequency	100 % = p2000	p2000 = p0211
Reference voltage	100 % = p2001	p2001 = r0206/r0207
Reference current	100 % = p2002	p2002 = p0207
Reference power	100 % = r2004	r2004 = p0206
Reference modulation depth	100 % = Maximum output voltage without overload	-
Reference temperature	100% = 100°C	-
Reference electrical angle	100 % = 90°	-

Scaling for object B_Inf

Table 6-4 Scaling for object B_Inf

Size	Scaling parameter	Default at initial commissioning
Reference frequency	100 % = p2000	P2000 = 50
Reference voltage	100 % = p2001	p2001 = r0206/r0207
Reference current	100 % = p2002	p2002 = p0207
Reference power	100 % = r2004	r2004 = p0206

Size	Scaling parameter	Default at initial commissioning
Reference temperature	100% = 100°C	-
Reference electrical angle	100 % = 90°	-

Overview of important parameters (refer to the List Manual)

- p0340 Automatic calculation of motor/control parameters
- p0573 Disable automatic calculation of reference values
- p2000 Reference speed reference frequency
- p2001 Reference voltage
- p2002 Reference current
- p2003 Reference torque
- r2004 Reference power
- p2005 Reference angle
- p2007 Reference acceleration

6.3 Modular machine concept

Description

The modular machine concept is based on a maximum target topology created offline in STARTER. The maximum design of a particular machine type is referred to as the maximum configuration in which all the machine components that may be used are pre-configured in the target topology. Sections of the maximum configuration can be removed by deactivating/removing drive objects (p0105 = 2).

If a component fails, the sub-topology can also be used to allow a machine to continue running until the spare part is available. In this case, however, no BICO sources must be interconnected from this drive object to other drive objects.

Example of a sub-topology

The starting point is a machine created offline in STARTER for which "Drive 1" has not yet been implemented.

- Drive object "Drive 1" must be removed from the target topology via p0105 = 2 in offline mode.
- The DRIVE-CLiQ cable is reconnected from the Control Unit directly to "Drive 2".
- Download the project by choosing "Load to drive object".
- Copy from RAM to ROM.

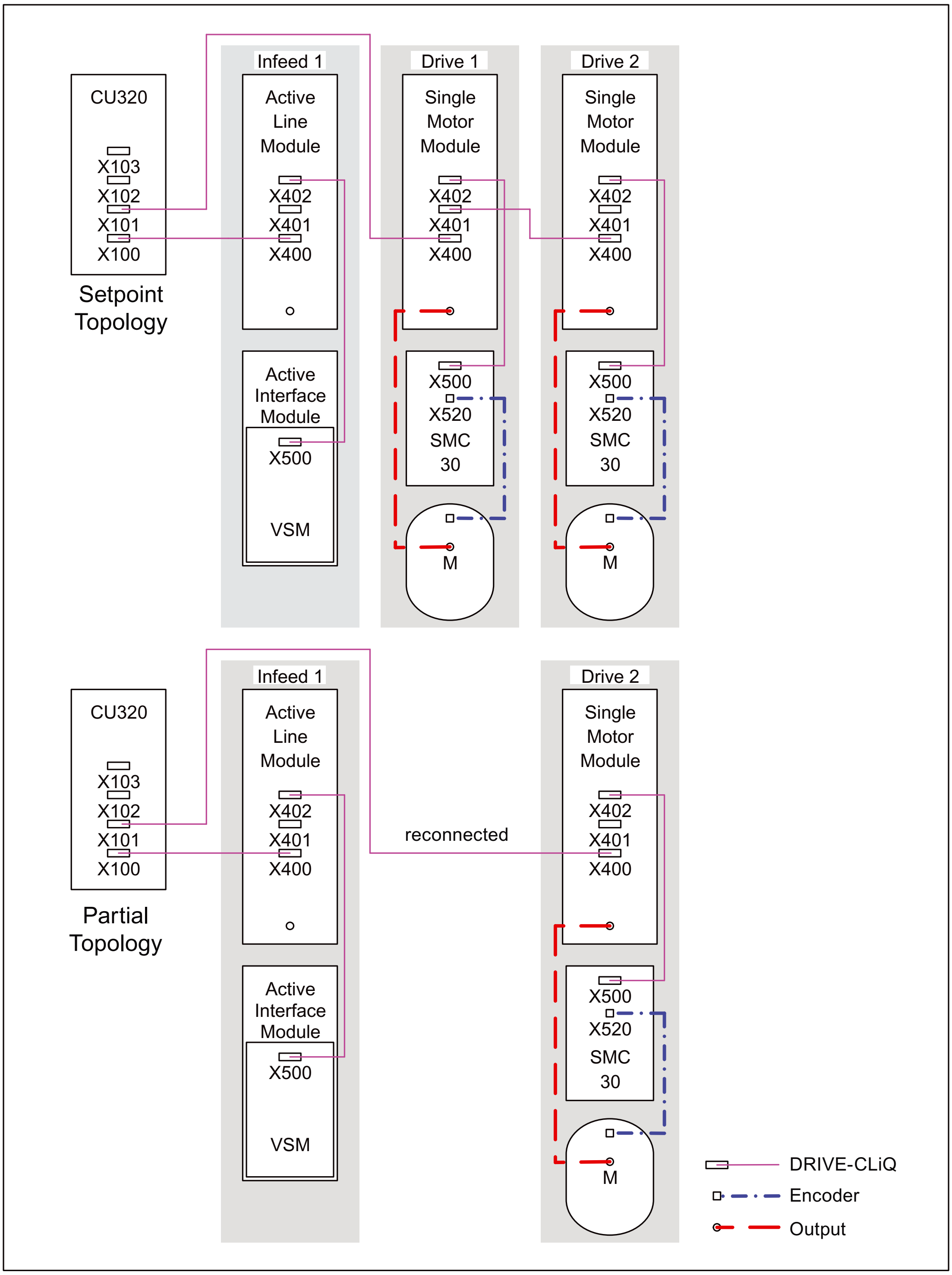


Figure 6-2 Example of a sub-topology

⚠ CAUTION
If a drive in a Safety Integrated line-up is deactivated via p0105, r9774 is not read correctly because the signals from the deactivated drive are no longer updated. Remedy: Remove this drive from the group before you deactivate it. See also: Function Manual (FH1), chapter Safety Integrated

Overview of key parameters (see SINAMICS S List Manual)

- p0105 Activate/deactivate drive object
- r0106 Drive object active/inactive
- p0125 Activate/de-activate power unit component
- r0126 Power unit component active/inactive
- p0145 Activate/deactivate encoder interface
- r0146 Encoder interface active/inactive
- p9495 BICO response to de-activated drive objects
- p9496 Re-establish BICO to the now activated drive objects
- r9498[0 ... 29] BICO BI/CI parameter to de-activated drive objects
- r9499[0 ... 29] BICO BO/CO parameter to de-activated drive objects

6.4 Sinusoidal filter

Description

The sinusoidal filter limits the rate of rise of voltage and the capacitive charge/discharge currents that usually occur with inverter operation. They also prevent additional noise caused by the pulse frequency. The service life of the motor is the same as that with direct line operation.

CAUTION
If a sinusoidal filter is connected to the converter, the converter must be activated during commissioning to prevent the filter from being destroyed.

Usage restrictions for sinusoidal filters

The following restrictions must be taken into account when a sinusoidal filter is used:

- The output frequency is limited to a maximum of 150 Hz.
- The modulation type is permanently set to space vector modulation without overmodulation. This reduces the maximum output voltage to approx. 85 % of the rated output voltage.

- Maximum permissible motor cable lengths:
  - Unshielded cables: max. 150 m
  - Shielded cables: max. 100 m
- Other restrictions: see the Equipment Manual.

Note

If a filter cannot be parameterized (p0230 < 3), this means that a filter has not been provided for the component. In this case, the drive converter must not be operated with a sinusoidal filter.

Table 6-5 Parameter settings for sinusoidal filters

Order no.	Name	Setting
p0233	Power unit motor reactor	Filter inductance
p0234	Power unit sinusoidal filter capacitance	Filter capacitance
p0290	Power unit overload response	Disable pulse frequency reduction
p1082	Maximum rotational speed	Fmax filter/pole pair number
p1800	Pulse frequency	Nominal pulse frequency of the filter
p1802	Modulator modes	Space vector modulation without overmodulation

6.5 dv/dt filter plus VPL

Description

The dv/dt filter plus VPL consists of two components, the dv/dt reactor and the voltage limiting network (**V**oltage **P**eak **L**imiter), which limits voltage peaks and returns the energy to the DC link.

The dv/dt filter plus VPL is to be used for motors for which the voltage strength of the insulation system is unknown or insufficient. Standard motors of the 1LA5, 1LA6 and 1LA8 series only require them at supply voltages > 500 V +10 %.

The dv/dt filter plus VPL limit the rate of voltage rise to values < 500 V/µs and the typical voltage peaks to the values below (with motor cable lengths of < 150 m):

< < 1000 V at Uline < 575 V

< 1250 V with 660 V < Uline < 690 V

⚠ **WARNING**

When a dv/dt filter is used, the maximum pulse frequency of the drive converter is 2.5 kHz (chassis power units up to 250 kW at 400 V) or 4 kHz (chassis power units from 250 kW to 800 kW at 400 V). If a higher pulse frequency is set, then this could destroy the dv/dt filter.

Restrictions

The following restrictions must be taken into account when a dv/dt filter is used:

- The output frequency is limited to a maximum of 150 Hz.
- Maximum permissible motor cable lengths:
  - Shielded cables: max. 300 m
  - Unshielded cables: max. 450 m
- Other restrictions: see the Equipment Manual.

Commissioning

The dv/dt filter must be activated when commissioning the system (p0230 = 2).

6.6 Direction reversal without changing the setpoint

Features

- Not change to the speed setpoint and actual value, the torque setpoint and actual value and the relative position change.
- Only possible when the pulses are inhibited

CAUTION
If direction reversal is configured in the data set configurations (e.g. p1821[0] = 0 and p1821[1] = 1), then when the function module basic positioner or position control is activated, the absolute adjustment is reset each time the system boots or when the direction changes (p2507), as the position reference is lost when the direction reverses.

Description

The direction of rotation of the motor can be reversed using the direction reversal via p1821 without having to change the motor rotating field by interchanging two phases at the motor and having to invert the encoder signals using p0410.

The direction reversal via p1821 can be detected as a result of the motor direction of rotation. The speed setpoint and actual value, torque setpoint and actual value and also the relative position change remain unchanged.

The direction change can be identified as a result of the phase voltage (r0089). When the direction reverses, then the absolute position reference is also lost.

In the vector control mode, in addition, the output direction of rotation of the drive converter can be reversed using p1820. This means that the rotating field can be changed without having to interchange the power connections. If an encoder is being used, the direction of rotation must, when required, be adapted using p0410.

Overview of key parameters (see SINAMICS S List Manual)

- r0069 Phase current, actual value
- r0089 Actual phase voltage
- p1820 Direction of rotation reversal of the output phases (vector)
- p1821 Reversal of direction
- p2507 LR absolute encoder adjustment status

6.7 Automatic restart (vector, servo, infeed)

Description

The automatic restart function is used to automatically restart the drive/drive group when the power is restored after a power failure. In this case, all of the faults present are automatically acknowledged and the drive is powered-up again. This function is not only restricted to line supply faults; it can also be used to automatically acknowledge faults and to restart the motor after any fault trips. In order to allow the drive to be powered-up while the motor shaft is still rotating, the "flying restart" function should be activated using p1200.

CAUTION
Automatic restart functions in the vector, servo mode and for infeeds with closed-loop infeed control. After the line supply voltage is connected, Smart Line Modules 5kW/10kW automatically power themselves up.

⚠ WARNING
If p1210 is set to the value > 1, the Line Modules / motors can start automatically once the line supply has been reestablished. This is especially critical, if, after longer line supply failures, motors come to a standstill (zero speed) and it is incorrectly assumed that they have been powered-down. For this reason, entering the area around the drive when it is in this condition can cause death, serious injury, or considerable material damage.

Automatic restart mode

Table 6-6 Automatic restart mode

p1210	Mode	Meaning
0	Disables automatic restart	Automatic restart inactive
1	Acknowledges all faults without restarting	When p1210 = 1, faults that are present are acknowledged automatically when their cause is rectified. If further faults occur after faults have been acknowledged, then these are also again automatically acknowledged. A minimum time of p1212 + 1s must expire between successful fault acknowledgement and a fault re-occurring if the signal ON/OFF1 (control word 1, bit 0) is at a HIGH signal level. If the ON/OFF1 signal is at a LOW signal level, the time between a successful fault acknowledgement and a new fault must be at least 1s. For p1210 = 1, fault F07320 is not generated if the acknowledge attempt failed (e.g. because the faults occurred too frequently).
4	Automatic restart after line supply failure, no additional start attempts	For p1210 = 4, an automatic restart is only carried out if in addition fault F30003 occurred at the Motor Module or there is a high signal at binector input p1208[1], or in the case of an infeed drive object (x_Infeed) F06200 has occurred. If additional faults are present, then these faults are also acknowledged and when successfully acknowledged, the starting attempt is continued. When the 24 V power supply of the CU fails, this is interrupted as a line supply failure.
6	Restart after any fault with additional start attempts	When p1210 = 6, an automatic restart is carried out after any fault or when p1208[0] = 1. If the faults occur one after the other, then the number of start attempts is defined using p1211. Monitoring over time can be set using p1213.

Starting attempts (p1211) and waiting time (p1212)

p1211 is used to specify the number of starting attempts. The number is internally decremented after each successful fault acknowledgement (line supply voltage must be re-applied or the infeed signals that it is ready. Fault F07320 is signaled if the number of parameterized startup attempts is exceeded.

When p1211 = x, x + 1 starting attempts are made.

Note

A start attempt immediately starts when the fault occurs.

The faults are automatically acknowledged in intervals of half the waiting time p1212.

After successfully acknowledgment and the voltage returns, then the system is automatically powered-up again.

The starting attempt has been successfully completed if the flying restart and the motor magnetization (induction motor) have been completed (r0056.4 = 1) and one additional second has expired. The starting counter is only reset back to the initial value p1211 after this time.

If additional faults occur between successful acknowledgement and the end of the startup attempt, then the startup counter, when it is acknowledged, is also decremented.

Monitoring time line supply return (p1213)

The monitoring time starts when the faults are detected. If the automatic acknowledgements are not successful, the monitoring time runs again. If the drive has not successfully started again after the monitoring time has expired (flying restart and motor magnetization must have been completed: r0056.4 = 1), fault F07320 is output. The monitoring is de-activated with p1213 = 0.

If p1213 is set lower than the sum of p1212, the magnetization time r0346 and the additional delay time due to flying restart, then fault F07320 is generated at each restart. If, for p1210 = 1, the time in p1213 is set lower than p1212, then fault F07320 is also generated at every restart attempt. The monitoring time must be extended if the faults that occur cannot be immediately and successfully acknowledged (e.g. when faults are permanently present).

Commissioning

1. Activating the function for vector and infeed drive object
   - Automatic restart: Set mode (p1210).
   - Flying restart: Activate function (p1200).
2. Set starting attempts (p1211).
3. Set waiting times (p1212, p1213).
4. Check function.

Overview of key parameters (see SINAMICS S List Manual)

- r0863 CO/BO: Drive coupling status word/control word
- p1207 BI: Automatic restart - connection to the following DO
- p1208 BI: Automatic restart - infeed fault
- p1210 Automatic restart, mode
- p1211 Automatic restart, attempts to start
- p1212 Automatic restart, delay time start attempts
- p1213 Automatic restart, waiting time increment

6.8 Armature short-circuit brake, internal voltage protection, DC brake

Features

- For permanent magnet synchronous motors
  - Controlling an external armature short-circuit configuration
  - Controlling an internal armature short-circuit configuration (booksize)
  - Internal voltage protection (booksize)

  Note

  The "internal voltage protection" function can only be used for modules with DAC processor.

  The usable booksize modules are identified by the code A3 at the end of their MLFB, e.g. 6SL3130-6TE21-6A**A3**. The booksize Compact modules are universally usable.

- For induction motors
  - Control of a DC brake (booksize, chassis)
- Configuration via parameter (p1231)
- Status message using a parameter (r1239)

Description

The armature short-circuit, internal voltage protection and DC brake functions cannot be simultaneously activated. The functions are selected individually via parameter p1231.

Armature short-circuit braking is only available for synchronous motors. They are mainly required when braking in a hazardous situation, if controlled braking using the drive converter is no longer possible, e.g. when the power fails, EMERGENCY STOP etc. or if a non-regenerative feedback infeed is used. In this case, the motor stator windings are short-circuited - either internally or via external braking resistors. This means that an additional resistance is inserted in the motor circuit that supports reducing the kinetic energy of the motor.

In order that the drive remains in closed-loop control during voltage dips and failures, a buffered 24 V power supply (UPS) must be used. High-speed permanent-magnet spindle drives for machine tools are a typical application for armature short-circuit braking.

The functions can be initiated with a "1" signal at binector input p1230. Initially, the pulses are canceled and then the armature is short-circuited or the voltage protection. Using r0046.4, the initiation of these functions via p1230 can be checked.

One of the advantages of an internal armature short-circuit brake is the superior response time of only a few ms. The response time of a mechanical brake is about 40 ms. With the external armature short-circuit brake, the slow contactor response causes a response in the range of > 60 ms.

The DC brake is only suitable for induction motors and is comparable with the internal armature short-circuit for synchronous motors. The DC brake works with Motor Modules of both booksize or chassis type.

External armature short-circuit braking

The external armature short-circuit is activated via p1231 = 1 (with contactor feedback signal) or p1231 = 2 (without contactor feedback signal). It is initiated when the pulses are canceled.

This function controls an external contactor via output terminals, which then short-circuits the motor through resistors when the pulses are canceled. Armature short-circuit braking has the advantage with respect to a mechanical brake that at the start of braking (at a high speed), the braking effect is initially high. However, at lower speeds, the braking effect is significantly decreases - this is the reason that we recommend a combination with a mechanical brake.

A prerequisite for the use of the external armature short-circuit is:

- One of the following motor types was parameterized:
  - Rotating permanent-magnet synchronous motor (p0300 = 2xx)
  - Linear permanent-magnet synchronous motor (p0300 = 4xx)

In case of incorrect parameterization (e.g. induction motor and external armature short-circuit selected), an error 7906 "Armature short-circuit / DC brake parameterization error" is generated.

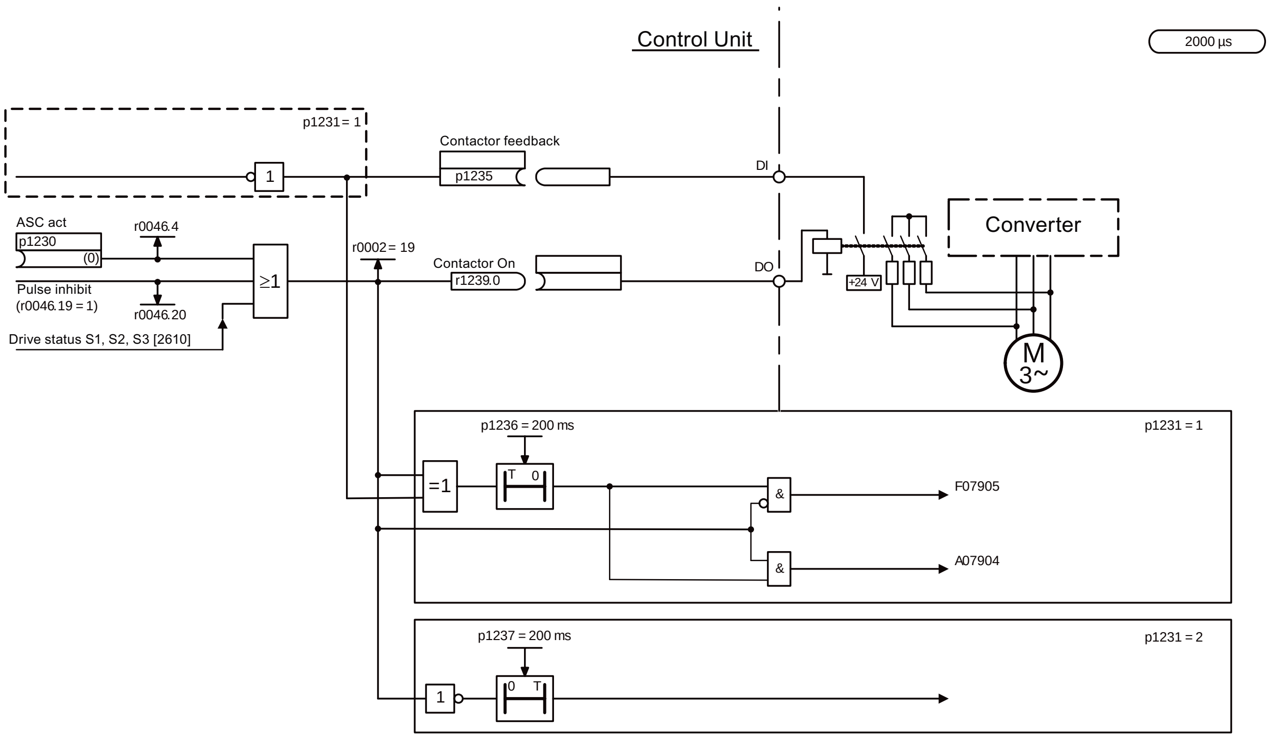


Figure 6-3 External armature short-circuit braking with/without contactor feedback signal

Internal voltage protection (booksize)

The internal voltage protection is activated with p1231 = 3. It is initiated when the pulses are canceled.

The internal voltage protection is used to protect the drive group when the pulses are cancelled. This is realized by short-circuiting a half bridge in the power unit (Motor Module).

This eliminates the necessity for using a VPM (Voltage Protection Module), for 1FE motors e.g. VPM 120 or VPM 200.

When the Motor Module supports the internal voltage protection (r0192.10=1), the Motor Module automatically decides on the basis of the DC link voltage whether the internal armature short-circuit is applied. In this case, the voltage protection is also valid if the DriveCliQ connection between the Control Unit and the Motor Module is interrupted.

A CSM (Control Supply Module) generates a 24 V supply from the DC link for the Motor Module and other components of the drive group. To ensure a stable power supply, the DC link voltage must be maintained within safe limits.

The DC link voltage is monitored in the Motor Module.

If the DC link voltage exceeds 800 V, the internal armature short-circuit is activated. This prevents switch-off of the Motor Module due to internal hardware error detection.

If the DC link voltage drops below 450 V, the internal armature short-circuit is deactivated again. This ensures that the necessary input voltage for the Control Supply Module is maintained.

Note

With the internal voltage protection active, the motor must not be powered by an external source for an extended period of time (e.g. by pulling loads or another coupled motor).

Prerequisites for the use of the internal voltage protection are:

- A Motor Module booksize is being used.
- The power unit current (r0289) must be at least 1.8 times the motor current (p0331).
- One of the following motor types was parameterized:
  - Rotating permanent-magnet synchronous motor (p0300 = 2xx)
  - Linear permanent-magnet synchronous motor (p0300 = 4xx)

Note

An activated internal voltage protection extends the speed range by raising the speed limits (p1082, ..) also for EMF values > 800 V. The original settings are not buffered.

⚠ CAUTION

With the internal voltage protection is active (p1231 = 3), after the pulses have been canceled, all of the motor terminals are at half of the DC link potential (without internal voltage protection the motor terminals have a no voltage condition)!

⚠ DANGER

The voltage protection is not switched-out. Kinetic energy is converted into heat (power loss) in the drive converter and motor. If the power loss is too high or if this operation takes too long, then this can result in thermal overload of the drive.

Note

Deactivation of the voltage protection can always be initiated but will only become effective after POWER ON.

Internal armature short-circuit braking (booksize)/DC brake

The "Internal armature short-circuit braking" function short-circuits a half-bridge in the power unit (Motor Module) to control the motor power consumption, thus braking the motor.

With the "DC brake" function, a DC current is applied after a demagnetization time that brakes the motor or maintains it at standstill.

The two functions can be initiated either as a "normal" operating mode via BI:p1230 (signal = 1) or as a presettable fault response. The function is initiated when the pulses are canceled.

The fault response is assigned the second-highest priority (second only to OFF2).

Before the function is initiated, a check is made as to whether the following conditions are met (otherwise fault F7906 is issued):

- Permanent-magnet synchronous motor (internal armature short-circuit)
  The firmware of the Motor Module supports the internal armature short-circuit (r192.9=1). If the Motor Module firmware does not support the internal armature short-circuit, any activation attempt will generate fault 1303 (DRIVE-CLiQ component does not support requested function) with fault value 101 (Motor Module does not support internal armature short-circuit).
- Induction motor (DC brake)
  The parameters of the DC brake must be carefully assigned (p1232, p1233, p1234).

When the motor type is changed (in p0300), these prerequisities are also checked, which may result in the cancellation of all alarms whose parameters have been changed (p2100 / p2101) and which have this function as a response. In parameter p0491 ("Motor encoder fault response"), the default response OFF2 is entered again if the response "Encoder fault results in internal armature short-circuit brake / DC brake" was previously entered there. Alternatively, all encoder faults 3yxxx, y=1,2,3 as well as F7412 (commutation angle incorrect (motor model)) provide the option of selecting the function as an alternative fault response. The user can also use parameter p0491 to select the function as a fault response for faults of the motor encoder.

The user can use the parameters p2100 and p2101 to set this function as a fault response for individual alarms.

It may be desired to brake the drive without field/rotor orientation even without the occurrence of a fault, e.g. to brake in non-regenerative mode.

NOTICE
Especially in servo control mode without an encoder it is not ensured whether the operation can be continued after the internal armature short-circuit or the DC brake are no longer applied. This applies both to the DC braking (induction motor) and to the internal armature short-circuit (synchronous motor). If the motor cannot continue to run after the end of the internal armature short-circuit or the DC brake, a fault with OFF2 response is issued.

Internal armature short-circuit (synchronous motors)

The internal armature short-circuit is activated via the parameter p1231 = 4. It can be triggered via an input signal p1230 (signal = 1) or a fault response.
Both types of activation are equivalent and are no longer distinguished during the braking operation, in contrast to DC brake (see paragraph "DC brake").

When the internal armature short-circuit protection is activated, the same mechanism as with the internal voltage protection will short-circuit one of the half-bridges in the Motor Module.

After completion of the internal armature short-circuit, it is continued rotor-oriented.

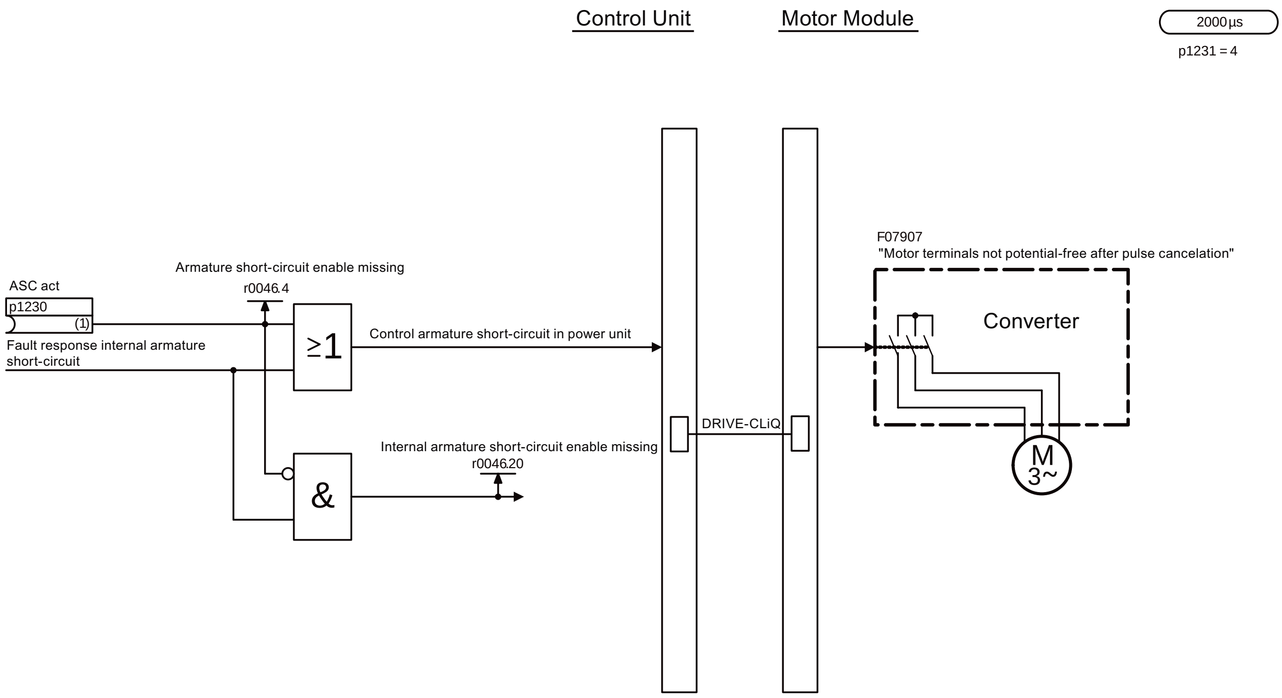


Figure 6-4 Internal armature short-circuit

DC brake (induction motors)

The DC brake is activated via the parameter p1231 = 4. It can be triggered via an input signal p1230 (signal = 1) or a fault response.

Activation of DC brake by BI

If the DC brake is activated by the digital input signal, the first step is that the pulses are blocked for the demagnetization time p0347 of the motor in order to demagnetize the motor - the parameter p1234 "Speed at the start of DC braking" is ignored.

Then the DC brake, braking current p1232 is applied as long as the input is initiated in order to brake the motor or hold it at standstill.

If the DC brake is removed, the drive returns to its selected operating mode.

The following is applicable:

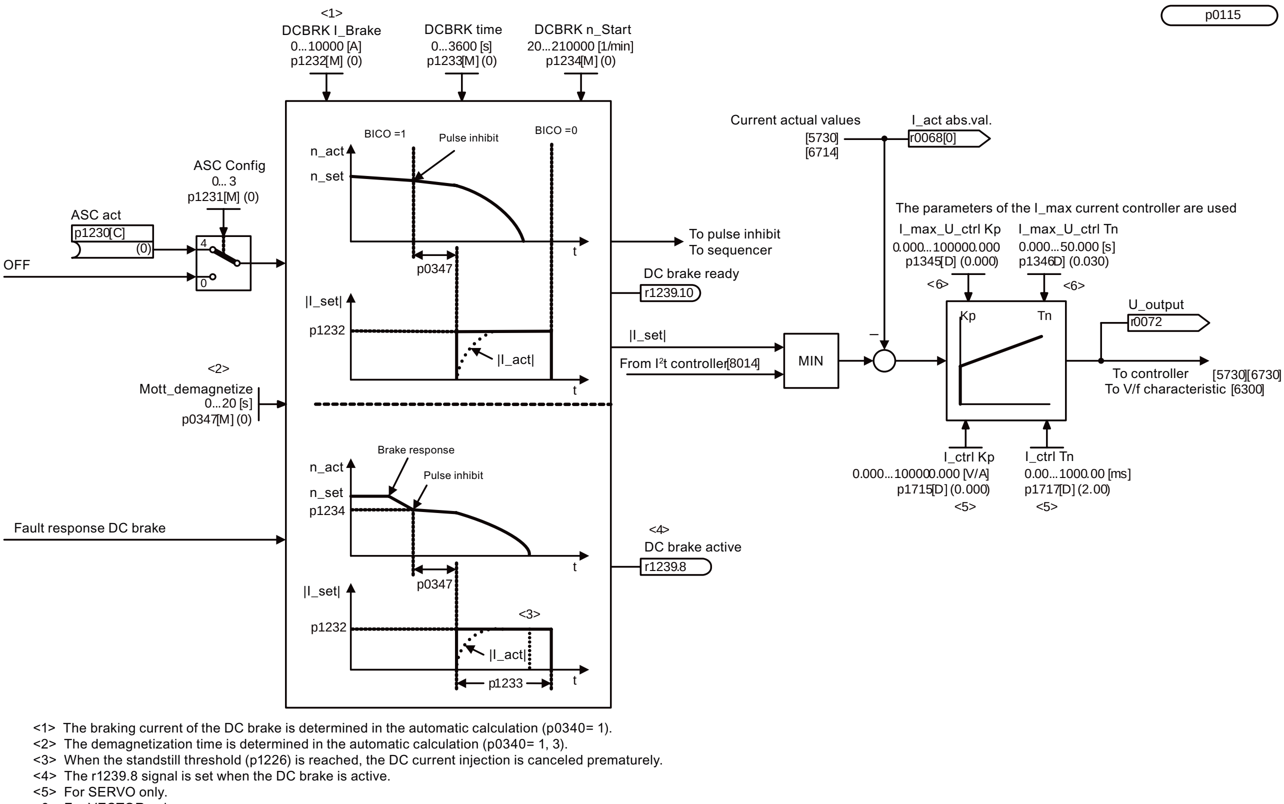
- With servo (controlled with encoder):
  The drive returns to field-oriented control after the demagnetization time has elapsed (p0347 can also be set to 0). Limitations apply in case of extreme field weakening.
- With vector control (controlled with or without encoder):
  The drive is synchronized with the motor frequency if the "Flying restart" function is activated, and

the drive then returns to controlled mode. If the "flying restart" function is not active, the drive can only be restarted from standstill without overcurrent fault.

- In V/f mode:
  With the "flying restart" function activated, the converter frequency is synchronized with the motor frequency, and the drive will then return to V/f mode. If
  the "flying restart" function is not available, the drive can only be restarted from standstill without overcurrent fault.

DC braking as fault response

If the DC brake is activated as a fault response, the motor is initially braked in field-oriented mode along the braking ramp up to the threshold set in p1234. The slope of the ramp is identical with that of the OFF1 ramp (parameterized using p1082, p1121). Subsequently, the pulses are disabled for the motor demagnetizing time p0347 in order to demagnetize the motor. The DC braking will start for the duration set in p1233.
If an encoder is used, braking will continue until the speed falls below the standstill threshold p1226.
If no encoder is used, only the period in p1233 will be applied.



<1> The braking current of the DC brake is determined in the automatic calculation (p0340= 1).
<2> The demagnetization time is determined in the automatic calculation (p0340= 1, 3).
<3> When the standstill threshold (p1226) is reached, the DC current injection is canceled prematurely.
<4> The r1239.8 signal is set when the DC brake is active.
<5> For SERVO only.
<6> For VECTOR only.

Figure 6-5 DC brake

Function diagrams (see SINAMICS S List Manual)

- 7014 External armature short circuit (p0300 = 2xx or 4xx, synchronous motors)
- 7016 Internal armature short circuit (p0300 = 2xx or 4xx, synchronous motors)
- 7017 DC brake (p0300 = 1xx, induction motors)

Overview of key parameters (see SINAMICS S List Manual)

- p1226 Standstill detection, velocity threshold
- p1230[0..n] BI: Armature short-circuit/DC brake activation
- p1231[0..n] Armature short-circuit/DC brake configuration
- p1232[0..n] DC braking, braking current
- p1233[0..n] DC braking time
- p1234[0..n] Speed at the start of DC braking
- p1235[0..n] BI: External armature short-circuit, contactor feedback signal
- p1236[0..n] External armature short-circuit, contactor feedback signal monitoring time
- p1237[0..n] External armature short-circuit, waiting time when opening
- r1238 CO: Armature short-circuit, external state
- r1239.0..10 CO/BO: Armature short-circuit/DC brake status word

6.9 OFF3 torque limits

Description

If the torque limits are externally specified (e.g. tension controller), then the drive can only be stopped with a reduced torque. If stopping in the selected time p3490 of the infeed has not been completed, the infeed shuts down and the drive coasts down.

In order to avoid this, there is a binector input (p1551), that for a LOW signal, activates the torque limits p1520 and p1521. This means that the drive can brake with the maximum torque by interconnecting the signal OFF 3 (r0899.5) to this binector.

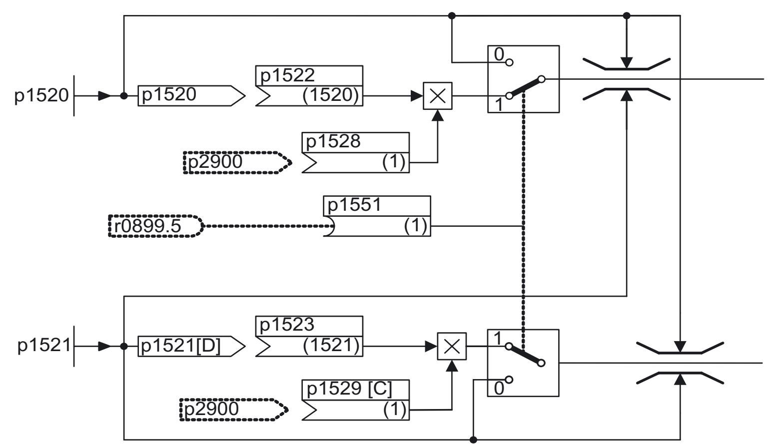


Figure 6-6 Torque limits OFF3

Function diagrams (see SINAMICS S List Manual)

- 5620 Motor/generator torque limits
- 5630 Upper/lower torque limit
- 6630 Upper/lower torque limit

Overview of key parameters (see SINAMICS S List Manual)

- p1520 Torque limit, upper/motoring
- p1521 Torque limit, lower/regenerative

6.10 Technology function: friction characteristic

Description

The friction characteristic curve is used to compensate the friction torque for the motor and the driven machine. A friction characteristic enables the speed controller to be pre-controlled and improves the response.

10 interpolation points are used for each friction characteristic curve. The coordinates of an interpolation point are described by a speed (p382x) and a torque parameter (p383x) (interpolation point 1 = p3820 and p3830).

Features

- 10 interpolation points are available for mapping the friction characteristic curve.
- An automatic function allows you to record the friction characteristic curve (record friction characteristic curve).
- A connector output (r3841) can be applied as friction torque (p1569).
- The friction characteristic can be activated and deactivated (p3842).

Function diagrams (see SINAMICS S List Manual)

- 5610 Torque limiting/reduction/interpolator
- 6710 Current setpoint filters
- 7010 Friction characteristic curve

Overview of key parameters (see SINAMICS S List Manual)

- p3820 Friction characteristic curve value n0
- ...
- p3839 Friction characteristic curve value M9
- r3840 CO/BO: Friction characteristic curve status
- r3841 CO: Friction characteristic curve output
- p3842 Friction characteristic curve activation
- p3845 Friction characteristic curve record activation

Commissioning via parameters

In p382x, speeds for the measurement are predefined as a function of the maximum speed p1082 during initial commissioning. They can be changed appropriately.

The automatic friction characteristic plot can be activated using p3845. The characteristic is then plotted the next time that it is enabled.

The following settings are possible:

- p3845 = 0 Friction characteristic curve recording deactivated

- p3845 = 1 Friction characteristic curve recording activated, all directions of rotation

  The friction characteristic curve is recorded in both directions of rotation. The results of the positive and negative measurement are averaged and entered in p383x.
- p3845 = 2 Friction characteristic curve recording activated, positive direction of rotation
- p3845 = 3 Friction characteristic curve recording activated, negative direction of rotation

> ⚠ **DANGER**
>
> When the friction characteristic is plotted, the drive can cause the motor to move. As a result, the motor may reach maximum speed.
>
> The emergency STOP functions must be fully operational during commissioning. To protect the machines and personnel, the relevant safety regulations must be observed.

Commissioning via STARTER

In STARTER, the friction characteristic curve can be started up via the dialog under "Functions".

6.11 Simple brake control

6.11.1 Features

- Automatic activation by means of sequence control
- Standstill (zero-speed) monitoring
- Forced brake release (p0855, p1215)
- Close the brake for a 1 signal "unconditionally close holding brake" (p0858)
- Application of brake after "Enable speed controller" signal has been removed (p0856)

6.11.2 Description

The "Simple brake control" is used exclusively for the control of holding brakes. The holding brake is used to secure drives against unwanted motion when deactivated.

The trigger command for releasing and applying the holding brake is transmitted via DRIVE-CLiQ from the Control Unit, which monitors and logically connects the signals to the system-internal processes, directly to the Motor Module.

The Motor Module then performs the action and activates the output for the holding brake. The exact execution control is shown in the SINAMICS S List Manual (FD 2701). The operating principle of the holding brake can be configured via parameter p1215.

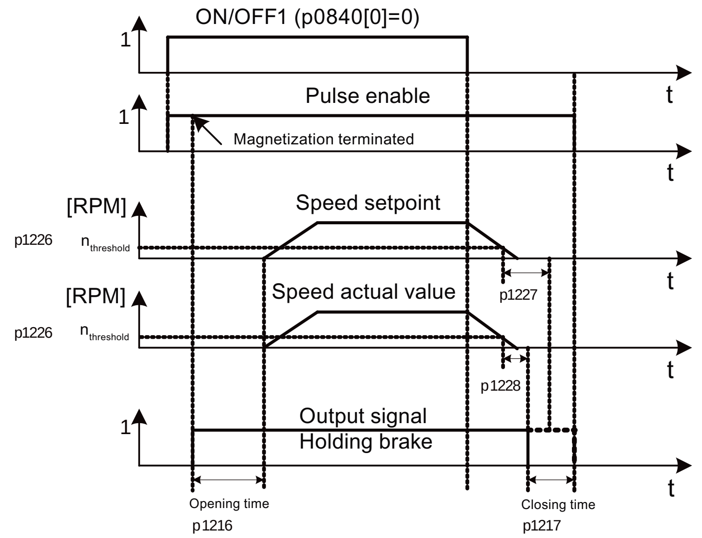


Figure 6-7 Function chart: simple brake control

The start of the closing time for the brake depends on the expiration of the shorter of the two times p1227 (Pulse cancellation, delay time) and p1228 (Zero speed detection monitoring time)

⚠ WARNING
The holding brake must not be used as a service brake. When holding brakes are used, the special technological and machine-specific conditions and standards for ensuring personnel and machine safety must be observed. The risks involved with vertical axes, for example, must also be taken into account.

6.11.3 Commissioning

Simple brake control will be activated automatically (p1215 = 1) when the Motor Module has an internal brake control and a connected brake has been found.

If no internal brake control is available, the control can be activated using a parameter (p1215 = 3).

CAUTION
If p1215 = 0 (no brake available) is set when a brake is present, the drive runs with applied brake. The can destroy the brake.

CAUTION
Brake control monitoring must only be activated for Booksize power units and Blocksize power units with Safe Brake Relay (p1278 = 0).

6.11.4 Integration

The simple brake control function is integrated in the system as follows.

Function diagrams (see SINAMICS S List Manual)

- 2701 Simple brake control (r0108.14 = 0)

Overview of key parameters (see SINAMICS S List Manual)

- r0056.4 Magnetizing complete
- r0060 CO: Speed setpoint before the setpoint filter
- r0063 CO: Actual speed smoothed (servo)
- r0063[0] CO: Actual speed, unsmoothed (vector)
- r0108.14 Extended brake control
- p0855[C] BI: Unconditionally release holding brake
- p0856 BI: Enable speed controller
- p0858 BI: Unconditionally close the holding brake
- r0899.12 BO: Holding brake open
- r0899.13 BO: Command, close holding brake
- p1215 motor holding brake configuration
- p1216 Holding brake release time
- p1217 Holding brake application time
- p1226 Threshold for zero speed detection
- p1227 Zero speed detection monitoring time
- p1228 Zero speed detection, delay time
- p1278 Deactivate monitoring of brake control

6.12 Runtime (operating hours counter)

Total system runtime

The total system runtime is displayed in p2114 (Control Unit). Index 0 indicates the system runtime in milliseconds after reaching 86.400.000 ms (24 hours), the value is reset. Index 1 indicates the system runtime in days.

At power-off the counter value is saved.

After the drive unit is powered-up, the counter continues to run with the value that was saved the last time that the drive unit was powered-down.

Relative system runtime

The relative system runtime after the last POWER ON is displayed in p0969 (Control Unit). The value is in milliseconds and the counter overflows after 49 days.

Actual motor operating hours

The motor operating hours counter p0650 (drive) is started when the pulses are enabled. When the pulse enable is withdrawn, the counter is stopped and the value saved.

The values can only be stored with a CU320 with order number 6SL3040-....-0AA1 and version C or higher.

If p0651 is at 0, the counter is de-activated.

If the maintenance interval set in p0651 is reached, fault F01590 is triggered. Once the motor has been maintained, the maintenance interval must be reset.

CAUTION
If the motor data set is switched during the star/delta switchover without the motor being changed, the two values in p0650 must be added to determine the correct number of motor operating hours.

Operating hours counter for the fan

The operating hours of the fan in the power unit are displayed in p0251 (drive).

The number of hours operated can only be reset to 0 in this parameter (e.g. after a fan has been replaced). The service life of the fan is entered in p0252 (drive). Alarm A30042 is output 500 hours before this figure is reached. Monitoring is deactivated when p0252 = 0.

6.13 Parking axis and parking sensor

6.13.1 Description

The parking function is used in two ways:

- "Parking sensor"
  - Monitoring of a certain encoder is suppressed.
  - The encoder is prepared for the "removed" state.
- "Parking axis"
  - Monitoring of all encoders and Motor Modules assigned to the "Motor control" application of a drive are suppressed.
  - All encoders assigned to the "Motor control" application of a drive are prepared for the "removed" state.
  - The Motor Module that is assigned the application "Motor control" of drive is prepared for the state "removed Motor Module".

Parking a sensor

When a sensor is parked, the sensor being addressed is switched to inactive (r0146 = 0).

- Control is carried out via the sensor control/status words of the cyclic telegram (Gn_STW.14 and Gn_ZSW.14).
- With a parked motor measuring system, the associated drive must be brought to a standstill by the higher-level control system (disable pulses e.g. via CTW1.0/OFF1).
- The monitoring functions for the power unit remain active (r0126 = 1).

Parking an axis

When an axis is parked, the power unit and all the sensors assigned to the "motor control" are switched to inactive (r0146[n] = 0).

- Control is carried out via the control/status words of the cyclic telegram (STW2.7 and ZSW2.7) or using parameters p0897 and r0896.0.
- The drive must be brought to a standstill by the higher-level controller (disable pulses e.g. via STW1.0/OFF1).
- DRIVE-CLiQ communication to downstream components via the deactivated power unit (r0126 = 0) remains active.
- A measuring system that is not assigned to the "motor control" (e.g. direct measuring system) remains active (r0146[n] = 1).
- The drive object remains active (r0106 = 1).

Note

Once the "Parking axis" / "Parking encoder" status has been canceled, you may have to carry out the following actions:

If the motor encoder has been replaced: determine the commutation angle offset (p1990).

A new encoder must be referenced again (e.g. to determine the machine zero point).

6.13.2 Example: parking axis and parking sensor

Example: parking axis

In the following example, an axis is parked. To ensure that the axis parking is effective, the drive must be brought to a standstill (e.g. via CTW1.0 (OFF1). All components assigned to the motor control (e.g. power unit and motor encoder) are shut down.

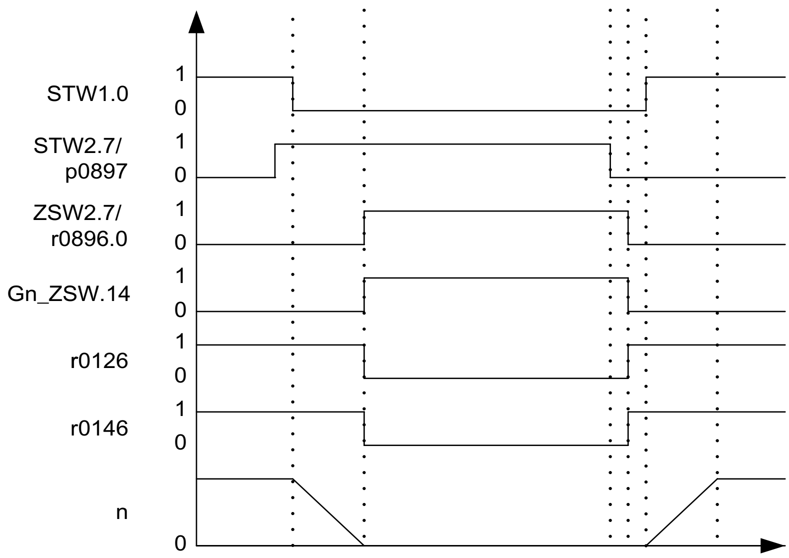


Figure 6-8 Function chart: parking axis

Example: parking sensor

In the following example, a motor sensor is parked. To ensure that the motor sensor parking is effective, the drive must be brought to a standstill (e.g. via CTW1.0 (OFF1).

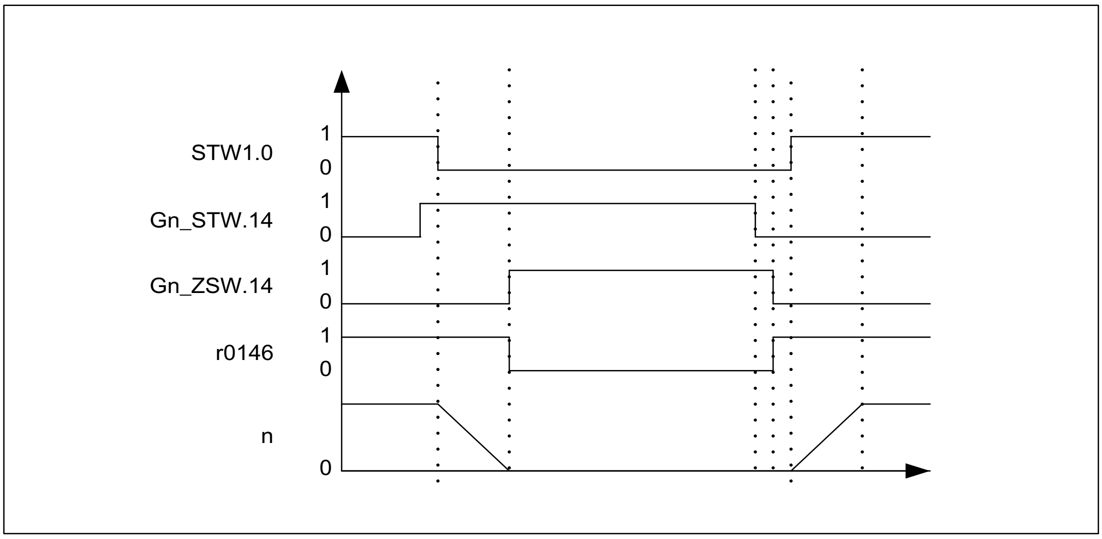


Figure 6-9 Function chart: parking sensor

6.13.3 Overview: key parameters

Note

For a description of the parameters, see the SINAMICS S List Manual.

- p0105 Activate/deactivate drive object
- r0106 Drive object active/inactive
- p0125 Activate power unit component
- r0126 Power unit component active
- p0145 Activate/deactivate encoder interface
- r0146 Encoder interface active/inactive
- r0896.0 Parking axis active
- p0895 BI: Activate/deactivate power unit component
- p0897 BI: Parking axis selection

6.14 Position tracking

6.14.1 General Information

Terminology

- Encoder range

  The encoder range is the position area that can itself represent the absolute encoder.
- Singleturn encoder

  A singleturn encoder is a rotating absolute encoder, which provides an absolute image of the position inside an encoder rotation.
- Multiturn encoder

  A multiturn encoder is an absolute encoder that provides an absolute image of several encoder revolutions (e.g. 4096 revolutions).

Description

Position tracking enables reproduction of the position of the load when gears are used. It can also be used to extend the position area.

With position tracking, an additional measuring gear can be monitored and also a load gear, if the "position control" function module (p0108.3 = 1) is active. Position tracking of the load gear is described under "Function modules" -> "Position control" -> Actual position value conditioning.

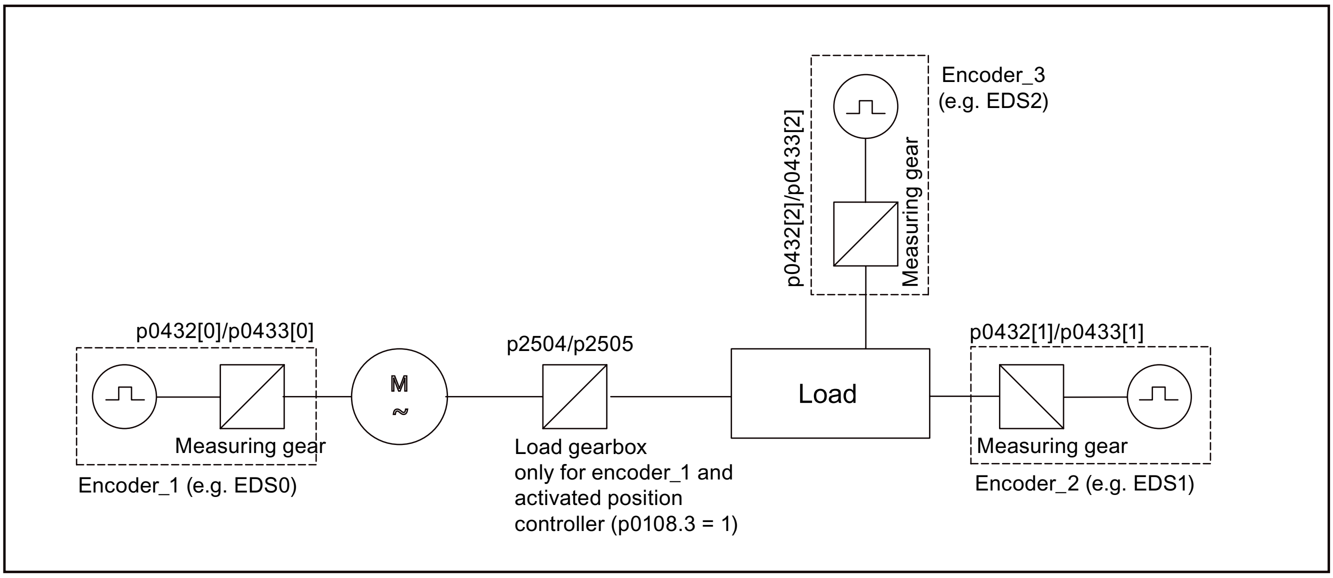


Figure 6-10 Overview of gears and encoders

The encoder position actual value in r0483 (must be requested via GnSTW.13) is limited to 2^{32} places. When position tracking (p0411.0 = 0) is switched off, the encoder position actual value r0483 comprises the following position information:

- Encoder pulses per revolution (p0408)
- Fine resolution per revolution (p0419)
- Number of resolvable revolutions of the rotary absolute encoder (p0421), this value is fixed at "1" for singleturn encoders.

When position tracking (p0411.0 = 1) is activated, the encoder position actual value r0483 is composed as follows:

- Encoder pulses per revolution (p0408)
- Fine resolution per revolution (p0419)
- Virtual number of resolvable motor revolutions of a rotary absolute encoder (p0412)

  If the measuring gear is absent (n=1), the actual number of the stored revolutions of a rotary absolute encoder p0421 is used. The position area can be extended by increasing this value.

  If the measuring gear is available, this value equals the number of resolvable motor revolutions, which is stored in r0483.
- The gear ratio (p0433/p0432)

6.14.2 Measuring gear

6.14.2.1 Features

Measuring gear characteristics

- Configuration via p0411
- Virtual multiturn via p0412
- Tolerance window for monitoring the position at switching on p0413
- Input of the measuring gear via p0432 and p0433
- Display via r0483

6.14.2.2 Description

If a mechanical gearbox (measuring gearbox) is located between an endlessly rotating motor/load and the encoder and position control is to be carried out using this absolute encoder, an offset occurs (depending on the gearbox ratio) between the zero position of the encoder and the motor/load whenever encoder overflow occurs.

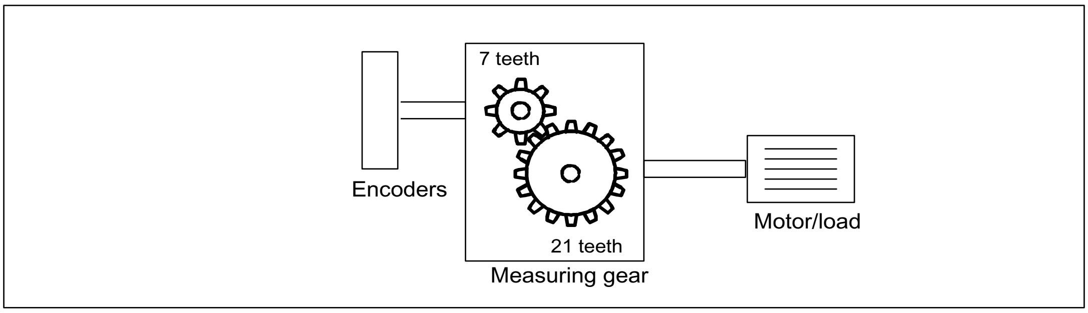


Figure 6-11 Measuring gearbox

In order to determine the position at the motor/load, in addition to the position actual value of the absolute encoder, it is also necessary to have the number of overflows of the absolute encoder.

If the power supply of the control module must be powered-down, then the number of overflows must be saved in a non-volatile memory so that after powering-up the position of the load can be uniquely and clearly determined.

Example: Gear ratio 1:3 (motor revolutions p0433 to encoder revolutions p0432), absolute encoder can count 8 encoder revolutions (p0421 = 8).

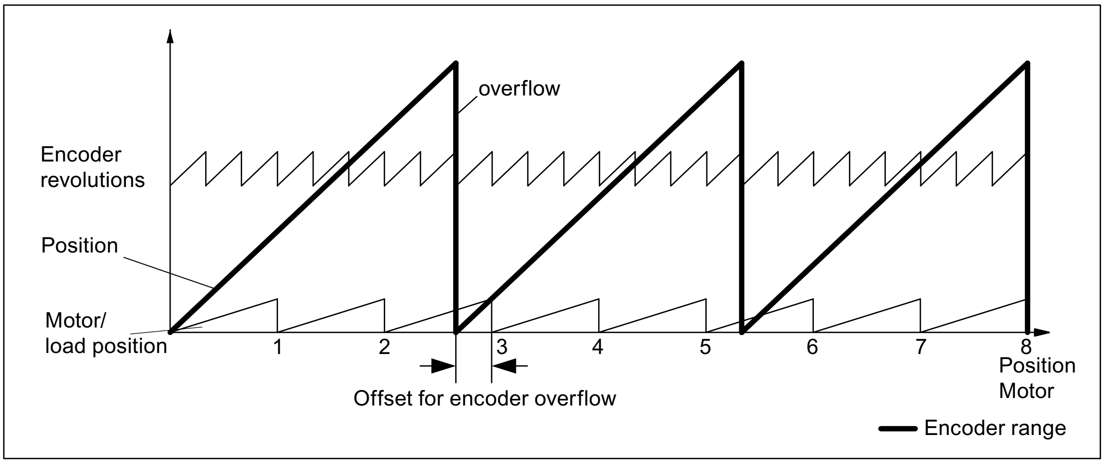


Figure 6-12 Drive with odd-numbered gears without position tracking

In this case, for each encoder overflow, there is a load-side offset of 1/3 of a load revolution, after 3 encoder overflows, the motor and load zero position coincide again. The position of the load can no longer be clearly reproduced after one encoder overflow.

If position tracking is activated via p0411.0 = 1, the gear ratio (p0433/p0432) is calculated with the encoder position actual value (r0483).

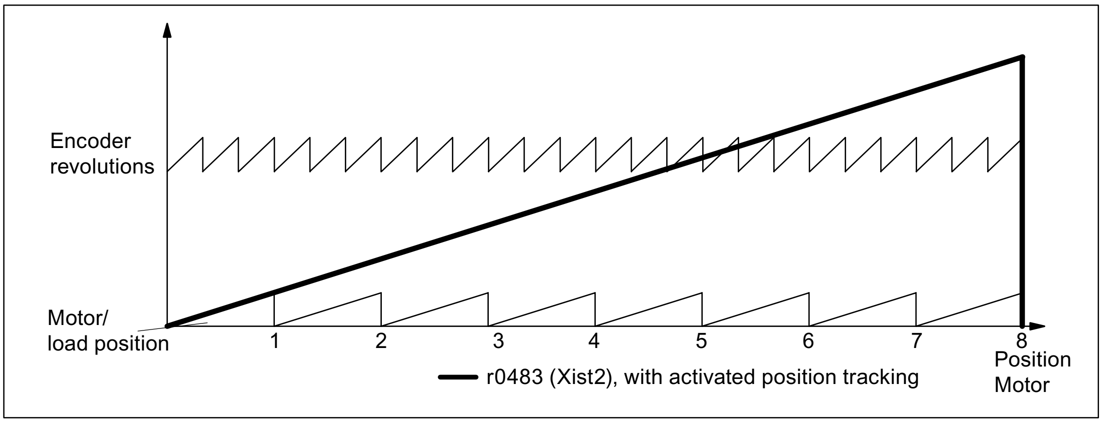


Figure 6-13 Odd-numbered gears with position tracking (p0412 = 8)

Measuring gearbox configuration (p0411)

The following points can be set by configuring this parameter:

- p0411.0: Activation of position tracking
- p0411.1: Setting the axis type (linear axis or rotary axis)

  Here, a rotary axis refers to a modulo axis (modulo offset can be activated through higher-level control or EPOS). With a linear axis, position tracking is mainly used to extend the position area (see section: Virtual multiturn encoder (p0412)).
- p0411.2: Reset position

  Overflows can be reset with this. This is required, for example, the encoder is turned by more than 1/2 the encoder range while switched off.

Virtual multiturn encoder (p0412)

With a rotary absolute encoder (p0404.1 = 1) with activated position tracking (p0411.0 = 1), p0412 can be used to enter a virtual multiturn resolution. This enables you to generate a virtual multiturn encoder value (r0483) from a singleturn encoder. It must be possible to display the virtual encoder range via r0483.

NOTICE
If the gear factor is not equal to 1, then p0412 always refers to the motor side. The virtual resolution, which is required for the motor, is then used here.

For rotary axes with modulo offset, the virtual multiturn resolution (p0412) is preset as p0421 and can be changed.

For linear axes, the virtual multiturn resolution (p0412) is preset as p0421 and extended by 6 bits for multiturn information (max. overflows 31 positive/negative)

If, as a result of extension of the multiturn information, the displayable area of r0483 (2^{32} bit) is exceeded, the fine resolution (p0419) must be reduced accordingly.

Tolerance window (p0413)

After switching on, the difference between the stored position and the actual position is ascertained and, depending on the result, the following is triggered:

Difference within the tolerance window -> the position is reproduced based on the current actual encoder value.

Difference outside the tolerance window -> An appropriate message (F7449) is output.

The tolerance window is preset to quarter of the encoder range and can be changed.

NOTICE
The position can only be reproduced if, in the powered-down state, the encoder was moved through less than half of the range that it can represent. For the standard EQN1325 encoder, this is 2048 revolutions or half a revolution for singleturn encoders.

Note

The ratio stamped on the gearbox type plate is often just a rounded-off value (e.g.1:7.34). If, for a rotary axis, it is not permissible to have any long-term drift, then the actual ratio of the gearbox teeth must be requested from the gearbox manufacturer.

Note regarding using synchronous motors with a measuring gearbox

Field-oriented control of synchronous motors requires a clear reference between the pole position and encoder position. This reference must also be carefully maintained when using measuring gearboxes: This is the reason that the ratio between the pole pair number and the encoder revolutions must be an integer multiple ≥ 1 (e.g. pole pair number 17, measuring gearbox 4.25, ratio = 4).

Commissioning

The position tracking of the measuring gearbox can be activated in the drive wizard (STARTER) during the configuration of the drive. During the configuration there is an item for encoder parameterization. In the encoder dialog, click on the "Details" button and activate the checkbox for position tracking in the displayed dialog.

The parameters p412 (Measuring gearbox, rotary absolute encoder, revolutions, virtual) and p413 (Mesasuring gearbox, position tracking tolerance window) can only be set via the expert list.

6.14.2.3 Prerequisites

- Absolute encoder
- Firmware release ≥ 2.4
- CU310 or CU320 with Order No. 6SL3040- ....- 0AA1 and Version C or higher

6.14.2.4 Integration

The "position tracking/measuring gearbox" function is integrated in the system as follows.

Function diagrams (see SINAMICS S List Manual)

- 4704 Position and temperature sensing, encoders 1 ... 3

Overview of key parameters (see SINAMICS S List Manual)

- p0402 Gearbox type selection
- p0411 Measuring gearbox configuration
- p0412 Measuring gearbox absolute encoder rotary revolutions virtual
- p0413 Measuring gearbox position tracking, tolerance window
- p0421 Absolute encoder rotary multiturn resolution
- p0432 gear factor encoder revolutions
- p0433 gear factor motor/load revolutions
- r0477 CO: Measuring gearbox, position difference
- r0485 CO: Measuring gearbox, raw encoder value, incremental
- r0486 CO: Measuring gearbox, raw encoder value, absolute

6.15 Terminal Module 41 (TM41)

Features

- General
  - Pulse encoder emulation, TTL signals (RS422)
  - Max. encoder output frequency 256 kHz (e.g. 1500 RPM at 8192 pulses)
  - 1 analog input
  - 4 digital inputs
  - 4 bidirectional digital inputs/outputs
  - Automatic adjustment of the sampling time for encoder emulation 4099[3]
- Pulse encoder emulation by presetting of a speed value (p4400 = 0)
  - PROFIdrive telegram 3
  - Own control word (r0898)
  - Own status word (r0899)
  - Sequence control (refer to function diagram 9682)
  - Settable pulse number (p0408)
  - Enable zero marks (p4401.0)

- Settable zero mark position (p4426)
- Operating display (r0002)

- Pulse encoder emulation by presetting of an encoder position actual value (p4400 = 1)
  - Deadtime compensation (p4421)
  - Settable pulse number (p0408) (range 1000 to 8192 pulses)
  - Settable fine resolution (p0418) (2 to 18 bits)
  - Enable zero marks (p4401.0)
  - Apply r479 (Diagnostics encoder position actual value, SERVO/VECTOR) to input P4420 (Incremental encoder emulation encoder position actual value). Parameter r482 must not be applied for encoder emulation.
  - No gear ratio between the encoder to be emulated and the associated TM41 is supported.
  - The pulse number and fine resolution setting of the TM41 must match that of the encoder so that the zero marks of TM41 and encoder are synchronized.
  - Only one Encoder Data Set (EDS) can be applied to exactly one TM41.
    If the same EDS is applied to another TM41, it is possible to emulate only the position actual value but not the zero mark position.
  - A TM41 cannot emulate the zero mark position and the position actual value of another TM41.
  - When an absolute encoder is emulated, the TM41 can only emulate the encoder actual position of the absolute encoder. In this case, the zero mark on the TM41 is output once per encoder revolution of the TM41. The zero mark does not correspond to the zero position of the absolute encoder but will have a different position at each POWER ON. It can only be used to detect a movement of the absolute encoder. If required, the output of the zero mark can be disabled via p4401.0=0.
  - Resolvers are not supported
  - The TM41 can only emulate a single zero mark of an incremental encoder. The search for the first zero mark requires at least one full encoder revolution. The detected zero mark is then output during the subsequent encoder revolution on the TM41.

General description

The TM41 outputs incremental encoder signals (TTL). The signals can be generated using a speed value via a process data word (p4400 = 0) or using an encoder position actual value of a drive (p4400 = 1). The incremental encoder signal can, for example, be evaluated by a control or other drives. One analog input, 4 digital inputs and 4 bidirectional digital inputs/outputs are available. The can, for example, be used to enter an analog speed setpoint and transfer control and status signals - e.g. OFF1/ON, ready or fault.

Example: Description (p4400 = 0) incremental encoder emulation using a speed setpoint

A speed setpoint is received via PROFIdrive telegram 3 (r2060), which is interconnected to p1155. The speed setpoint can be filtered using a (p1414.0) PT2 element (p1417 and p1418) and delayed with a deadtime (p1412). The number of encoder pulses per revolution can be set using parameter p0408. The distance between the zero marks and the position when enabling the A/B tracks (r4402.1) can be entered into parameter p4426 and enabled with p4401.0.

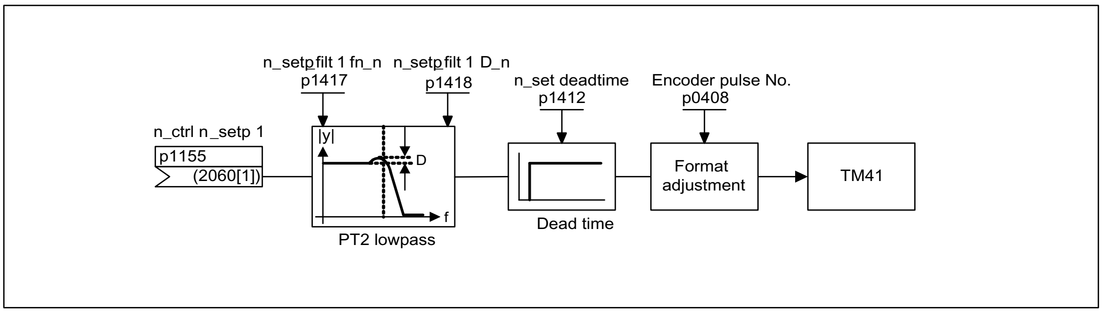


Figure 6-14 Block diagram of the incremental encoder emulation

Description (p4400 = 1) incremental encoder emulation using encoder position actual value

The encoder position actual value of a drive (r0479) is interconnected to the TM41 via a connector input (p4420) and is therefore available at the TM41 as pulse encoder emulation. The signals of the pulse encoder emulation can, for example, be read-in from one control. In this way, it is possible, for example, to implement the position controller in a higher-level control without PROFIBUS and to assign the speed setpoint to the drive via the analog output of the control and the analog input of the TM41 (see example TM41). The number of encoder pulses per revolution (p0408) and the fine interpolation (p0418) must be set the same as the drive.

The runtime of the encoder position actual value up to the pulse encoder emulation can be compensated using the deadtime compensation with p4421. If p4422 = 1, input signal p4420 is inverted.

The sampling time for encoder emulation (p4099[3]) is automatically adjusted to the application cycle of the connected encoder (connector input p4420) if the factory setting of p4099[3] does not match the application cycle. The adjustment is made after initial POWER ON and following the logical application (connector input p4420) of the encoder. The error message F35228 indicates that the value p4099[3] has been changed.
The message can be acknowledged immediately. The new sampling time is active after saving (RAM to ROM) and a POWER ON.

Hardware requirements:

- The TM41 shall operate on a DRIVE-CLiQ line that is separated from the Motor Modules. The communication cycle of the DRIVE-CLiQ line must match the application cycle of the associated encoder.
- If multiple TM41s operate on the same DRIVE-CLiQ line, the sampling times p4099[3] must be identical for all TM41s. In this case, the emulated encoders must have the same application cycle.

Example: Commissioning the incremental encoder emulation using the encoder position actual value (p4400 = 1)

Encoder signals from the motor encoder are to be output from the SERVO drive object via TM41.

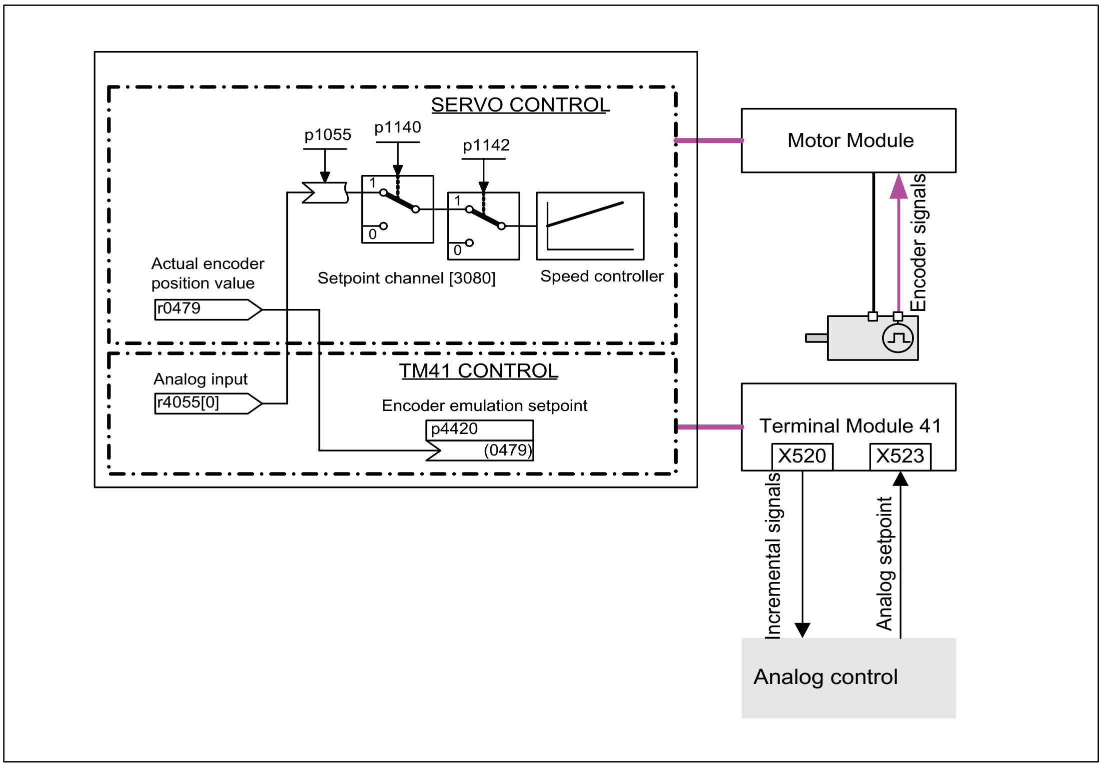


Figure 6-15 Example, TM41

Commissioning steps

Input of parameter values via STARTER dialog or expert list:

- p4400 = 1 (encoder emulation by means of encoder position actual value)
- p4420 = r0479[n] (SERVO or VECTOR), n = 0 ..2
- p0010 = 4 (encoder commissioning TM41)
- p0408 = pulse number of the motor encoder from SERVO/VECTOR
- p0418 = fine resolution of the motor encoder from SERVO/VECTOR
- p0010 = 0 (complete encoder commissioning TM41)

Other sequences:

1. An error message appears (F35228). This indicates that the sampling time for encoder emulation has been adjusted automatically.
2. Copy from RAM to ROM
3. POWER ON reset (also acknowledges error message)

Prerequisites

- Firmware release 2.4
- Terminal Module 41 (TM41)

Function diagrams (see SINAMICS S List Manual)

- 9660 Digital inputs, electrically isolated (DI 0 ... DI 3)
- 9661 Digital inputs/outputs, bi-directional (DI/DO 0 and DI/DO 1)
- 9662 Digital inputs/outputs, bi-directional (DI/DO 2 and DI/DO 3)
- 9663 Analog input (AI 0)
- 9674 Incremental encoder emulation (p4400 = 0)
- 9676 Incremental encoder emulation (p4400 = 1)
- 9678 Control word sequence control
- 9680 Execution control status word
- 9682 Processor

Overview of key parameters (see SINAMICS S List Manual)

General

- r0002 TM41 operating display
- p0408 Rotary encoder pulse No.
- p0418 Fine resolution Gx_XIST1 (in bits)
- p4400 TM41 incremental encoder emulation mode
- p4401 TM41 incremental encoder emulation mode
- p4402 CO/BO: TM41 incremental encoder emulation, status
- p4099 TM41 inputs/outputs, sampling time

Incremental encoder emulation using a speed setpoint (p4400 = 0)

- p0840 BI: ON/OFF1
- r0898 CO/BO: Control word sequence control
- r0899 CO/BO: Status word sequence control
- p1155 CI: Incremental encoder emulation speed setpoint 1
- p4426 Incremental encoder emulation, pulses for zero mark

Incremental encoder emulation using a position setpoint (p4400 = 1)

- p4420 CI: TM41 incremental encoder emulation encoder position actual value
- p4421 TM41 Incremental encoder emulation deadtime compensation compensation
- p4422 TM41 position actual value inversion

6.16 Updating the firmware

The software must be updated if extended functions are made available in a more recent version and these functions are to be used.

The software for the SINAMICS drive system is distributed in the system. Firmware is installed on each individual DRIVE-CLiQ component and the Control Unit.

The Control Unit receives its software automatically from the CF card during startup, which means that it does not need to be updated separately; you simply have to exchange the CF card with a new one containing the latest software version.

When the firmware is updated, the software is saved in a non-volatile manner in the DRIVE-CLiQ component. The firmware of the DRIVE-CLiQ components is also on the CF card and, by means of the factory setting p7826 = 1, it is automatically copied to the DRIVE-CLiQ components when the CF card is first installed (from FW 2.5).

After project download or automatic configuration, a firmware update is started on all connected DRIVE-CLiQ components. This upgrades all DRIVE-CLiQ components to the firmware release that matches the CF card.

This may take a few minutes, and is indicated by the green/red flashing of the READY-LED of the relevant component and by the orange blinking (0.5 Hz) of the Control Unit.

Parameter p7827 indicates the progress.

When all updates have run, the READY-LED of the Control Unit flashes orange at 2 Hz and the READY-LED of the relevant component flashes green/red at 2 Hz. For the firmware to be activated, a POWER ON must be carried out for the components.

For individual components, STARTER dialogs (drive unit -> configuration -> version overview) can serve to read out the firmware version or to start the firmware update for individual components manually.

Note

The versions of the DRIVE-CLiQ components and that of the Control Unit can differ. An overview of the versions is provided on the CF card in the file "content.txt" or can be read out via the parameter r7825.

6.16.1 Upgrading firmware and the project in STARTER

To ensure that the project functions, you need a CompactFlash card containing the new firmware and a current version of STARTER.

Upgrade the project

1. Is the project in STARTER? Yes: continue with 3.
2. Upload project with STARTER.
   – Connect with target system (go online)
   – Downloading the project into the PG
3. Install the latest firmware version for the project.
   – in the project navigator, right-click the drive unit -> Target -> Device version
   – e.g. select version "SINAMICS S120 V2.5x" -> Change version

Update the firmware and load the new project to the target device.

1. Insert CompactFlash Card with the new firmware version.
   – Disconnect the Control Unit from the power supply ->
   – Insert the CF card with the new firmware version ->
   – Power-up the Control Unit again.
2. Go online and download the project to the target device -> Copy from RAM to ROM
3. The firmware upgrade for the DRIVE-CLiQ components will occur automatically from FW 2.5.
4. Reset the drive unit using a POWER ON (Control Unit and all DRIVE-CLiQ components). The new firmware release is only effective in the DRIVE-CLiQ components now and is also displayed in the version overview.

Function modules 7

7.1 Function modules - Definition and commissioning

Description

A function module is a functional expansion of a drive object that can be activated during commissioning.

Examples of function modules:

- Technology controller
- Setpoint channel for SERVO drive object
- Parallel connection of Motor Modules or Line Modules
- Extended brake control
- Linear motor

A function module generally has separate parameters and, in some cases, separate faults and warnings too. These parameters and messages are only displayed when the function module is active. An active function module also generally requires additional processing time, which must be taken into account during configuration.

Commissioning with STARTER

In the commissioning screen forms of STARTER, you can either directly or indirectly activate the function modules (e.g. technology controller direct, linear motor indirect by selecting a linear motor).

Commissioning via parameter (only with BOP20)

The function modules can be activated/de-activated using parameter p0108 of the Control Unit (CU). The indices of parameters r0107, p0108 and p0124 represent the different drive object types; these are displayed in r0107 (CU) after the device has been configured. The READY LED of the main component of the drive object (e.g. Motor Module, TM31) can be made to flash using parameter p0124 (CU).

Overview of key parameters (see SINAMICS S List Manual)

- r0107 Drive object type
- p0108 Drive objects, function module
- p0124 Identifying the main components using LEDs

7.2 Technology controller

7.2.1 Description

The technology controller is designed as a PID controller, whereby the differentiator can be switched to the control deviation channel or the actual value channel (factory setting). The P, I, and D components can be set separately. A value of 0 deactivates the corresponding component. Setpoints can be specified via two connector inputs. The setpoints can be scaled via parameters (p2255 and p2256). A ramp-function generator in the setpoint channel can be used to set the setpoint ramp-up/ramp-down time via parameters p2257 and p2258. The setpoint and actual value channel each have a smoothing element. The smoothing time can be set via parameters p2261 and p2265.

The setpoints can be specified via separate fixed setpoints (p2201 to p2215), the motorized potentiometer, or via the field bus (e.g. PROFIBUS).

Pre-control can be integrated via a connector input.

The output can be scaled via parameter p2295 and the control direction reversed. It can be limited via parameters p2291 and p2292 and interconnected as required via a connector output (r2294).

The actual value can be integrated, for example, via an analog input on the TB30.

If a PID controller has to be used for control reasons, the D component is switched to the setpoint/actual value difference (p2263 = 1) unlike in the factory setting. This is always necessary when the D component is to be effective, even if the reference variable changes. The D component can only be activated when p2274 > 0.

7.2.2 Features

Simple control functions can be implemented with the technology controller, e.g.:

- Level control
- Temperature control
- Dancer position control
- Pressure control
- Flow control
- Simple closed-loop control without higher-level controller
- Tension control

The technology controller features:

- Two scalable setpoints
- Scalable output signal
- Separate fixed values
- Separate motorized potentiometer
- The output limits can be activated and deactivated via the ramp-function generator.

- The D component can be switched to the control deviation or actual value channel.
- The motorized potentiometer of the technology controller is only active when the drive pulses are enabled.

7.2.3 Commissioning with STARTER

The "technology controller" function module can be activated via the commissioning Wizard or the drive configuration (configure DDS).

You can check the actual configuration in parameter r0108.16.

7.2.4 Examples

Fill level control

The objective here is to maintain a constant level in the container.

This is carried out by means of a variable-speed pump in conjunction with a sensor for measuring the level.

The level is determined via an analog input (e.g. AI0 on TB30) and sent to the technology controller. The level setpoint is defined in a fixed setpoint. The resulting controlled variable is used as the setpoint for the speed controller.

In this example, terminal board 30 (TB30) is used.

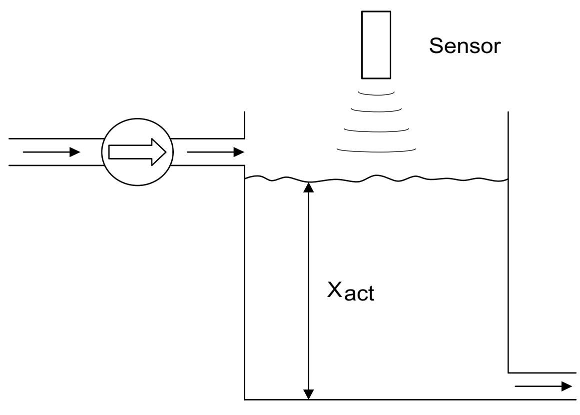


Figure 7-1 Liquid level control: application

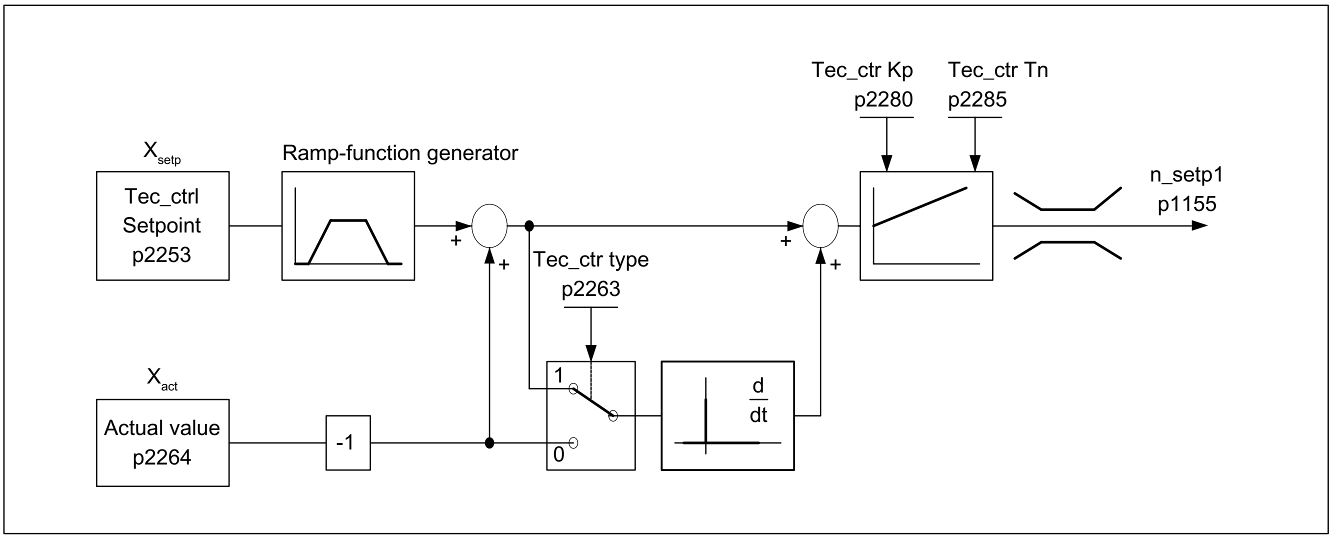


Figure 7-2 Fill level control: controller structure

Table 7-1 Key parameters for the level control

Parameter	Designation	Example
p1155	n_setp1 downstream of RFG	p1155 = r2294 Tec_ctrl output_sig [FP 3080]
p2200	BI: Technology controller enable	p2200 = 1 Technology controller enabled
p2253	CI: Technology controller setpoint 1	p2253 = r2224 Fixed setpoint active [FP 7950]
p2263	Technology controller type	p2263 = 1 D component in fault signal [FP 7958]
p2264	CI: Technology controller actual value (X_{ACTUAL})	p2264 = r4055 [1] Analog input AI1 of TB30
p2280	Technology controller p-gain	p2280 Determine by optimization
p2285	Technology controller integral action time	p2285 Determine by optimization

7.2.5 Integration

The technology controller function is integrated in the system as follows.

Function diagrams (see SINAMICS S List Manual)

- 7950 Fixed values (r0108.16 = 1)
- 7954 Motorized potentiometer (r0108.16 = 1)
- 7958 Closed-loop control (r0108.16 = 1)

Overview of key parameters (see SINAMICS S List Manual)

Fixed setpoints

- p2201[0..n] CO: Technology controller, fixed value 1

- ...
- p2215[0..n] CO: Technology controller, fixed value 15
- p2220[0..n] BI: Technology controller fixed value selection bit 0
- p2221[0..n] BI: Technology controller fixed value selection bit 1
- p2222[0..n] BI: Technology controller fixed value selection bit 2
- p2223[0..n] BI: Technology controller fixed value selection bit 3

Motorized potentiometer

- p2230[0..n] Technology controller motorized potentiometer configuration
- p2235[0..n] BI: Technology controller motorized potentiometer, raise setpoint
- p2236[0..n] BI: Technology controller motorized potentiometer, lower setpoint
- p2237[0..n] Technology controller motorized potentiometer maximum value
- p2238[0..n] Technology controller motorized potentiometer minimum value
- p2240[0..n] Technology controller motorized potentiometer start value
- r2245 CO: Technology controller motorized potentiometer setpoint before RFG
- p2247[0..n] Technology controller motorized potentiometer ramp-up time
- p2248[0..n] Technology controller motorized potentiometer ramp-down time
- r2250 CO: Technology controller motorized potentiometer setpoint after RFG

Closed-loop control

- p2200 BI: Technology controller enable
- p2253[0..n] CI: Technology controller setpoint 1
- p2254 [0..n] CI: Technology controller setpoint 2
- p2255 Technology controller setpoint 1 scaling
- p2256 Technology controller setpoint 2 scaling
- p2257 Technology controller ramp-up time
- p2258 Technology controller ramp-down time
- p2261 Technology controller setpoint filter time constant
- p2263 Technology controller type
- p2264[0..n] CI: Technology controller actual value
- p2265 Technology controller actual value filter time constant
- p2280 Technology controller proportional gain
- p2285 Technology controller integral action time
- p2289[0..n] CI: Technology controller pre-control signal
- p2295 Technology controller output scaling

7.3 Extended monitoring functions

7.3.1 Features

When the extension is activated, the monitoring functions are extended as follows:

- Speed setpoint monitoring: |n_setp| ≤ p2161
- Speed setpoint monitoring: n_set > 0
- Load monitoring

Description of load monitoring

This function monitors power transmission between the motor and the working machine. Typical applications include V-belts, flat belts, or chains that loop around the belt pulleys or cog wheels for drive and outgoing shafts and transfer the peripheral speeds and forces. Load monitoring can be used here to identify blockages in the working machine and interruptions to the power transmission.

During load monitoring, the current speed/torque curve is compared with the programmed speed/torque curve (p2182 to p2190). If the current value is outside the programmed tolerance bandwidth, a fault or alarm is triggered depending on parameter p2181. The fault or alarm message can be delayed by means of parameter p2192 to prevent false alarms caused by brief transitional states.

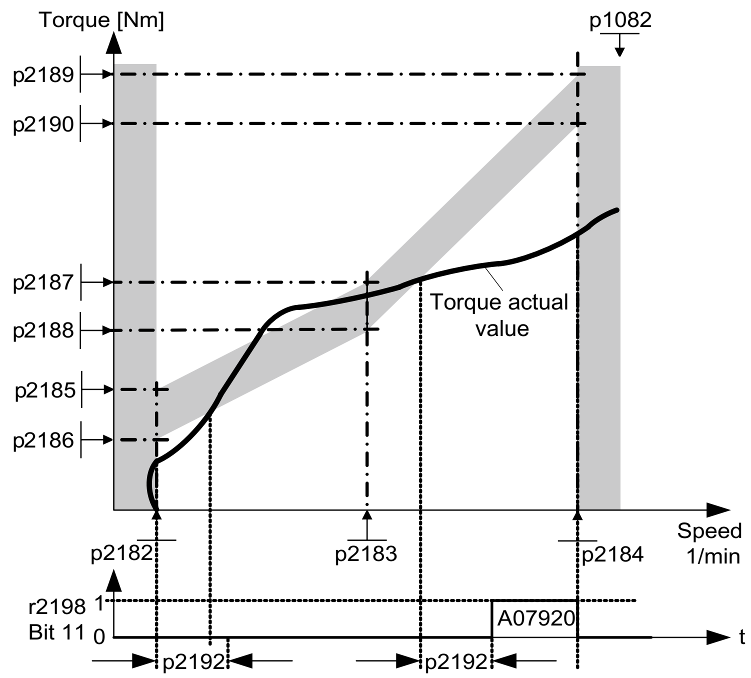


Figure 7-3 Load monitoring

7.3.2 Commissioning

The extended monitoring functions are activated while the commissioning Wizard is running. Parameter r0108.17 indicates whether it has been activated.

7.3.3 Integration

The extended monitoring functions are integrated as follows in the system.

Function diagrams (see SINAMICS S List Manual)

- 8010 Speed messages
- 8013 Load monitoring

Overview of key parameters (see SINAMICS S List Manual)

Load monitoring

- p2181[D] Load monitoring response
- p2182[D] Load monitoring speed threshold 1
- p2183[D] Load monitoring speed threshold 2
- p2184[D] Load monitoring speed threshold 3
- p2185[D] Load torque monitoring torque threshold 1 upper
- ...
- p2190[D] Load torque monitoring torque threshold 3 lower
- p2192[D] Load monitoring delay time

Speed setpoint monitoring

- p2150[D] Hysteresis speed 3
- p2151[C] CI: Speed setpoint
- p2161[D] Speed threshold value 3
- r2198.4 BO: ZSW monitoring 2, |n_setp| ≤ p2161
- r2198.5 BO: ZSW monitoring 2, n_setp < 0

7.4 Extended brake control

7.4.1 Features

The extended brake control function has the following features:

- Forced brake release (p0855, p1215)
- Close the brake for a 1 signal "unconditionally close holding brake" (p0858)
- Binector inputs for releasing/applying the brake (p1218, p1219)
- Connector input for threshold value for releasing/applying the brake (p1220)
- OR/AND block, each with two inputs (p1279, r1229.10, p1229.11)
- Holding and operational brakes can be activated.
- Function for monitoring brake feedback signals (r1229.4, r1229.5)
- Configurable responses (A7931, A7932)
- Application of brake after "Enable speed controller" signal has been removed (p0856)

7.4.2 Description

The "Extended brake control" function allows complex braking control for motor holding brakes and operational brakes.

The brake is controlled as follows (the sequence reflects the priority):

- Via parameter p1215
- Via binectors p1219[0..3] and p0855
- Via zero speed detection
- Via a connector interconnection threshold value

For an AC drive with "Safe Brake Relay," the "Safe Brake Control" safety function requires that the type of the brake control must be set, in parameter p1278, to "Brake control with diagnostic evaluation" (p1278 = 0). This parameter is automatically set for booksize components.

7.4.3 Commissioning

The extended brake control function can be activated while the commissioning Wizard is running. Parameter r0108.14 indicates whether the function module has been activated.

Unless you change the default settings, the extended brake control function behaves in exactly the same way as the simple brake control function.

Brake control will be activated automatically (p1215 = 1) when the Motor Module has an internal brake control and a connected brake has been found.

If no internal brake control is available, the control can be activated using a parameter (p1215 = 3).

When braking with a feedback signal (p1222), the inverted signal must be connected to the BICO input for the second (p1223) feedback signal. The response times of the brakes can be set in p1216 and p1217.

Note

If p1215 = 0 (no brake available) is set when a brake is present, the drive runs with applied brake. The can destroy the brake.

CAUTION
Brake control monitoring must only be activated for Booksize power units and Blocksize power units with Safe Brake Relay (p1278 = 0).

7.4.4 Examples

Starting against applied brake

When the device is switched on, the setpoint is enabled immediately (if other enable signals are issued), even if the brake has not yet been released (p1152 = 1). The factory setting p1152 = r0899.15 must be disconnected here. The drive first generates torque against the applied brake. The brake is not released until the motor torque or motor current (p1220) has exceeded braking threshold 1 (p1221).

This configuration is used, for example, when the drive is connected to a belt that is under tension (loop accumulator in the steel industry).

Emergency brake

If emergency braking is required, electrical and mechanical braking is to take place simultaneously. This can be achieved if OFF3 is used as a tripping signal for emergency braking:
p1219[0] = r0898.2 (OFF3 to "apply brake immediately").

The OFF3 ramp (p1135) should be set to 0 seconds so that the converter does not work against the brakes. Regenerative energy may accumulate, and this must be either fed back into the supply system or converted into heat using a braking resistor.

This is often used, for example, in calendar stacks, cutting tools, running gears, and presses.

Operating brake for crane drives

For cranes with a manual control, it is important that the drive immediately response when the control lever is moved (master switch). The drive is powered-up using the on command (p0840) (the pulses are enabled). Speed setpoint (p1142) and speed controller (p0856) are inhibited. The motor is magnetized. The magnetization time generally applicable for three-phase motors (1-2 seconds) is therefore eliminated.

Now, there is only the brake opening time that is applicable as delay between moving the master switch and the motor rotating. If the master switch is moved (deflected), then there is a "setpoint enable from the control" (bit interconnected with p1142, p1229.2, p1224.0). The speed controller is immediately enabled - the speed setpoint is enabled after the brake opening time (p1216). When the master switch is in the zero position, the speed setpoint is inhibited - the drive is ramp-down using the ramp function generator. The brake closes once the standstill limit (p1226) has been fallen below. After the brake closing time (p1217), the speed controller is inhibited (the motor is no longer generating any force). The extended brake control is used with the modifications described below.

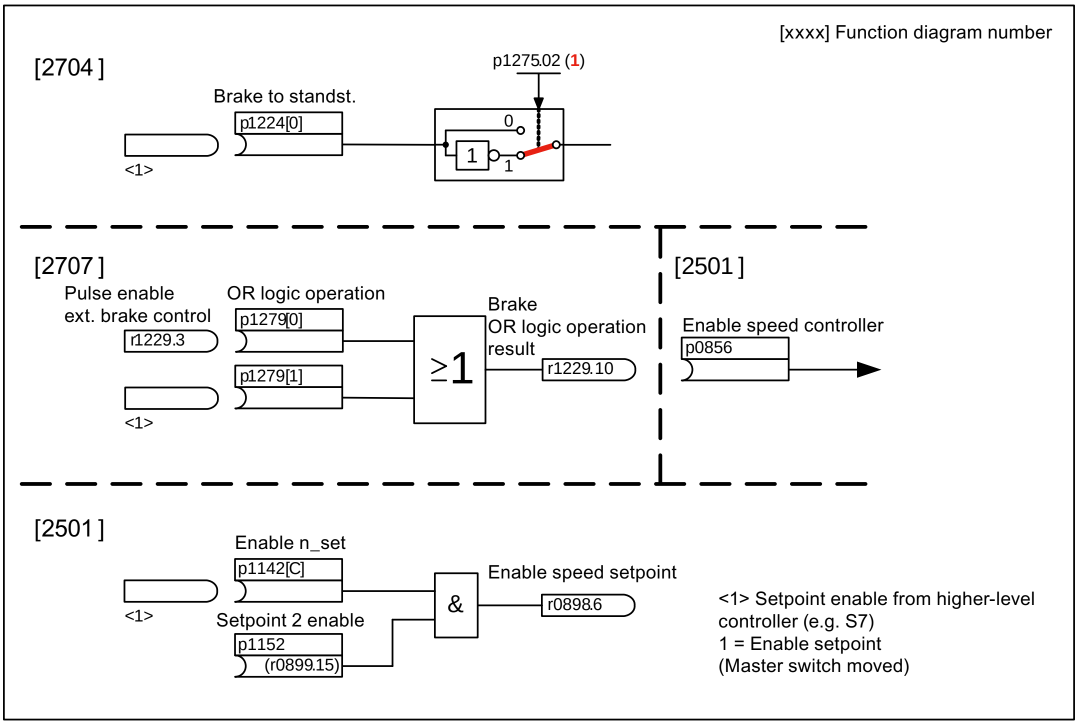


Figure 7-4 Example, operating brake for a crane drive

7.4.5 Integration

The extended brake control function is integrated in the system as follows.

Function diagrams (see SINAMICS S List Manual)

- 2704 Zero speed detection (r0108.14 = 1)
- 2707 Releasing/applying brake (r0108.14 = 1)
- 2711 Signal outputs (r0108.14 = 1)

Overview of key parameters (see SINAMICS S List Manual)

- r0108.14 Extended brake control
- r0899 CO/BO: Status word sequence control

Standstill (zero-speed) monitoring

- r0060 CO: Speed setpoint before the setpoint filter
- r0063 CO: Actual speed smoothed (servo)
- r0063[0] CO: Actual speed, unsmoothed (vector)
- p1225 CI: Standstill detection, threshold value
- p1226 Threshold for zero speed detection
- p1227 Zero speed detection monitoring time
- p1228 Zero speed detection, delay time
- p1224[0..3] BI: Close motor holding brake at standstill
- p1276 Motor holding brake standstill detection bypass

Release/apply brake

- p0855 BI: Unconditionally release holding brake
- p0858 BI: Unconditionally close the holding brake
- p1216 Holding brake release time
- p1217 Holding brake application time
- p1218[0..1] BI: Open motor holding brake
- p1219[0..3] BI: Immediately close motor holding brake
- p1220 CI: Open motor holding brake, signal source, threshold
- p1221 Motor holding brake open threshold
- p1277 Motor holding brake delay braking threshold exceeded

Free modules

- p1279 BI: Motor holding brake, OR/AND logic operation

Brake monitoring functions

- p1222 BI: Motor holding brake, feedback signal, brake closed
- p1223 BI: Motor holding brake, feedback signal, brake open

Configuration, control/status words

- p1215 Motor holding brake configuration
- r1229 CO/BO: Motor holding brake status word
- p1275 Motor holding brake control word
- p1278 Motor holding brake type

Control and status messages for extended brake control

Table 7-2 Control: extended brake control

Signal name	Binector input	Control word sequence control / interconnection parameters
Enable speed setpoint	p1142 BI: Enable speed setpoint	STWA.6
Enable setpoint 2	p1152 BI: Setpoint 2 enable	p1152 = r899.15
Unconditionally release holding brake	p0855 BI: Unconditionally release holding brake	STWA.7
Enable speed controller	p0856 BI: Enable speed controller	STWA.12
Unconditionally close the holding brake	p0858 BI: Unconditionally close the holding brake	STWA.14

Table 7-3 Status message: extended brake control

Signal name	Parameters	Brake status word
Command, open brake (continuous signal)	r1229.1	B_ZSW.1
Pulse enable, expanded brake control	r1229.3	B_ZSW.3
Brake does not open	r1229.4	B_ZSW.4
Brake does not close	r1229.5	B_ZSW.5
Brake threshold exceeded	r1229.6	B_ZSW.6
Brake threshold fallen below	r1229.7	B_ZSW.7
Brake monitoring time expired	r1229.8	B_ZSW.8
Request, pulse enable missing/n_ctrl inhibited	r1229.9	B_ZSW.9
Brake OR logic operation result	r1229.10	B_ZSW.10
Brake AND logic operation result	r1229.11	B_ZSW.11

7.5 Braking Module

7.5.1 "Braking Module" function module

Features

- Braking the motor without any possibility of regenerating into the line supply (e.g. power failure)
- Fast DC link discharge (booksize design)
- The Braking Module terminals are controlled via the drive object infeed (booksize and chassis designs)
- Controlling up to 8 Braking Modules in a parallel circuit configuration
- Acknowledging faults at the Braking Module

Description

The "Braking Module" function module can be activated in the infeed drive object. The appropriate binectors must be interconnected via digital inputs/outputs (e.g.: Control Unit, TM31 or TB30) with the Braking Module.

In order to obtain the maximum power of a Braking Module, the Vdc_max control must be disabled.

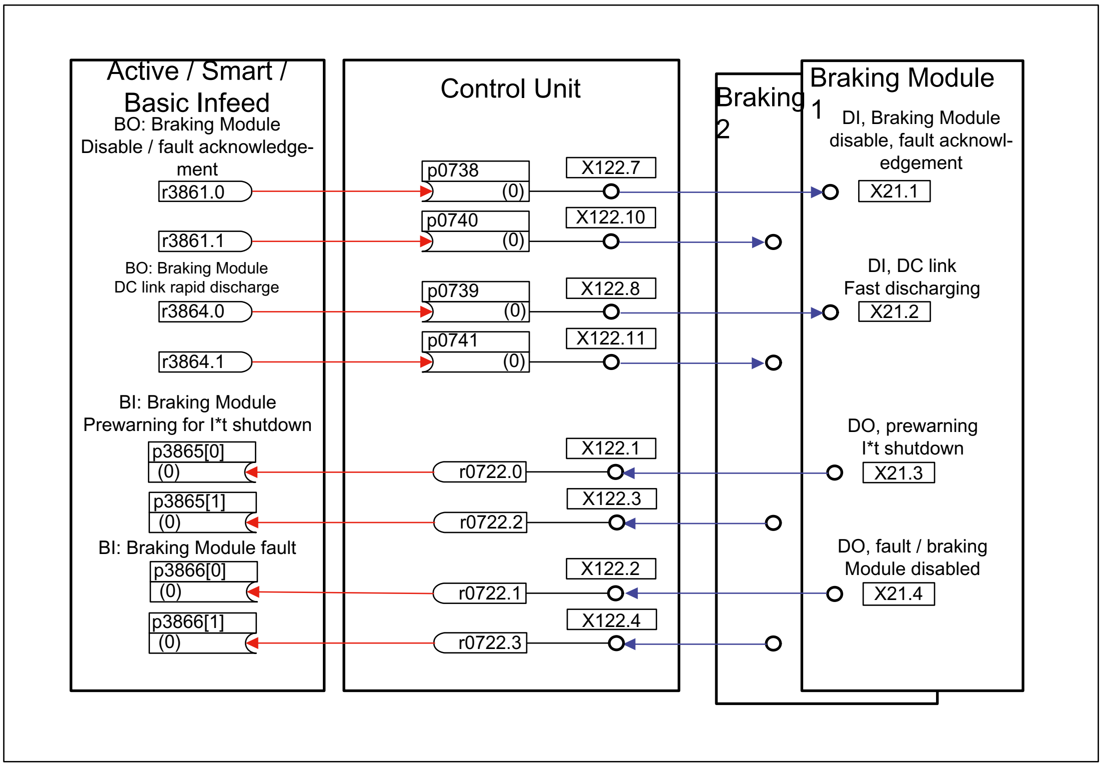


Figure 7-5 Example of controlling two Booksize Braking Modules

Acknowledgement of faults

When the Braking Module issues a fault message at binector input p3866, an attempt is made to acknowledge the fault using signal p3861 at terminal X21.1 Booksize or X41.3 Chassis every 10 ms. Alarm A06900 is simultaneously is output.

Fast DC link discharge (booksize)

It is only possible to quickly discharge the DC link via the Braking Module for the booksize design. It is activated via binector input p3863 and started after the line contactor opens and the adjustable delay time (p3862) has expired. The fast discharge is completed when the line contactor contact closes.

NOTICE
Prerequisites for a fast DC link discharge is the use of a line contactor with feedback signal (p0860) that is controlled via r0863.1.

Overview of key parameters (see SINAMICS S List Manual)

- r0108.26 Drive object function module - Braking Module
- p3860 Braking Module number of modules connected in parallel
- r3861 BO: Inhibit Braking Module
- p3862 Braking Module DC link fast discharge delay time
- p3863 BI: Braking Module activate DC link fast discharge
- p3864 BO: Braking Module DC link fast discharge
- p3865 Bi: Braking Module pre-alarm I*t shutdown
- p3866 BI: Braking Module fault

7.6 Cooling system

7.6.1 "Cooling system" function module

Features

- Control and monitoring functions of a cooling unit
- Automatically activated when using water-cooled power units
- Evaluation of a leakage water sensor (p0266.4)
- Evaluation of a water flow sensor (p0266.5, p0260, p0263)
- Evaluation of a conductivity sensor (p0266.6, p0266.7, p0261, p0262)
- Monitoring the water intake temperature using internal temperature sensors
- Monitoring the flow rating using internal temperature sensors

Description

A cooling unit (RKA) is responsible for cooling the water and the (non) conductivity in the de-ionized water cooling circuit of a water-cooled power unit. The cooling unit is controlled and monitored from a PLC that is part of the cooling unit. The "cooling unit" function module described here is used as an interface between the closed-loop control and the external control (open-loop) (PLC) of the cooling unit.. The cooling unit is controlled via terminals (e.g. Control Unit, TM31).

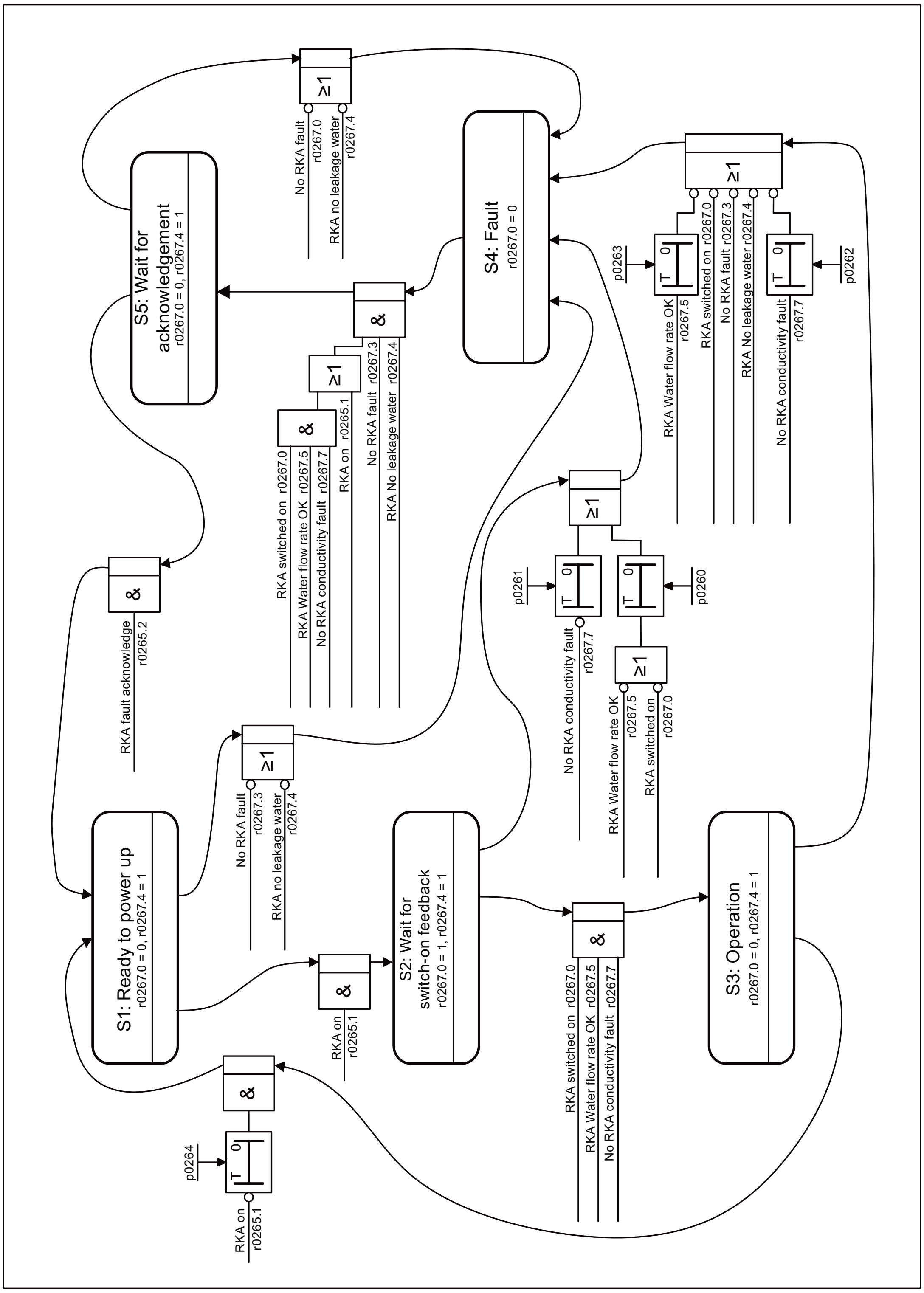


Figure 7-6 Sequence control cooling unit

Function diagrams (see SINAMICS S List Manual)

- 9794 Cooling unit, control and feedback signals
- 9795 Cooling unit sequence control

Overview of key parameters (see SINAMICS S List Manual)

- r0046.29 Missing enable signals - cooling unit ready missing
- p0192.06 Power unit firmware properties - water cooling
- r0204.06 Power unit hardware properties - water cooling
- p0260 Cooling unit, starting time 1
- p0261 Cooling unit, starting time 2
- p0262 Cooling unit fault conductivity delay time
- p0263 Cooling unit fault water flow delay time
- p0264 Cooling unit, run-on time
- r0265 BO: Cooling unit control word
- p0266[0...7] BI: Cooling unit signal source feedback signals
- r0267 BO: Cooling unit status word display

7.7 Extended torque control (kT estimator, Servo)

Description

The "extended torque control" function module comprises two modules - the k_T estimator and the compensation of the voltage emulation error of the drive converter. This allows the torque accuracy to be increased.

Note

When this function module is activated, the maximum number of drives that can be controlled from a Control Unit is reduced by at least one drive.

Features

- k_T estimator (only for synchronous motors)
- Compensation of the voltage emulation error of the drive converter (p1952, p1953)
- Configuration via p1780

Commissioning via STARTER

The extended torque control can be activated via: Right-click the drive > Properties > Function Modules.

Parameter r0108.1 indicates whether it has been activated.

Description of the k_T estimator

The adaptation of the torque constants for synchronous motors is used to improve the absolute torque accuracy for the control (closed-loop) of synchronous motors. The magnetization of the permanent magnets varies as a result of production tolerances and temperature fluctuations and saturation effects. This function "k_T estimator" adapts the torque constant k_T [Nm/A] in the control to the instantaneous magnetization. It only makes sense to use the k_T estimator in conjunction with the friction characteristic as the k_T estimator can only correct the inner motor torque. The frictional losses must be compensated from the friction characteristic using a supplementary torque.

The k_T estimator requires the most accurate values for the motor parameters as possible in order to achieve a high torque accuracy. Before using the k_T estimator, it is therefore necessary to carry-out a motor identification routine (p1909, p1910) with the k_T estimator activated; this determines the values for the stator resistance (p0350), leakage inductance (p0356) and voltage emulation errors (p1952, p1953). The cable resistance must be entered in p0352 before motor identification.

The motor should be at room temperature when the identification routine is carried out. Compensation of the voltage emulation error must be activated (p1780.8 = 1). The motor temperature (p0600) should be recorded via a KTY sensor (p0601 = 2 or 3).

The estimator requires the motor temperature in order to track/correct the temperature-dependent quantities. If a motor temperature sensor is not connected, then the accuracy is significantly restricted.

The k_T estimator is only activated above a specific speed (p1752). The terminal voltage of the drive converter always has small errors, caused by voltage drives across the power semiconductors etc. The lower the speed and therefore the output voltage, the greater the negative influence on the estimation as a result of low voltage errors. This is the reason that the estimation is de-activated below a specific speed. The estimated value is smoothed using time constant p1795. The correction value for the torque constant is displayed in r1797. By identifying the torque constant k_T using the rotating motor identification routine, the torque accuracy can be improved also below the speed threshold (p1752).

The k_T estimator is activated using p1780.3 and the voltage compensation using p1780.8.

Function diagrams (see SINAMICS S List Manual)

- 7008 kT estimator

Overview of key parameters (see SINAMICS S List Manual)

- r0108.1 Function module - extended torque control active
- p1780.3 Selects motor model PEM k_T adaptation
- p1780.8 Compensation of the voltage emulation error in the drive converter

Motor/drive converter identification

- p0352 Cable resistance
- p1909 Motor data identification control word
- p1910 Activates motor data identification routine, stationary (standstill)

kT estimator:

- p1752 Motor model, changeover speed operation with encoder
- p1795 Motor model PEM k_T adaptation smoothing time
- r1797 Motor model PEM k_T adaptation correction value

Compensation of the voltage emulation error of the drive converter:

- p1952 Voltage emulation error, final value
- p1953 Voltage emulation error, current offset

7.8 Closed-loop position control

7.8.1 General features

The position controller essentially comprises the following parts:

- Position actual value conditioning (including the lower-level measuring probe evaluation and reference mark search)
- Position controller (including limits, adaptation and the pre-control calculation)
- Monitoring functions (including standstill, positioning, dynamic following error monitoring and cam signals)
- There is still no position actual value conditioning for distance-coded measuring systems.
- Position tracking of the load gear (motor encoder), using absolute encoders for rotary axes (modulo) as for linear axes.

7.8.2 Position actual value conditioning

7.8.2.1 Features

- Correction value (p2512, p2513)
- Setting value (p2514, p2515)
- Position offset (p2516)
- Position actual value (r2521)
- Velocity actual value (r2522)
- Motor revolutions (p2504)
- Load revolutions (p2505)
- Spindle pitch (p2506)
- Position tracking (p2720ff)

7.8.2.2 Description

The position actual value conditioning implements the conditioning of the position actual value in a neutral position unit LU (LENGTH UNIT). To do this, the function block uses the encoder evaluation/motor control with the available encoder interfaces Gn_XIST1, Gn_XIST2, Gn_STW and Gn_ZSW. These just provide position information in encoder pulses and fine resolution (increments).

The position actual value is conditioned independently of whether the position controller is enabled immediately after the system has booted and as soon as valid values are received via the encoder interface.

Parameter p2502 (encoder assignment) is used to define from which encoder (1, 2 or 3), the position actual value is sensed.

The following interconnections are automatically established after the assignment has been made.

- p0480[0] (G1_STW) = encoder control word r2520[0]
- p0480[1] (G2_STW) = encoder control word r2520[1]
- p0480[2] (G3_STW) = encoder control word r2520[2]

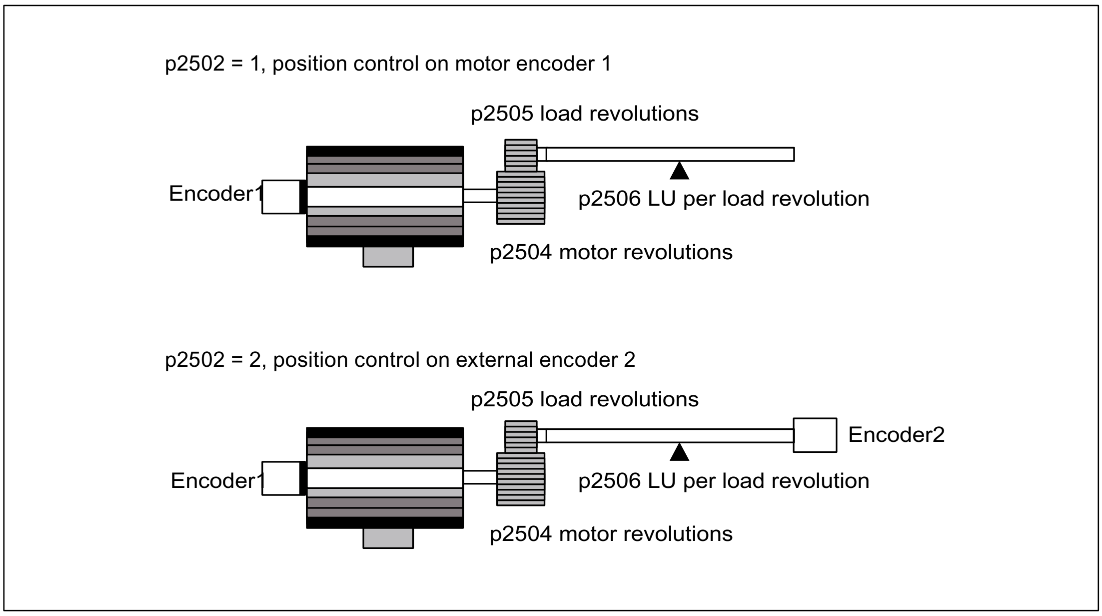


Figure 7-7 Position actual value sensing with rotary encoders

The link between the physical variables and the neutral length unit LU is established via parameter p2506 (LU per load revolution) for rotary encoders. Parameter p2506 mirrors, together with p2504, p2505, the interrelationship between encoder increments and the neutral position unit LU.

Example:

Rotary encoder, ball screw with a pitch of 10 mm/revolution. 10 mm should have a resolution of 1 µm (i.e. 1 LU = 1 µm).

-> One load revolution corresponds to 10000 LU

-> p2506 = 10000

Note

The effective actual value resolution is obtained from the product of the encoder pulses (p0408) and the fine resolution (p0418) and a measuring gear that is possibly being used (p0402, p0432, p0433).

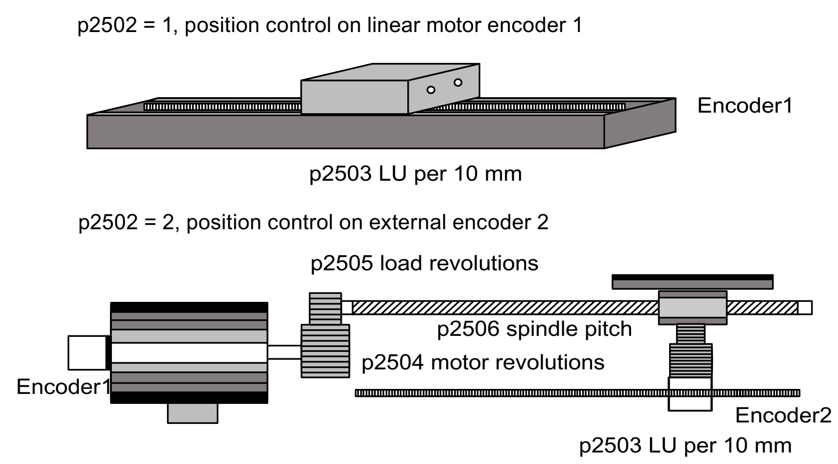


Figure 7-8 Position actual value sensing with linear encoders

For linear encoders, the interrelationship between the physical quantity and the neutral length unit LU is configured using parameter p2503 (LU/10 mm).

Example:

Linear encoder, 10 mm should have a resolution of 1 µm (i.e. 1 LU = 1 µm).

-> p2503 = 10000

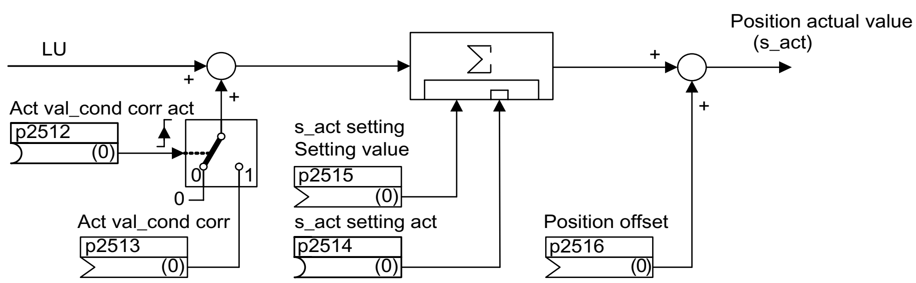


Figure 7-9 Actual position value preparation

A correction can be made using connector input p2513 (correction value, position actual value conditioning) and a positive edge at binector input p2512 (activates the correction value). When the "basic positioning" function module is activated, p2513 is automatically interconnected with r2685 (EPOS correction value) and p2512 with r2684.7 (activate correction). This interconnection enables modulo offset by EPOS, for example.

p2516 can be used to switch in position offset. Using EPOS, p2516 is automatically interconnected to r2667. Backlash compensation is implemented using this interconnection.

Using the connector input p2515 (position setting value) and a "1" signal at binector input p2514 (set position actual value), a position setting value can be entered.

⚠ WARNING

When the actual position value is set (p2514 = "1" signal), the actual position value of the position controller is kept at the value of connector p2515 as standard.

Incoming encoder increments are not evaluated. A difference in position cannot be compensated for in this situation.

An inversion of the actual position value resulting from the encoder is undertaken using parameter p0410. An inversion of the axis motion can be entered using a negative value in p2505.

7.8.2.3 Indexed actual value acquisition

Properties

- Encoder assignment (p2502[DDS])
- Absolute encoder adjustment (p2507[EDS])
- Enable encoder evaluation (p2509[0..3])
- Encoder evaluation selection (p2510[0..3])
- Encoder edge (p2511[0..3])
- Enable position actual value preprocessing, corrective value (p2512[0..3])
- Position actual value preprocessing, corrective value (p2513[0..3])
- Position offset (p2516[0..3])
- Position actual value (r2521[0..3])
- Velocity actual value (r2522[0..3])
- Measuring probe evaluation/Reference mark search (p2523[0..3])
- Encoder adjustment, offset (p2525[EDS])
- Status word position controller (r2526)
- Status word encoder1 (r2527)
- Status word encoder2 (r2528)
- Status word encoder3 (r2529)
- EPOS reference point coordinate, signal source (p2598[0..3])
- Function diagram 4010 Position control - Position actual value preprocessing

Description

The indexed position actual value acquisition permits e.g. length measurements on parts as well as the detection of axis positions by a higher-level controller (e.g. SIMATIC S7) in addition to the position control e.g. of a belt conveyor.

Two more encoders can be operated in parallel with the encoders for actual value preprocessing and position control in order to collect actual values and measured data.

The indexed acquisition of actual values can preprocess a position actual value at each of the three encoder outputs. The parameter p2502[0..3] is used to select the encoder evaluation for position control.

The parameters of the indexed actual value acquisition are indexed four times. The indexes 1..3 are assigned to the encoder evaluations 1..3. The index 0 is assigned to position control.

The parameter r2521[0..3] can be used to retrieve the current actual values of all connected encoders. For example, the position actual value for position control in r2521[0] is identical with the value r2521[1] if the position control uses encoder evaluation 1. The signal source for a position offset can be set in parameter p2516[0..3].

The absolute encoder adjustment is initiated via p2507[0..3].2, and its successful completion is reported via p2507[0..3].3. The signal source "Reference point coordinate for the position controller" p2598[0] is interconnected with p2599 during basic positioning. The other signal sources are not interconnected in the standard configuration.

The measuring probe evaluation can be enabled for the encoder evaluation x, which is not assigned to position control, via p2509[x]. The signal sources are assigned via p2510[0..3], the edge evaluation is set via p2511[0..3]. The measured value is then available in r2523[x] if the status word for encoder x (encoder 0: r2526.0..9, encoder1: 2627.0..2, encoder2: r2628.0..2, encoder3: r2529.0..2) has the "Valid measurement" bit set.

The current values of the position actual values of the different encoders can be read out via parameter r2521[0..3]. These position actual values can be corrected with a signed value from p2513[0..3] after a 0/1 signal from the signal source in p2512[0..3].

In addition, the velocity actual value (r2522[0..3]) and the position offset for absolute encoders p2525[0..3] can be processed for each encoder by the higher-level controller.

7.8.2.4 Load gear position tracking

Features

- Configuration via p2720
- Virtual multiturn via p2721
- Tolerance window for monitoring the position at switching on p2722
- Input of the load gear via p2504 and p2505
- Display via r2723

Description

Position tracking for load gearing functions in the same way as position tracking for the measuring gearbox (see "Position tracking for measuring gearbox"). Position tracking is activated via the parameter p2720.0 = 1. The position tracking of the load gear, however, is only relevant for the motor encoder (encoder 1). The load gear ratio is entered via parameters p2504 and p2505. Position tracking can be activated with rotary axes (modulo) and linear axes.

For linear axes, the virtual multiturn resolution (p2721) is preset with p0421 and extended by 6 bits for multiturn information (max. overflows 31 positive/negative)

Position tracking for the load gearing can only be activated once for each motor data set MDS.

The load position actual value in r2723 (must be requested via GnSTW.13) is limited to 2^{32} places. When position tracking (p2720.0 = 1) is switched on, the load position actual value r2723 comprises the following position information:

- Encoder pulses per revolution (p0408)
- Fine resolution per revolution (p0419)
- Virtual number of stored revolutions of a rotary absolute encoder (p2721)
- Load gear ratio (p2504/p2505)
- Measuring gearbox ratio (p0433/p0432), if p0411.0 = 1

Example: Absolute encoder can count 8 encoder revolutions (p0421 = 8)

Note

Load gear problems and solutions, see example in chapter Position tracking -> Measuring gearbox.

Example of position area extension

With absolute encoders without position tracking, it must be ensured that the traversing range is 0 smaller than half the encoder range, because beyond this range, no unique reference remains after switching on and off (see description on parameter p2507). This traversing range can be extended using the virtual multiturn (p2721).

For reasons of presentation, an absolute encoder was selected in the figure below that can represent 8 encoder revolutions (p412 = 8). The parameter p2721 is pre-assigned a value of 512. To simplify the presentation, p2721=24 as well as a setting of p2504 = p2505 =1 (gear factor = 1) were selected.

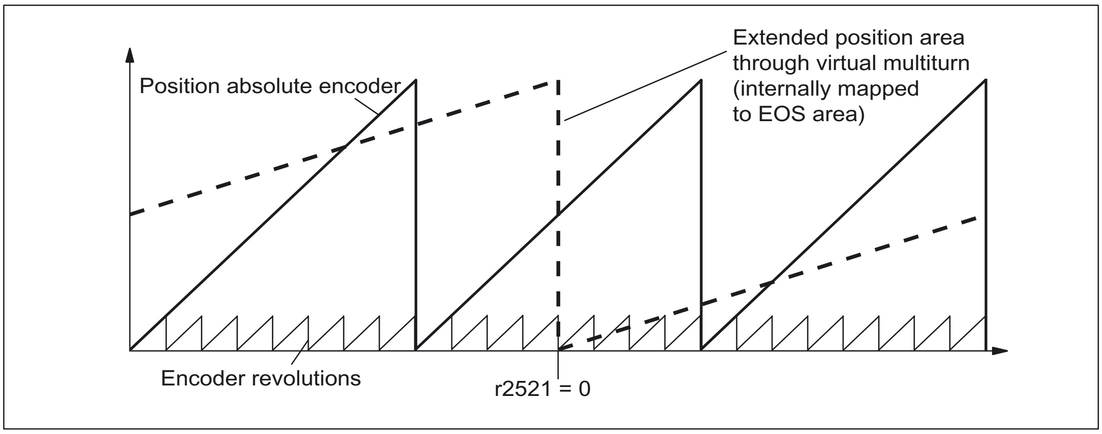


Figure 7-10 Position tracking (p2721 = 24)

In this example, this means:

Without position tracking, the position for +/- 4 encoder revolutions about r2521 = 0 LU can be reproduced.

With position tracking, the position for +/- 12 encoder revolutions (+/- 12 load revolutions with load gearbox) can be reproduced (p2721 = 24).

Practical example:
For a linear axis, the value for p2721 is set to 262144 for an encoder with p0421 = 4096. That means, +/- 131072 encoder revolutions or load revolutions can be reproduced in this way.

For a rotary axis, a value for p2721 = p0421 is set for an encoder.

Configuration of the load gear (p2720).

The following points can be set by configuring this parameter:

- p2720.0: Activation of position tracking
- p2720.1: Setting the axis type (linear axis or rotary axis)

  Here, a rotary axis refers to a modulo axis (modulo offset can be activated through higher-level control or EPOS). With a linear axis, position tracking is mainly used to extend the position area (see section: Virtual multiturn encoder (p2721)).
- p2720.2: Reset position

Note

If position tracking of the load gearbox is activated after an adjustment p2507=3 has been made, the adjustment will be reset.

Another adjustment will reset the position (overruns).

Position tracking can be activated in the FW2.5 SP1 only for a single DDS.
If multiple DDS are configured, it will not be possible to active the position tracking function.

Virtual multiturn encoder (p2721)

With a rotary absolute encoder (p0404.1 = 1) with activated position tracking (p2720.0 = 1), p2721 can be used to enter a virtual multiturn resolution. This enables you to generate a virtual multiturn encoder value (r2723) from a singleturn encoder. It must be possible to display the virtual encoder range via r2723.

For rotary axes with modulo offset, the virtual multiturn resolution (p2721) is preset as p0421 and can be changed.

For linear axes, the virtual multiturn resolution (p2721) is preset with p0421 and extended by 6 bits for multiturn information (max. overflows 31 positive/negative)

If, as a result of extension of the multiturn information, the displayable area of r2723 (2^{32} bit) is exceeded, the fine resolution (p0419) must be reduced accordingly.

Tolerance window (p2722)

After switching on, the difference between the stored position and the actual position is ascertained and, depending on the result, the following is triggered:

Difference within the tolerance window -> the position is reproduced based on the current actual encoder value.

Difference outside the tolerance window -> an appropriate message (F07449) is output.

The tolerance window is preset to quarter of the encoder range and can be changed.

⚠ CAUTION

The position can only be reproduced if, in the powered-down state, if the encoder was moved through less than half of the range that it can represent. For the standard EQN1325 encoder, this is 2048 revolutions or half a revolution for singleturn encoders.

Note

The ratio stamped on the gearbox type plate is often just a rounded-off value (e.g.1:7.34). If, for a rotary axis, it is not permissible to have any long-term drift, then the actual ratio of the gearbox teeth must be requested from the gearbox manufacturer.

Prerequisites

- CU320 with Order No. 6SL3040- ....- 0AA1 and Version C or higher or CU310
- Firmware release from FW2.5
- Absolute encoder

7.8.2.5 Commissioning with STARTER

The "position control" function module can be activated via the commissioning Wizard or the drive configuration (configure DDS).

When the "basic positioner" function module (r0108.4 = 1) is activated, then the function module "position control" (r0108.3) is automatically activated.

The current configuration can be checked in parameter r0108.

The "load gearbox position tracking" function can be configured in the commissioning wizard via the "Mechanical system" dialog, as well as in the project navigator under "Technology" -> "Position control" via the "Mechanical system" dialog.

7.8.2.6 Integration

Function diagrams (see SINAMICS S List Manual)

- 4010 Position actual value conditioning
- 4704 Position and temperature sensing, encoders 1 - 3
- 4710 Actual speed value and rotor pos. meas., motor enc. (encoder 1)

Overview of key parameters (see SINAMICS S List Manual)

- p2502 LR encoder assignment
- p2503 LR length unit LU per 10 mm
- p2504 LR motor/load motor revolutions
- p2505 LR motor/load load revolutions
- p2506 LR length unit LU per load revolution
- r2520 CO: LR actual position value preparations encoder control word
- r2521 CO: LR actual position value
- r2522 CO: LR actual velocity value
- r2523 CO: LR measured value
- r2524 CO: LR LU/revolutions
- r2525 CO: LR encoder adjustment offset
- r2526 CO/BO: LR status word
- p2720 Load gearing configuration
- p2721 Load gearing absolute encoder rotary revolutions virtual
- p2722 Load gearing position tracking tolerance window
- r2723 CO: Load gearing absolute value
- r2724 CO: Load gearing position difference

7.8.3 Position controller

Features

- Symmetrization (p2535, p2536)
- Limiting (p2540, p2541)
- Pre-control (p2534)
- Adaptation (p2537, p2538)

Note

We only recommend that experts use the position controller functions without using the basic positioner.

Description

The position controller is a PI controller. The P gain can be adapted using the product of connector input p2537 (position controller adaptation) and parameter p2538 (Kp).

Using connector input p2541 (limit), the speed setpoint of the position controller can be limited without pre-control. This connector input is pre-interconnected with connector output p2540.

The position controller is enabled by an AND link of the binector inputs p2549 (position controller 1 enable) and p2550 (position controller 2 enable).

The position setpoint filter (p2533 time constant position setpoint filter) is a PT1 element, the symmetrizing filter as deadtime element (p2535 symmetrizing filter speed pre-control (deadtime) and PT1 element (p2536 symmetrizing filter speed pre-control (PT1)). The speed pre-control p2534 (factor, speed pre-control) can be disabled via the value 0.

Function diagrams (see SINAMICS S List Manual)

- 4015 Position controller

Overview of important parameters (refer to the SINAMICS List Manual)

- p2533 LR position setpoint filter, time constant
- p2534 LR speed pre-control factor
- p2535 LR speed pre-control symmetrizing filter dead time
- p2536 LR speed pre-control symmetrizing filter PT1
- p2537 CI: LR position controller adaptation
- p2538 LR proportional gain
- p2539 LR integral action time
- p2540 CO: LR position controller output speed limit
- p2541 CI: LR position controller output speed limit signal source

7.8.4 Monitoring functions

Features

- Standstill monitoring (p2542, p2543)
- Positioning monitoring (p2544, p2545)
- Dynamic following error monitoring (p2546, r2563)
- Cam controllers (p2547, p2548, p2683.8, p2683.9)

Description

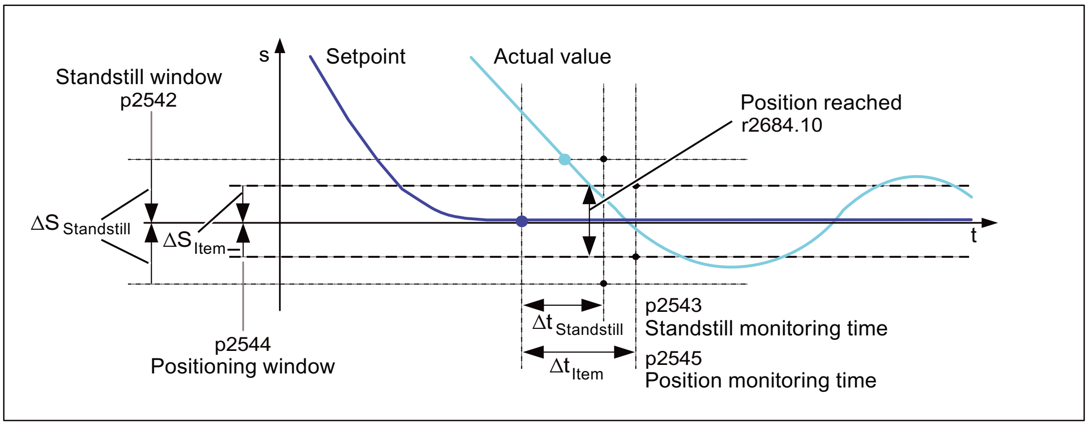


Figure 7-11 Zero-speed monitoring, positioning window

The position controller monitors the standstill, positioning and following error.

Zero-speed monitoring is activated by binector inputs p2551 (setpoint stationary) and p2542 (zero-speed window). If the zero-speed window is not reached once the monitoring time (p2543) has lapsed, fault F07450 is triggered.

Positioning monitoring is activated via binector inputs p2551 (setpoint stationary), p2554 = "0" (travel command not active) and p2544 (positioning window). Once the monitoring time (p2545) has elapsed, the positioning window is checked once. If this is not reached, fault F07451 is triggered.

The standstill monitoring and the positioning monitoring can be de-activated using the value "0" in p2542 and p2544. The standstill window should be greater than or equal to the positioning window (p2542 ≥ p2544). The standstill monitoring time should be less than or equal to the positioning monitoring time (p2543 ≤ p2545).

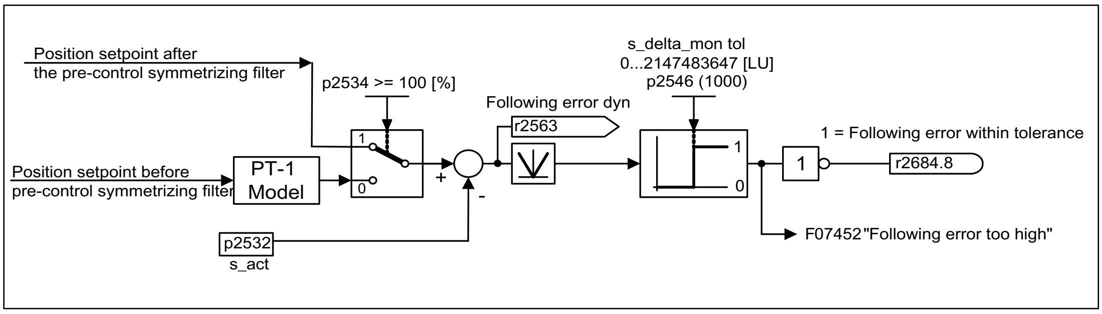


Figure 7-12 Following error monitoring

Following error monitoring is activated via p2546 (following error tolerance). If the absolute value of the dynamic following error (r2563) is greater than p2546, fault F07452 is output and bit r2648.8 is reset.

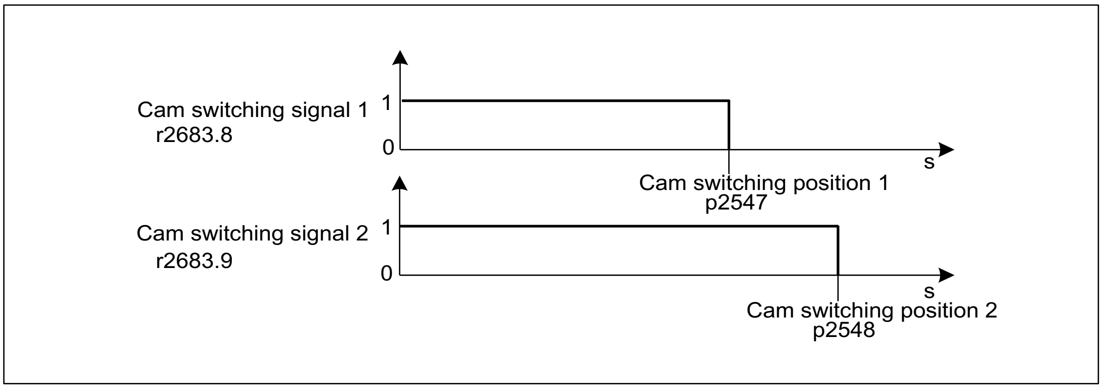


Figure 7-13 Cam controllers

The position controller has two cam controllers. If cam position p2547 or p2548 is passed in the positive direction (p2521 > p2547 or 2548), then cam signals r2683.8 and r2683.9 are reset.

Function diagrams (see SINAMICS S List Manual)

- 4020 Zero-speed / positioning monitoring
- 4025 Dynamic following error monitoring, cam controllers

Overview of key parameters (see SINAMICS S List Manual)

- p2530 CI: LR setpoint position
- p2532 CI: LR actual position value
- p2542 LR standstill window
- p2543 LR standstill monitoring time
- p2544 LR positioning window
- p2545 LR positioning monitoring time

- p2546 LR dynamic following error monitoring tolerance
- p2547 LR cam switching position 1
- p2548 LR cam switching position 2
- p2551 BI: LR setpoint message present
- p2554 BI: LR travel command message active
- r2563 CO: LR latest following error
- r2683.8 Actual position value <= cam switching position 1
- r2683.9 Actual position value <= cam switching position 2
- r2684 CO/BO: EPOS status word 2

7.8.5 Measuring probe evaluation and reference mark search

Description

The "Reference mark search" and "Measuring probe evaluation" functions can be initiated and carried-out via binector input p2508 (activate reference mark search) and p2509 (activate measuring probe evaluation). Binector inputs p2510 (measurement probe selection) and p2511 (measurement probe edge evaluation) define the mode for measurement probe evaluation.

The probe signals are recorded via the encoder encoder status and control word. To speed up signal processing, direct measuring probe evaluation can be activated by selecting the input terminals for probes 1/2 via p2517 and p2518. Measuring probe evaluation is carried out in the position controller cycle, whereby the set send clock cycle of the controller (r2064[1]) must be an integer multiple of the position controller cycle (p0115[4]).

The system outputs a message if the same probe input is already being used (see also p0488, p0489, p0580, and p0680).

The appropriate function is started using a 0/1 edge at the appropriate input p2508 (activate reference mark search) or p2509 (activate measuring probe evaluation) via the encoder control word. Status bit r2526.1 (reference function) signals that the function is active (feedback from the encoder status word). Status bit r2526.2 (measurement value valid) shows the presence of the measurement required r2523 (position for reference mark or measurement probe).

Once the function is complete (position determined for reference mark or measurement probe), r2526.1 (reference function active) and r2526.2 (measurement valid) continue to remain active and the measurement is provided by r2523 (reference measurement) until the corresponding input p2508 (activate reference mark searches) or p2509 (activate measurement probe evaluation) is reset (0 signal).

If the function (reference mark search or measuring probe evaluation) has still not been completed and the corresponding input p2508 or p2509 is reset, then the function is interrupted via the encoder control word and status bit r2526.1 (reference function active) is reset via the encoder status word.

If both binector inputs p2508 and p2509 are simultaneously set, this causes the active function to be interrupted and no function is started. This is indicated using alarm A07495 "reference function interrupted" and remains until the signals at the binector inputs are reset.

The alarm is also generated if, during an activated function (reference mark search or measuring probe evaluation), a fault is signaled using the encoder status word.

If the "position control" function module is selected, these parameters (p2508 to p2511) are preassigned with "0". If the "basic positioner" function module is selected, the functions "reference mark search" (for the function reference point search) and "measuring probe evaluation" (for the function flying referencing) are initiated by the function module basic positioner and the feedback signal (r2526, r2523) is fed back to this (see also: Commissioning Manual, section "Control and status words for encoders").

Function diagrams (see SINAMICS S List Manual)

- 4010 Position actual value conditioning
- 4720 Encoder interface, receive signals, encoder 1 ... 3
- 4730 Encoder interface, send signals, encoder 1 ... 3

Overview of key parameters (see SINAMICS S List Manual)

- p2508 BI: LR activate reference mark search
- p2509 BI: LR activate measuring probe evaluation
- p2510 BI: LR measuring probe evaluation, selection
- p2511 BI: LR measuring probe evaluation edge
- p2517 LR direct probe 1 input terminal
- p2518 LR direct probe 2 input terminal
- r2523 CO: LR measured value
- r2526 CO/BO: LR status word

7.8.6 Integration

The "position control" function module is integrated in the system as follows:

Commissioning

The "position control" function module can be activated via the commissioning Wizard or the drive configuration (configure DDS).

When the "basic positioner" function module (r0108.4 = 1) is activated, then the function module "position control" (r0108.3) is automatically activated.

The current configuration can be checked in parameter r0108.

The position controller can be parameterized in a user-friendly fashion using the screen forms in STARTER.

The "position control" function module is absolutely essential for operating the basic positioner.

If the "position control" function module is active, and to optimize the speed controller, a function generator signal is interconnected to the speed controller input p1160, then the position controller monitoring functions respond. To prevent this from happening, the position controller must be disabled (p2550 = 0) and switch to tracking mode (p2655 = 1, for control using PROFIdrive telegram 110 PosSTW.0 = 1). In this way, the monitoring functions are switched off and the position setpoint is tracked.

Function diagrams (see SINAMICS S List Manual)

- 4010 Position actual value conditioning
- 4015 Position controller
- 4020 Zero-speed / positioning monitoring
- 4025 Dynamic following error monitoring, cam controllers

7.9 Basic positioner

General description

The basic positioner is used to position linear and rotary axes (modulo) in absolute/relative terms with motor encoder (indirect measuring system) or machine encoder (direct measuring system). It is available in the servo and vector modes.

User-friendly configuration, commissioning, and diagnostic functions are also available in STARTER for the basic positioner functionality (graphic navigation). In STARTER, there is a control panel for the basic positioner and speed-controlled operation; using this control panel, the functionality can be started from a PC/PG to commission the system or carry-out diagnostics.

When the basic positioner is activated (r0108.4 = 1), then the position control (r0108.3 = 1) should also be activated. This is realized automatically when activating the basic positioner via the STARTER commissioning Wizard. Further, the necessary "internal interconnections" (BICO technology) are automatically established.

⚠ CAUTION

The basic positioner requires the position controller functions. The BICO interconnections established by the basic positioner must be changed by experienced users only.

This means that naturally the position control functions are also available (e.g. standstill monitoring, positioning monitoring, dynamic following error monitoring, cam controllers, modulo function, measuring probe evaluation). Also refer to the section "Position control".

In addition, the following functions can be carried-out using the basic positioner:

- Mechanical system
  - Backlash compensation
  - Modulo offset
  - Position tracking of the load gear (motor encoder) with absolute encoders

- Limits
  - Traversing profile limits
  - Traversing range limits
  - Jerk limitation
- Referencing or adjusting
  - Set reference point (for an axis at standstill that has reached its target position)
  - Reference point approach
    (autonomous mode including reversing cam functionality, automatic direction of rotation reversal, referencing to "cams and encoder zero mark" or only "encoder zero mark" or "external equivalent zero mark (BERO)")
  - Flying referencing
    (during the "normal" traversing motion, it is possible to reference, superimposed, using the measuring probe evaluation; generally, evaluating e.g. a BERO. Higher-level (superimposed) function for the modes "jog", direct setpoint input/MDI and "traversing blocks")
  - Referencing with incremental measuring systems
  - Absolute encoder adjustment
- Traversing blocks mode (64 traversing blocks)
  - Positioning using traversing blocks that can be saved in the drive unit including block change enable conditions and specific tasks for an axis that was previously referenced
  - Traversing block editor using STARTER
  - A traversing block contains the following information:
    traversing block number
    job (e.g. positioning, wait, GOTO block step, setting of binary outputs)
    motion parameters (target position, velocity override for acceleration and deceleration)
    mode (e.g: Skip block, block change enable conditions such as "Continue_with_stop" and "Continue_flying")
    Task parameters (e.g. delay time, block step conditions)
- Direct setpoint input (MDI) mode
  - Positioning (absolute, relative) and setting-up (endless closed-loop position control) using direct setpoint inputs (e.g. via the PLC or process data)
  - It is always possible to influence the motion parameters during traversing (on-the-fly setpoint acceptance) as well as on-the-fly change between the Setup and Positioning modes.
- Jog mode
  - Closed-loop position controlled traversing of the axis with the "endless position controlled" or "jog incremental" modes that can be toggled between (traverse through a "step width")
- Standard PROFIdrive positioning telegrams are available (telegrams 7, 9 and 110), the selection of which automatically establishes the internal "connection" to the basic positioner.
- Control using PROFIdrive telegrams 7 and 110
  (for additional information, see the Commissioning Manual.)

7.9.1 Mechanical system

Features

- Backlash compensation (p2583)
- Modulo offset (p2577)

Description

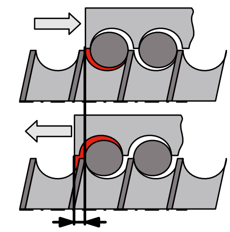


Figure 7-14 Backlash compensation

When mechanical force is transferred between a machine part and its drive, generally backlash occurs. If the mechanical system was to be adjusted/designed so that there was absolutely no play, this would result in high wear. Thus, backlash (play) can occur between the machine component and the encoder. For axes with indirect position sensing, mechanical backlash results in a falsification of the traversing distance, as, at direction reversal, the axis travels either too far or not far enough corresponding to the absolute value of the backlash.

Note

The backlash compensation is active, after

- the axis has been referenced for incremental measuring systems
- the axis has been adjusted for absolute measuring systems

In order to compensate the backlash, the determined backlash must be specified in p2583 with the correct polarity. At each direction of rotation reversal, the axis actual value is corrected dependent on the actual traversing direction and displayed in r2667. This value is taken into account in the position actual value using p2516 (position offset).

If a stationary axis is referenced by setting the reference point or an adjusted axis is powered-up with an absolute encoder, then the setting of parameter p2604 (reference point approach, starting direction) is relevant for switching-in the compensation value.

Table 7-4 The compensation value is switched in as a function of p2604

p2604	Traversing direction	Switch in compensation value
0	positive	none
	negative	immediately
1	positive	immediately
	negative	none

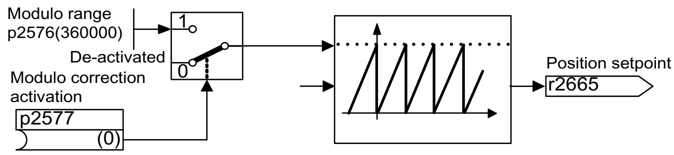


Figure 7-15 Modulo offset

A modulo axis has an unrestricted traversing range. The value range of the position repeats itself after a specific value that can be parameterized (the modulo range or axis cycle), e.g. after one revolution: 360° -> 0°. The modulo range is set in parameter p2576, the offset is activated with parameter p2577. The modulo offset is undertaken at the setpoint end. This is provided with the correct sign via connector output r2685 (correction value) to appropriately correct the position actual value. EPOS initiates the activation of the correction via a rising edge of binector output r2684.7 (activate correction) (r2685 (correction value) and r2684.7 (activate correction) are already connected as standard with the corresponding binector/connector input of the position actual value conditioning). Absolute positioning details (e.g. in a motion command) must always be within the modulo range. Modulo offset can be activated for linear and rotary length units. The traversing range cannot be limited by a software limit switch.

With active modulo offset and the application of absolute encoders, as a result of potential encoder overflows, it must be ensured that there is an integer ratio v between the multiturn resolution and the modulo range.

The ratio v can be calculated as follows:

- 1. Motor encoder without position tracking:

  v = p421 * p2506 * p0433 * p2505 / (p0432 * p2504 * p2576)
- 2. Motor encoder with position tracking for the measuring gearbox:

  v = p0412 * p2506 * p2505 / (p2504 * p2576)
- 3. Motor encoder with position tracking for the load gear:

  v = p2721 * p2506 * p0433 / (p0432 * p2576)
- 4. Motor encoder with position tracking for the load and measuring gearbox:

  v = p2721 * p2506 / p2576)
- 5. Direct encoder without position tracking:

  v = p0421 * p2506 * p0433 / (p0432 * p2576)
- 6. Direct encoder with position tracking for the measuring gearbox:

  v = p0412 * p2506 / p2576)

With position tracking it is recommended to change p0412 or p2721.

Function diagrams (see SINAMICS S List Manual)

- 3635 Interpolator
- 4010 Position actual value conditioning

Overview of key parameters (see SINAMICS S List Manual)

- p2576 EPOS modulo offset, modulo range
- p2577 BI: EPOS modulo offset activation
- p2583 EPOS backlash compensation
- r2684 CO/BO: EPOS status word 2
- r2685 CO: EPOS correction value

Commissioning with STARTER

In STARTER, the mechanical system screen form can be found under position control.

7.9.2 Limits

Description

The velocity, acceleration and deceleration can be limited and the software limit switches and stop cams set.

Features

- Traversing profile limits
  - Maximum velocity (p2571)
  - Maximum acceleration (p2572) / maximum deceleration (p2573)
- Traversing range limits
  - Software limit switch (p2578, p2579, p2580, p2581, p2582)
  - STOP cams (p2568, p2569, p2570)
- Jerk limitation
  - Jerk limitation (p2574)
  - Activation of jerk limitation (p2575)

Maximum velocity

The maximum velocity of an axis is defined using parameter p2571. The velocity should not be set to be greater than the maximum speeds in r1084 and r1087.

The drive is limited to this velocity if a higher velocity is specified or programmed via the override (p2646) for the reference point approach or is programmed in the traversing block.

Parameter p2571 (maximum velocity) defines the maximum traversing velocity in units 1000 LU/min. If the maximum velocity is changed, then this limits the velocity of a traversing task that is presently being executed.

This limit is only effective in the positioning mode for:

- Jog mode
- Processing traversing blocks
- Direct setpoint input/MDI for positioning/setting-up
- Reference point approach

Maximum acceleration/deceleration

Parameter p2572 (maximum acceleration) and p2573 (maximum deceleration) define the maximum acceleration and the maximum deceleration. In both cases, the units are 1000 LU/s^2.

Both values are relevant for:

- Jog mode
- Processing traversing blocks
- Direct setpoint input/MDI for positioning and setting-up
- Reference point approach

The parameters do not have any effect when faults occur with the fault responses OFF1 / OFF2 / OFF3.

In the traversing blocks mode, the acceleration and deceleration can be set in multiple integer steps (1 %, 2 % ... 100 %) of the maximum acceleration and deceleration. In “direct setpoint input/MDI for positioning and setting up” operating mode, the acceleration/delay override (assignment of 4000 hex = 100%) is specified.

Note

A maximum acceleration or deceleration dependent on the actual velocity (transitioned acceleration) is not supported.

Note

When using the PROFIdrive message frame 110, the velocity override is already connected and has to be supplied by the message frame.

Software limit switches

The connector inputs p2578 (software limit switch minus) and p2579 (software limit switch plus) limit the position setpoint if the following prerequisites are fulfilled:

- The software limit switches are activated (p2582 = "1")
- The reference point is set (r2684.11 = 1)

- The modulo correction is not active (p2577 = "0")

The connector inputs are, in the factory setting, linked to the connector output p2580 (software limit switch minus) and p2581 (software limit switch plus).

Stop cam

A traversing range can, on one hand, be limited per software using the software limit switches and on the other hand, the traversing range can be limited per hardware. In this case, the functionality of the stop cam (hardware limit switch) is used. The function of the stop cams is activated by the 1 signal on the binector input p2568 (activation of stop cams).

Once enabled, the activity of binector inputs p2569 (stop cam, minus) and p2570 (stop cam, plus) is checked. These are low active; this means if a 0 signal is present at binector input p2569 or p2570, then these are active.

When a stop cam (p2569 or p2570) is active, the actual motion is stopped with the maximum deceleration (p2573) and the appropriate status bit r2684.13 (stop cam minus active) or r2684.14 (stop cam plus active) is set.

When stop cams are actuated, only motion that allows the axis to move away from the stop cam is permitted (if both stop cams are actuated, then no motion is possible). When the stop cam is exited, this is identified by the 0/1 edge in the permitted traversing direction and this means that the corresponding status bits (r2684.13 or r2684.14) are reset.

Jerk limitation

Acceleration and deceleration can change suddenly if jerk limiting has not been activated. The diagram below shows the traversing profile when jerk limitation has not been activated. The diagram shows that maximum acceleration (a_{max}) and deceleration (d_{max}) are effective immediately. The drive accelerates until the target speed (v_{target}) is reached and then switches to the constant velocity phase.

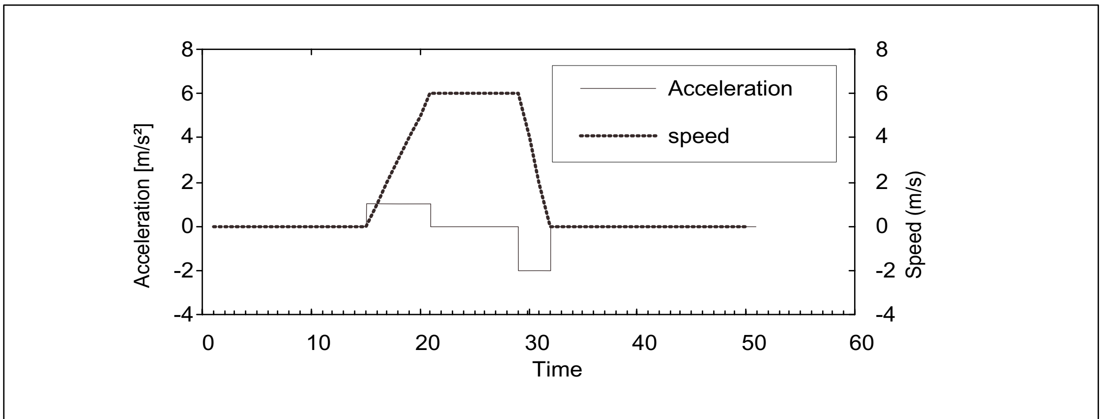


Figure 7-16 Without jerk limitation

Jerk limitation can be used to achieve a ramp-like change of both variables, which ensures "smooth" acceleration and braking as shown in the diagram below. Ideally, acceleration and deceleration should be linear.

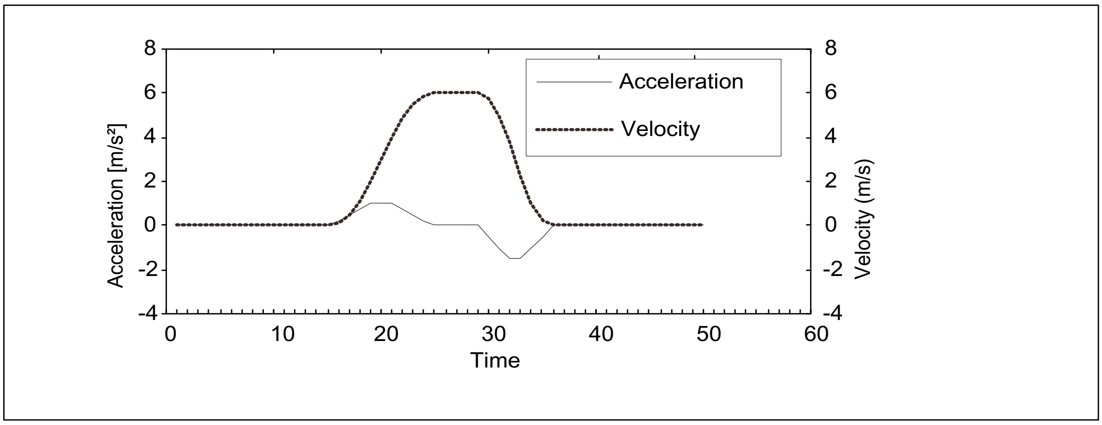


Figure 7-17 Activated jerk limitation

The maximum inclination (r_k) can be set in parameter p2574 ("Jerk limitation") in the unit LU/s^3 for both acceleration and braking. The resolution is 1000 LU/s^3. To activate limiting permanently, set parameter p2575 ("Active jerk limitation") to 1. In this case, limitation cannot be activated or deactivated in traversing block mode by means of the command "JERK" as this would require parameter p2575 ("Activate jerk limitation") to be set to zero. The status signal r2684.6 ("Jerk limitation active") indicates whether or not jerk limitation is active.

Limitation is effective:

- In jog mode
- When traversing blocks are processed
- When setpoints are defined directly/MDI for positioning and setup
- during referencing
- During stop responses due to alarms

Jerk limitation is not active when alarms occur with stop responses OFF1 / OFF2 / OFF3.

Function diagram overview (see SINAMICS S List Manual)

- 3630 Traversing range limits

Overview of key parameters (see SINAMICS S List Manual)

- p2571 EPOS maximum velocity
- p2572 EPOS maximum acceleration
- p2573 EPOS maximum deceleration
- p2646 CI: EPOS velocity override

Software limit switches:

- p2578 CI: EPOS software limit switch, minus signal source
- p2579 CI: EPOS software limit switch, plus signal source
- p2580 CO: EPOS software limit switch, minus

- p2581 CO: EPOS software limit switch, plus
- p2582 BI: EPOS software limit switch activation
- r2683 CO/BO: EPOS status word 1

STOP cam

- p2568 BI: EPOS STOP cam activation
- p2569 BI: EPOS STOP cam, minus
- p2570 BI: EPOS STOP cam, plus
- r2684 CO/BO: EPOS status word 2

7.9.3 Referencing

Features

- Reference point offset (p2600)
- Reversing cams (p2613, p2614)
- Reference cam (p2612)
- Binector input start (p2595)
- Binector input setting (p2596)
- Velocity override (p2646)
- Reference point coordinate (p2598, p2599)
- Selecting the referencing type (p2597)
- Absolute encoder adjustment (p2507)

NOTICE
Referencing distance-coded zero marks is not supported.

Description

After a machine has been powered-up, for positioning, the absolute dimension reference must be established to the machine zero. This operation is known as referencing.

The following referencing types are possible:

- Setting the reference point (all encoder types)
- Incremental encoder
  Active referencing (reference point approach (p2597 = 0)):
  – Reference cams and encoder zero mark (p2607 = 1)
  – Encoder zero mark (p0495 = 0)
  – External zero mark (p0495 ≠ 0)

- Flying referencing (passive (p2597 = 1))
- Absolute encoder
  - Absolute encoder adjustment
  - Flying referencing (passive (p2597 = 1))

A connector input is provided for all referencing types to input the reference point coordinate; this allows, e.g. the change/input via the higher-level control. However, to permanently enter the reference point coordinate, a setting parameter for this quantity is also required. As standard, this setting parameter p2599 is interconnected to connector input p2598.

Set reference point

The reference point can be set using a 0/1 edge at binector input p2596 (set reference point) if no traversing commands are active or they have been interrupted by an intermediate stop and the actual position value is valid (p2658 = 1 signal). The current actual position of the drive is set here as the reference point using the coordinates specified by connector input p2598 (reference point coordinates). The setpoint (r2665) is adjusted accordingly.

This function also uses actual position value correction for the position controller (p2512 and p2513). Connector input p2598 is connected to setting parameter p2599 as standard. The binector input is not effective for the traversing task being presently executed.

Absolute encoder adjustment

Absolute encoders must be adjusted while commissioning. After the machine has been powered-down the position information of the encoder is kept.

When p2507 = 2 is entered, using the reference point coordinate in p2599, an offset value (p2525) is determined. This is used to calculate the position actual value (r2521). Parameter p2507 signals the adjustment with a "3" - in addition bit r2684.11 (reference point set) is set to "1".

The offset of the encoder adjustment (p2525) should be saved in a non-volatile fashion (RAM to ROM) to permanently save it.

Note

If an adjustment is lost on an already adjusted axis, the axis will remain unadjusted from CU320 with order number 6SL3040-...-0AA1 and version C or higher or CU310 even when the drive unit is switched OFF/ON. The axis needs to be adjusted again in such cases.

> **CAUTION**
>
> During adjustment with the rotary absolute encoder, a range is aligned symmetrically around the zero point with half the encoder range within which the position is restored after switch off/on. If position tracking is deactivated (2720.0 = 0), only one encoder overflow is permitted to occur in this range (further details are given in chapter Position controller -> Actual position value conditioning). Once adjustment has been carried out, the range must not be exited because a unique reference between the actual encoder value and the mechanical components cannot be established outside the range.
>
> If the reference point p2599 is in the encoder range, the actual position value is set in line with the reference point during adjustment. Otherwise, it is set to a corrected value in the encoder range.
>
> No overflow occurs with linear absolute encoders, which means that the position can be restored within the entire traversing range after switch on/off once adjustment has been carried out. During adjustment, the actual position value is set in line with the reference point.

Reference point approach for incremental measurement systems

When the reference point approach (in the case of an incremental measuring system), the drive is moved to its reference point. In so doing, the drive itself controls and monitors the complete referencing cycle.

Incremental measuring systems require that after the machine has been powered-up, the absolute dimension reference is established to the machine zero point. When powering-up the position actual value x_0 in the non-referenced state is set to $x_0 = 0$. Using the reference point approach, the drive can be reproducibly moved to its reference point. The geometry with a positive starting direction (p2604 = "0") is shown in the following.

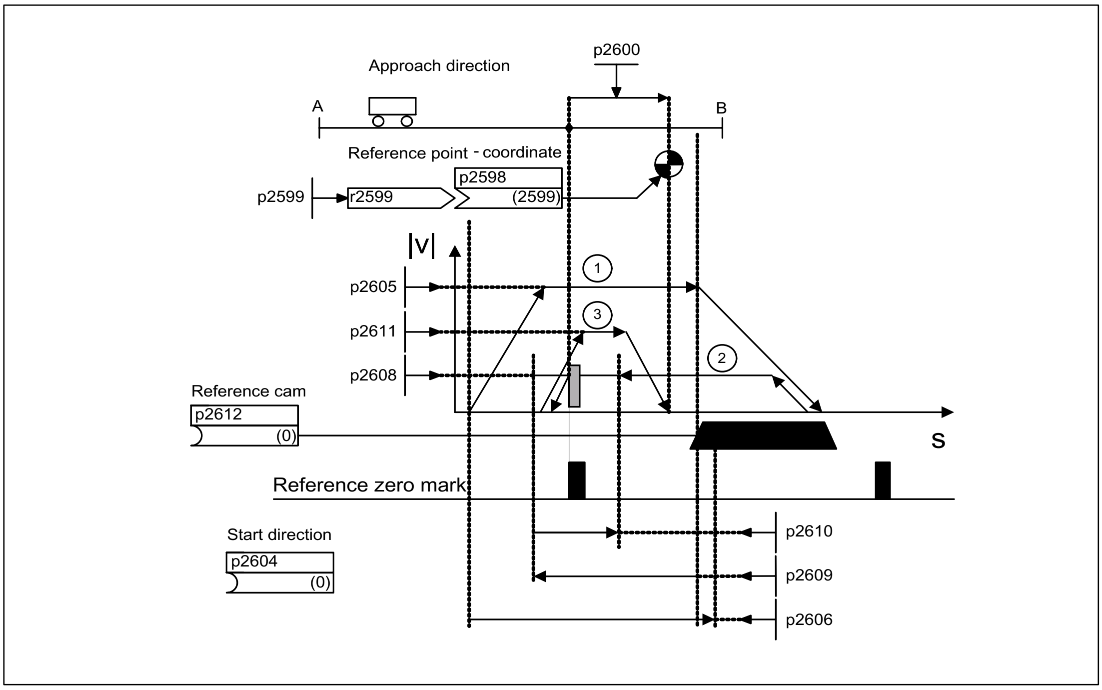


Figure 7-18 Example: homing with reference cam

The signal on binector input p2595 (start homing) is used to trigger travel to the reference cam (p2607 = 1) if search for reference is selected at the same time (0 signal at binector input p2597 (homing type selection). The signal in binector input p2595 (start homing) must be set during the entire referencing process otherwise the process is aborted. Once started, the status signal r2684.11 (reference point set) is reset.

The software limit switch monitoring is inactive during the complete reference point approach; only the maximum traversing range is checked. The SW limit switch monitoring is, if required, re-activated after completion.

The velocity override set is only effective during the search for the reference cam (step 1). This ensures that the "cam end" and "zero mark" positions are always overrun at the same speed. If signal propagation delays arise during switching processes, this ensures that the offset caused during establishment of position is the same in each homing process.

Axes that only have one zero mark over their complete traversing or modulo range are designated with parameter p2607 = 0 (no reference cam present). After starting the homing process, synchronization to the reference zero marks is started straight away (see step 2) for these axes.

Search for reference, step 1: travel to reference cam

If there is no reference cam present (p2607 = 0), go to step 2.

When the homing process is started, the drive accelerates at maximum acceleration (p2572) to the reference cam approach velocity (p2605). The direction of the approach is determined by the signal of binector input p2604 (search for reference start direction).

When the reference cam is reached, this is communicated to the drive using the signal at binector input p2612 (reference cam); the drive then brakes down to standstill with the maximum deceleration (p2573).

If a signal at binector input p2613 (reversing cam, minus) or at binector input p2614 (reversing cam, plus) is detected during the search for reference, the search direction is reversed. The reversing cams are low active. If both reversing cams are active (p2613 = "0" and p2614 = "0"), the drive remains stationary. As soon as the reference cam is found, then synchronization to the reference zero mark is immediately started (refer to step 2).

If the axis leaves its start position and travels the distance defined in parameter p2606 (max. distance to reference cam) heading towards the reference cam without actually reaching the reference cam, the drive remains stationary and fault F07458 (reference cam not found) is issued.

If the axis is already located at the cam, when referencing is started, then traversing to the reference cam is not executed, but synchronization to the reference zero mark is immediately started (refer to step 2).

Note

The velocity override is effective during the search for the cam. By changing the encoder data set, status signal r2684.11 (reference point set) is reset.

The cam switch must be able to delivery both a rising and a falling edge. For a reference point approach with evaluation of the encoder zero mark, for increasing position actual values the 0/1 edge is evaluated and for decreasing position actual values, the 1/0 edge. Inversion of the edge evaluation is not possible at the sensor zero mark.

If the length measuring system has several zero marks which repeat at cyclic intervals (e.g. incremental, rotary measuring system), you must ensure that the cam is adjusted so that the same zero mark is always evaluated.

The following factors may impact on the characteristics of the "reference cam" control signal:

- Switching accuracy and time delay of reference cam switch
- Position controller cycle of drive
- Interpolation cycle of drive
- Temperature sensitivity of machine’s mechanical system

Search for reference, step 2: Synchronizing to the reference zero mark (encoder zero mark or external zero mark)

Reference cam available (p2607 = 1):

In step 2, the drive accelerates to the velocity, specified in p2608 (zero mark approach velocity) in the direction opposite to that specified using binector input p2604 (reference point approach start direction). The zero mark is expected at distance p2609 (max. distance to zero mark). The search for the zero mark is active (status bit r2684.0 = "1" (search for reference active)) as soon as the drive leaves the cam (p2612 = "0") and is within the tolerance band for evaluation (p2609 - p2610). If the position of the zero mark is known (encoder evaluation), the actual position of the drive can be synchronized using the zero mark. The drive starts the search for reference (see step 3). The distance moved between the end of the cam and the zero mark is displayed in diagnostics parameter r2680 (difference between the cam - zero mark).

Encoder zero mark available (p0495 = 0), no reference cam (p2607 = 0):

Synchronization to the reference zero mark begins as soon as the signal at binector input p2595 (start homing) is detected. The drive accelerates to the velocity, specified in parameter p2608 (zero mark approach velocity) in the direction specified by the signal of binector input p2604 (reference point approach start direction).

The drive synchronizes to the first zero mark and then starts to travel towards the reference point (see step 3).

Note

In this case the direction of approach to the reference zero mark is the opposite to the axes with reference cams!

External zero mark present (p0495 ≠ 0), no reference cam (p2607 = 0):

Synchronization to an external zero mark begins as soon as the signal at binector input p2595 (start homing) is detected. The drive accelerates to the velocity, specified in parameter p2608 (zero mark approach velocity) in the direction specified by the signal of binector input p2604 (reference point approach start direction). The drive synchronizes to the first external zero mark (p0495). The drive continues to travel with the same velocity and travel is started to the reference point (refer to step 3).

Note

The velocity override is inoperative during this process.

An equivalent zero mark can be set using parameter p0495 (equivalent zero mark input terminal) and the corresponding digital input selected. As standard, for increasing actual position values, the 0/1 edge is evaluated and for decreasing position actual values, the 1/0 edge. For the equivalent zero mark, this can be inverted using parameter p0490 (invert measuring probe or equivalent zero mark).

Search for reference, step 3: Travel to reference point

Travel to the reference point is started when the drive has successfully synchronized to the reference zero mark (see step 2). Once the reference zero mark has been detected, the drive accelerates on-the-fly to the reference point approach velocity set in parameter p2611. The reference point offset (p2600), the distance between the zero mark and reference point, is extended.

If the axis has reached the reference point, then the position actual value and setpoint are set to the value specified using connector input p2598 (reference point coordinate) (as standard, connector input p2598 is connected with setting parameter p2599). The axis is then homed and the status signal r2684.11 (reference point set) set.

Note

The velocity override is inoperative during this process.

If the braking distance is longer than the reference point offset or a direction reversal is required as a result of the selected reference point offset, then after detecting the reference zero mark, the drive initially brakes to standstill and then travels back.

On-the-fly homing

The mode "flying referencing" (also known as post-referencing, positioning monitoring), which is selected using a "1" signal at binector input p2597 (select referencing type), can be used in every mode (jogging, traversing block and direct setpoint input for positioning/setting-up) and is superimposed on the currently active mode. Flying referencing can be selected both with incremental and absolute measuring systems.

When "flying referencing" during incremental positioning (relative) you can select whether the offset value is to be taken into account for the travel path or not (p2603).

The "flying referencing" is activated by a 0/1 edge at binector input p2595 (start referencing). The signal in binector input p2595 (start homing) must be set during the entire referencing process otherwise the process is aborted.

Status bit r2684.1 (passive/flying referencing active) is linked with binector input p2509 (activate measurement probe evaluation). It activates measurement probe evaluation. Binector inputs p2510 (measurement probe selection) and p2511 (measurement probe edge evaluation) can be used to set which measurement probe (1 or 2) and which measurement edge (0/1 or 1/0) is to be used.

The measurement probe pulse is used to supply connector input p2660 (home measurement value) with the measurement via parameter r2523. The validity of the measurement is reported to binector input p2661 (measurement valid feedback) via r2526.2.

Note

The following must always apply to the "Flying referencing mode" windows:

p2602 (outer window) > p2601 (inner window).

See function diagram 3614 for more information on the "Flying referencing mode" function.

The following then happens:

- If the drive has not yet been homed, status bit r2684.11 (reference point set) is set to "1".
- If the drive has already been homed, status bit r2684.11 (reference point set) is not reset when starting flying referencing.
- If the drive has already been homed and the position difference is less than the inner window (p2601), the old actual position value is retained.
- If the drive has already been homed and the position difference is more than the outer window (p2602), warning A07489 (reference point offset outside window 2) is output and the status bit r2684.3 (pressure mark outside window 2) set. No offset to the actual position value is undertaken.
- If the drive has already been referenced and the absolute value of the position difference is greater than the inner window (p2601) and less the outer window (p2602), then the position actual value is corrected.

Note

Flying referencing is not an active operating mode. It is superimposed by an active operating mode.

In contrast to searches for reference, flying referencing can be carried out superimposed by the machine process.

As standard, for flying referencing, measuring probe evaluation is used; when enabled, the measuring probe is selected (p2510) and the edge evaluation (p2511) (in the factory setting, measuring probe 1 is always the measuring probe, flank evaluation in the factory setting is always the 0/1 edge).

Instructions for switching data sets

Using drive data set switching (DDS), motor data sets (p0186) and encoder data sets (p0187 to p0189) can be switched. The following table shows when the reference bit (r2684.11) or the status of the adjustment with absolute encoders (p2507) is reset.

In the following cases, when a DDS switch takes place, the current actual position value becomes invalid (p2521 = 0) and the reference point (r2684.11 = 0) is reset.

- The EDS that is effective for the position control changes.
- The encoder assignment changes (p2502).
- The mechanical relationships change (p2503...p2506)

With absolute encoders, the status of the adjustment (p2507) is also reset, if the same absolute encoder is selected for the position control although the mechanical relationships have changed (p2503 ... p2506).

In operating mode, an error message (F07494) is also generated.

The following table contains a few examples for data set switching. The initial data set is always DDS0.

Table 7-5 DDS switch without load gearbox position tracking

DDS	p186 (MDS)	p187 (encoder_1)	p188 (encoder_2)	p189 (encoder_3)	Encoder for position control p2502	Mecha-nical conditions p2504/ p2505/ p2506 or p2503	Load gearbox position tracking	Changeover response
0	0	EDS0	EDS1	EDS2	encoder_1	xxx	disabled	---
1	0	EDS0	EDS1	EDS2	encoder_1	xxx	disabled	Switching during pulse inhibition or operation has no effect
2	0	EDS0	EDS1	EDS2	encoder_1	yyy	disabled	Pulse disabling: Position actual value preprocessing is newly initiated [1)] and reference bit [2)] is reset. Operation: Error message is generated. Position actual value preprocessing is newly initiated [1)] and reference bit [2)] is reset.
3	0	EDS0	EDS1	EDS2	encoder_2	xxx	disabled	Pulse disabling: Position actual value preprocessing is newly initiated [1)] and
4	0	EDS0	EDS3	EDS2	encoder_2	xxx	disabled	
5	1	EDS4	EDS1	EDS2	encoder_1	xxx	disabled	

6	2	EDS5	EDS6	EDS7	encoder_1	zzz	disabled	reference bit 3) is reset. Operation: Error message is generated. Position actual value preprocessing is newly initiated 1) and reference bit 3) is reset.
7	3	EDS0	EDS1	EDS2	encoder_1	xxx	disabled	MDS switching alone during pulse disable or operation has no effect

1) Is newly initiated means: For absolute encoders, the absolute value is newly read out, and for incremental encoders, a restart will take place as after POWER ON.
2) For incremental encoders, r2684.11 ("Reference point set") is reset, and for absolute encoders, also the status of the adjustment (p2507).
3) For incremental encoders, r2684.11 ("Reference point set") is reset, and for absolute encoders, the adjustment status (p2507) is not reset because the EDS differs from the original one.
xxx, yyy, zzz: different mechanical conditions

Function diagrams (see SINAMICS S List Manual)

- 3612 Referencing
- 3614 Flying referencing

Overview of key parameters (see SINAMICS S List Manual)

- p2596 BI: EPOS set reference point
- p2597 BI: EPOS homing type selection
- p2598 CI: EPOS reference point coordinate, signal source
- p2599 CO: EPOS reference point coordinate value
- p2600 EPOS reference point approach, reference point offset

7.9.4 Traversing blocks

Description

Up to 64 different traversing tasks can be saved. The maximum number is set using parameter p2615 (maximum number of traversing tasks). All parameters which describe a traversing order are effective during a block change, i.e. if:

- The appropriate traversing block number is selected using binector inputs p2625 to p2630 (block selection, bits 0...5) and started using the signal at binector input p2531 (activate traversing task).
- A block change is made in a sequence of traversing tasks.

- An external block change p2632 "External block change" is triggered.

Traversing blocks are parameterized using parameter sets that have a fixed structure:

- Traversing block number (p2616[0...63])
  Every traversing block must be assigned a traversing block number (in STARTER "No.").
  The traversing blocks are executed in the sequence of the traversing block numbers.
  Numbers containing the value "-1" are ignored so that the space can be reserved for subsequent traversing blocks, for example.
- Task (p2621[0...63])
  1: POSITIONING
  2: FIXED ENDSTOP
  3: ENDLESS_POS
  4: ENDLESS_NEG
  5: WAIT
  6: GOTO
  7: SET_O
  8: RESET_O
  9: JERK
- Motion parameters
  - Target position or traversing distance (p2617[0...63])
  - Velocity (p2618[0...63])
  - Acceleration override (p2619[0...63])
  - Deceleration override (p2620[0...63])
- Task mode (p2623[0...63])
  The execution of a traversing task can be influenced by parameter p2623 (task mode).
  This is automatically written by programming the traversing blocks in STARTER.
  Value = 0000 cccc bbbb aaaa
  - aaaa: Display/hide
    0000: Block is not hidden
    0001: Block is hidden
    A hidden block cannot be selected binary-coded via binector inputs p2625 to p2630.
    An alarm is output if you attempt to do so.
  - bbbb: Continuation condition
    0000, END: 0/1 edge at p2631
    0001, CONTINUE_WITH_STOP:
    The exact position parameterized in the block is approached (brake to standstill and positioning window monitoring) before block processing can continue.
    0010, CONTINUE_ON-THE-FLY:
    The system switches to the next traversing block "on the fly" when the braking point for the current block is reached (if the direction needs to be changed, this does not occur until the drive stops within the positioning window).
    0011, CONTINUE_EXTERNAL:
    Same as "CONTINUE_ON-THE-FLY", except that an instant block change can be triggered up to the braking point by a 0/1 edge. The 0/1 edge can be connected to parameter r2526.2 of the "position control" function module, via the binector input p2633 with p2632 = 1, or via the measuring input p2661 with p2632 = 0. Position detection via the measuring input can be used as an accurate starting position for relative positioning. If an external block change is not triggered, a block change is triggered at the braking point.
    0100, CONTINUE_EXTERNAL_WAIT
    Control signal "External block change" can be used to trigger a flying changeover to

the next task at any time during the traveling phase. If "External block change" is not triggered, the axis remains in the parameterized target position until the signal is issued. The difference here is that with CONTINUE_EXTERNAL, a flying changeover is carried out at the braking point if "External block change" has not been triggered, while here the drive waits for the signal in the target position.
0101, CONTINUE_EXTERNAL_ALARM
This is the same as CONTINUE_EXTERNAL_WAIT, except that alarm A07463 "External traversing block change in traversing block x not requested" is output when "External block change" is not triggered by the time the drive comes to a standstill. The alarm can be converted to an alarm with a stop response so that block processing can be aborted if the control signal is not issued.

– cccc: positioning mode
With the POSITON task (p2621 = 1), defines how the position specified in the traversing task is to be approached.
0000, ABSOLUTE:
The position specified in p2617 is approached.
0001, RELATIVE:
The axis is traveled along the value specified in p2617.
0010, ABS_POS:
For rotary axes with modulo offset only. The position specified in p2617 is approached in a positive direction.
0011, ABS_NEG:
For rotary axes with modulo offset only. The position specified in p2617 is approached in a negative direction.

- Task parameter (command-dependent significance) (p2622[0...63])

Intermediate stop and reject traversing task

The intermediate stop is activated when a 0 signal at p2640. After activation, the system brakes with the parameterized deceleration value (p2620 or p2645).

The current traversing task can be canceled by a 0 signal at p2641. After activation, the system brakes with the maximum deceleration (p2573).

The "intermediate stop" and "cancel traversing task" functions are only effective in the modes "traversing blocks" and "direct setpoint input/MDI".

POSITIONING

The POSITIONING task initiates motion. The following parameters are evaluated:

- p2616[x] Block number
- p2617[x] Position
- p2618[x] Velocity
- p2619[x] Acceleration override
- p2620[x] Acceleration override
- p2623[x] Task mode

The task is executed until the target position is reached. If, when the task is activated, the drive is already located at the target position, then for the block change enable (CONTINUE_ON-THE-FLY or CONTINUE_EXTERNAL, the text task is selected in the same interpolation clock cycle. For CONTINUE_WITH_STOP, the next block is activated in the next interpolation clock cycle. CONTINUE_EXTERNAL_ALARM causes a message to be output immediately.

FIXED STOP

The FIXED STOP task triggers a traversing movement with reduced torque to fixed stop.

The following parameters are relevant:

- p2616[x] Block number
- p2617[x] Position
- p2618[x] Velocity
- p2619[x] Acceleration override
- p2620[x] Acceleration override
- p2623[x] Task mode
- p2622[x] Task parameter clamping torque in Nm with rotary motors or clamping force in N with linear motors.

Possible continuation conditions include END, CONTINUE_WITH_STOP, CONTINUE_EXTERNAL, CONTINUE_EXTERNAL_WAIT.

ENDLESS POS, ENDLESS NEG

Using these tasks, the axis is accelerated to the specified velocity and is moved, until:

- A software limit switch is reached.
- A STOP cam signal has been issued.
- The traversing range limit is reached.
- Motion is interrupted by the control signal "no intermediate stop/intermediate stop (p2640).
- Motion is interrupted by the control signal "do not reject traversing task/reject traversing task" (p2641).
- An external block change is triggered (with the appropriate continuation condition).

The following parameters are relevant:

- p2616[x] Block number
- p2618[x] Velocity
- p2619[x] Acceleration override
- p2623[x] Task mode

All continuation conditions are possible.

JERK

Jerk limitation can be activated (command parameter = 1) or deactivated (task parameter = 0) by means of the JERK task. The signal at the binector input p2575 "Active jerk limitation" must be set to zero. The value parameterized in "jerk limit" p2574 is the jerk limit.

A precise stop is always carried out here regardless of the parameterized continuation condition of the task preceding the JERK task.

The following parameters are relevant:

- p2616[x] Block number
- p2622[x] Task parameter = 0 or 1

All continuation conditions are possible.

WAITING

The WAIT order can be used to set a waiting period, which should expire before the following order is processed.

The following parameters are relevant:

- p2616[x] Block number
- p2622[x]Task parameter = delay time in milliseconds ≥ 0 ms
- p2623[x] Task mode

The delay time is entered in milliseconds - but is rounded-off to a multiple of the interpolator clock cycles p0115[5]. The minimum delay time is one interpolation clock cycle; this means that if a delay time is parameterized, which is less than an interpolation clock cycle, then the system waits for one interpolation clock cycle.

Example:

Wait time: 9 ms
Interpolation clock cycle: 4 ms
Active waiting time: 12 ms

A precise stop is always carried out here before the wait time regardless of the parameterized continuation condition of the order preceding the WAIT order. The WAIT task can be executed by an external block change.

Possible continuation conditions include END, CONTINUE_WITH_STOP, CONTINUE_EXTERNAL, CONTINUE_EXTERNAL_WAIT, and CONTINUE_EXTERNAL_ALARM. The alarm is triggered when "External block change" has still not been issued after the waiting time has elapsed.

GOTO

Using the GOTO task, jumps can be executed within a sequence of traversing tasks. The block number which is to be jumped to must be specified as task parameter. A continuation condition is not permissible. If there is a block with this number, then alarm A07468 (jump destination does not exist in traversing block x) is output and the block is designated as being inconsistent.

The following parameters are relevant:

- p2616[x] Block number
- p2622[x] Task parameter = Next traversing block number

Any two of the SET_O, RESET_O and GOTO orders can be processed in an interpolation cycle and a subsequent POSITION and WAIT order can be started.

SET_O, RESET_O

The tasks SET_O and RESET_O allow up to two binary signals (output 1 or 2) to be simultaneously set or reset. The number of the output (1 or 2) is specified bit-coded in the task parameter.

The following parameters are relevant:

- p2616[x] Block number
- p2622[x] Task parameter = bit-coded output:
  0x1: Output 1
  0x2: Output 2
  0x3: Output 1 + 2

Possible continuation conditions are END, CONTINUE_ON-THE-FLY and CONTINUE_WITH_STOP, and CONTINUE_EXTERNAL_WAIT.

The binary signals (r2683.10 (output 1) (or r2683.11 (output 2)) can be assigned to digital outputs. The assignment in STARTER is made using the button "configuration digital output".

Any two of the SET_O, RESET_O and GOTO orders can be processed in an interpolation cycle and a subsequent POSITION and WAIT order can be started.

Function diagrams (see SINAMICS S List Manual)

- 3616 Traversing blocks operating mode

Overview of key parameters (see SINAMICS S List Manual)

- p2616 EPOS traversing block, block number
- p2617 EPOS traversing block, position
- p2618 EPOS traversing block, velocity
- p2619 EPOS traversing block, acceleration override
- p2620 EPOS traversing block, deceleration override
- p2621 EPOS traversing block, task
- p2622 EPOS traversing block, task parameter
- p2623 EPOS traversing block, task mode
- p2625...p2630 BI: EPOS block selection bits 0 ... 5

7.9.5 Travel to fixed stop

7.9.5.1 Introduction

The "Travel to fixed stop" function can be used, for example, to traverse sleeves to a fixed stop against the workpiece with a predefined torque. In this way, the workpiece can be securely clamped. The clamping torque can be parameterized in the traversing task (p2622). An adjustable monitoring window for travel to fixed stop prevents the drive from traveling beyond the window if the fixed stop should break away.

In positioning mode, traversing to a fixed stop is started when a traversing block is processed with the FIXED STOP command. In this traversing block, in addition to the specification of the dynamic parameterized position, speed, acceleration override and delay override, the required clamping torque can be specified as task parameter p2622. From the start position onwards, the target position is approached with the parameterized speed. The fixed stop (the workpiece) must be between the start position and the braking point of the axis; that is, the target position is placed inside the workpiece. The preset torque limit is effective from the start, i.e. traversing to fixed stop also occurs with a reduced torque. The preset acceleration and delay overrides and the current speed override are also effective. Dynamic following error monitoring (p2546) in the position controller is not effective when traveling to the fixed stop. As long as the drive travels to the fixed stop or is in fixed stop, the "Traversing to fixed stop active" status bit r2683.14 is active.

7.9.5.2 Fixed stop reached

As soon as the axis comes into contact with the mechanical fixed stop, the closedloop control in the drive raises the torque so that the axis can move on. The torque increases up to the value specified in the task and then remains constant. Depending on the binector input p2637 (fixed stop reached), the "fixed stop reached" status bit r2683.12 is set if:

- the permissible following error exceeds the value (p2637 = r2526.4) set in parameter p2634 (fixed stop: maximum following error)
- external status via the signal at binector input p2637 (fixed stop reached), if this p2637 ≠ r2526.4

In traversing to fixed stop, the clamping torque or clamping force in the traversing block is configured via the task parameter. It is specified in the units 0.01 Nm or 1 N (rotary axis or linear axis). The function module is coupled to the torque limit of the basic system via the connector output r2686[0] (torque limit upper) or r2686[1] (torque limit lower), which are connected to the connector input p1528 (torque limit upper scaling) or p1529 (torque limit lower scaling). The connector outputs r2686[0] (torque limit upper) and r2686[1] (torque limit lower) are not set to 100% during active fixed stop. During active fixed stop, r2686[0] (torque limit upper) or r2686[1] (torque limit lower) are evaluated as p1522/p1523 in such a way that a limitation to the predefined clamping torque or clamping force is applied.

When the fixed stop is acknowledged (p2637), the "Speed setpoint total" (p2562) is recorded, as long as the binector input p2553 (fixed stop reached message) is set. The speed control holds the target torque on the basis of the available speed setpoint. The target torque is output for diagnosis via the connector output r2687 (torque setpoint).

In the fixed stop, if the parameterized clamping torque has been reached, the status bit r2683.13 "fixed stop clamping torque reached" is set.

Once the "fixed stop reached" status has been detected, the traversing task "traverse to fixed stop" is ended. Block relaying is carried out in accordance with the parameterization. The drive remains in fixed stop until the next positioning task is processed or the system is switched to jog mode. The clamping torque is therefore also applied during subsequent waiting tasks. The continuation condition CONTINUE_EXTERNAL_WAIT can be used to specify that the drive should remain in fixed stop until an external signal is given for progression.

As long as the drive remains in fixed stop, the position setpoint is adjusted to the actual position value (position setpoint = actual position value). Fixed stop monitoring and controller enable are active.

Note

If the drive is in fixed stop, it can be referenced using the control signal "set reference point."

If the axis leaves the position that it had at detection of the fixed stop by more than the selected monitoring window for the fixed stop p2635, then the status bit r2683.12 is reset. At the same time, the speed setpoint is set to zero, and the alarm F07484 "fixed stop outside of the monitoring window" is triggered with the reaction OFF3 (quick stop). The monitoring window can be set using the parameter p2635 ("Fixed stop monitoring window"). It applies to both positive and negative traversing directions and must be selected in such a way that only a breaking away causes the alarm to be triggered.

7.9.5.3 Fixed stop is not reached

If the braking point is reached without the "fixed stop reached" status being acknowledged, then the fault F07485 "Fixed stop is not reached" is output with fault reaction OFF1, the torque limit is cancelled and the drive cancels the traversing block.

Note

- The fault can be changed into a warning (see chapter: "Message configuration" in the Commissioning Manual IH1), so that the drive continues processing with the specified block relaying.
- The target point must be sufficiently far inside the workpiece.

7.9.5.4 Cancel

The "traverse to fixed stop" traversing task can be interrupted and continued using the "intermediate stop" signal at the binector input p2640. The block is cancelled using the binector input signal p2641 "Reject traversing task" or by removing the controller enable. In all of these cases, the drive is correspondingly braked. When cancelling occurs, it is ensured that an almost-achieved fixed stop (setpoint already beyond the fixed stop, but still within the threshold for fixed stop detection) will not result in damage. To do this, the setpoint is updated after the standstill (position setpoint = actual position value). As soon as the fixed stop is reached, the drive remains in fixed stop even after cancellation. It can be moved on from the fixed stop using jogging or by selecting a new traversing task.

Note

The fixed stop monitoring window (p2635) is only activated when the drive is in fixed stop and remains active until the fixed stop is exited.

7.9.5.5 Vertical axes

Note

In servo mode, with suspended axes, a torque limit offset (p1532) can be entered (see chapter: Servo Control -> Suspended axes).

With asymmetrical torque limits p1522 and p1523, when traversing to fixed stop, the fixed weight is taken into account in the parameters r2686 and r2687.

If, for example, with a suspended load, the values of p1522 = +1000 Nm and of p1523 = -200 Nm are specified, then a fixed weight of 400 Nm (p1522 - p1523) is assumed. If the clamping torque is now configured as 400 Nm, then, during active traversing to fixed stop, r2686[0] is set with the value 80% and r2686[1] with the value 0% and r2687 with the value 800 Nm.

7.9.5.6 Integration

Function diagram overview (see List Manual)

- 3616 Traversing blocks mode (r0108.4 = 1)
- 3617 Traversing to fixed stop (r0108.4 = 1)
- 4025 Dynamic following error monitoring, cam controllers (r0108.3 = 1)

Overview of important parameters (refer to the List Manual)

- p1528 CI: Torque limit, upper/motoring, scaling
- p1529 CI: Torque limit, lower/regenerative scaling
- p1545 BI: Activates travel to fixed stop
- r2526 CO/BO: LR status word
- p2622 EPOS traversing block, task parameter
- p2634 EPOS Fixed stop maximum permissible following error
- p2635 EPOS Fixed stop monitoring window
- p2637 BI: EPOS Fixed stop reached
- p2638 BI: EPOS Fixed stop outside monitoring window
- r2683 CO/BO: EPOS status word 1
- r2686 CO: EPOS Torque limit effective

7.9.6 Direct setpoint input (MDI)

Features

- Select direct setpoint input (p2647)
- Select positioning type (p2648)
- Direction selection (p2651, p2652)
- Setting-up (p2653)
- Fixed setpoints
  - CO: Position setpoint (p2690)
  - CO: Velocity setpoint (p2691)
  - CO: Acceleration override (p2692)
  - CO: Deceleration override (p2693)
- Connector inputs
  - CI: MDI position setpoint (p2642)
  - CI: MDI velocity setpoint (p2643)
  - CI: MDI acceleration override (p2644)
  - CI: MDI deceleration override (p2645)
  - CI: Velocity override (p2646)
- Accept (p2649, p2650)

Description

The direct setpoint input function allows for positioning (absolute, relative) and setup (endless position-controlled) by means of direct setpoint input (e.g. via the PLC using process data).

During traversing, the motion parameters can also be influenced (on-the-fly setpoint acceptance) and an on-the-fly change can be undertaken between the Setup and Positioning modes. The "direct setpoint input" mode (MDI) can also be used if the axis is not referenced in the "setup" or "relative positioning" modes, which means that "flying referencing" (see the separate section), flying synchronization, and post-referencing are possible.

The direct setpoint input function is activated by p2647 = 1. A distinction is made between two modes: positioning mode (p2653 = 0) and setup mode (p2653 = 1).

In "positioning" mode, the parameters (position, velocity, acceleration and deceleration) can be used to carry out absolute (p2648 = 1) or relative (p2648 = 0) positioning with the parameter p2690 (fixed setpoint position).

In the setting-up mode, using parameters (velocity, acceleration and deceleration) "endless" closed-loop position control behavior can be carried-out.

It is possible to make a flying changeover between the two modes.

If continuous acceptance (p2649 = 1) is activated, changes to the MDI parameters are accepted immediately. Otherwise the values are only accepted when there is a positive edge at binector input p2650 (setpoint acceptance edge).

Note

Continuous acceptance p2649 = 1 can only be set with free telegram configuration p0922 = 999. No relative positioning is allowed with continuous acceptance.

The direction of positioning can be specified using p2651 (positive direction specification) and p2652 (negative direction specification). If both inputs have the same status, the shortest distance is traveled during absolute positioning (p2648 = "1") of modulo axes (p2577 = "1").

To use the positioning function, the drive must be in operating mode (r0002 = 0). The following options are available for starting positioning:

- p2649 is "1" and positive edge on p2647
- p2649 is "0" and p2647 is "1"
  - positive edge on p2650 or
  - positive edge on p2649

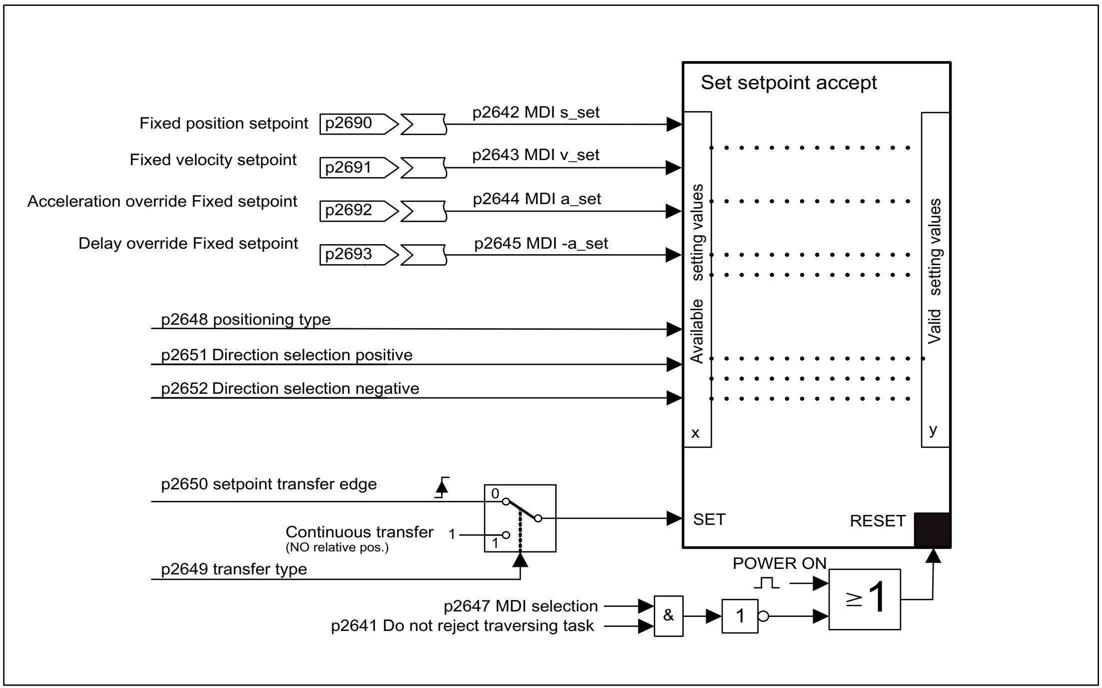


Figure 7-19 Setpoint transfer

MDI mode with the use of PROFIdrive telegram 110.

If the connector input p2654 is preset with a connector input <> 0 (e.g. with PROFIdrive telegram 110 with r2059[11]), then it will internally manage the control signals "Select positioning type", "Positive direction selection" and "Negative direction selection". The following characteristics are evaluated from the value of the connector input:

- xx0x = absolute -> p2648
- xx1x = relative -> p2648

- xx2x = ABS_POS -> p2648, p2651
- xx3x = ABS_NEG -> p2648, p2652

Intermediate stop and canceling traversing block

The intermediate stop is activated by a 0 signal at p2640. After activation, the system brakes with the parameterized deceleration value (p2620 or p2645).

The current traversing task can be canceled by a 0 signal at p2641. After activation, the system brakes with the maximum deceleration (p2573).

The "intermediate stop" and "cancel traversing task" functions are only effective in the modes "traversing blocks" and "direct setpoint input/MDI".

Function diagrams (see SINAMICS S List Manual)

- 3618 EPOS - direct setpoint input mode/MDI, dynamic values
- 3620 EPOS - direct setpoint input mode/MDI

Overview of key parameters (see SINAMICS S List Manual)

- p2577 BI: EPOS modulo offset activation
- p2642 CI: EPOS direct setpoint input/MDI, position setpoint
- p2643 CI: EPOS direct setpoint input/MDI, velocity setpoint
- p2644 CI: EPOS direct setpoint input/MDI, acceleration override
- p2645 CI: EPOS direct setpoint input/MDI, delay override
- p2648 BI: EPOS direct setpoint input/MDI, positioning type
- p2649 BI: EPOS direct setpoint input/MDI, acceptance type
- p2650 BI: EPOS direct setpoint input/MDI, setpoint acceptance edge
- p2651 BI: EPOS direct setpoint input/MDI, positive direction selection
- p2652 BI: EPOS direct setpoint input/MDI, negative direction selection
- p2653 BI: EPOS direct setpoint input/MDI, setup selection
- p2654 CI: EPOS direct setpoint input/MDI, mode adaptation
- p2690 CO: EPOS position, fixed setpoint
- p2691 CO: EPOS velocity, fixed setpoint
- p2692 CO: EPOS acceleration override, fixed setpoint
- p2693 CO: EPOS delay override, fixed setpoint

7.9.7 Jog

Features

- Jog signals (p2589, p2590)
- Velocity (p2585, p2586)
- Incremental (p2587, p2588, p2591)

Description

Using parameter p2591 it is possible to change over between jog incremental and jog velocity.

The traversing distances p2587 and p2588 and velocities p2585 and p2586 are entered using the jog signals p2589 and p2590. The traversing distances are only effective for a "1" signal at p2591 (jog, incremental). For p2591 = "0" then the axis moves to the start of the traversing range or the end of the traversing range with the specified velocity.

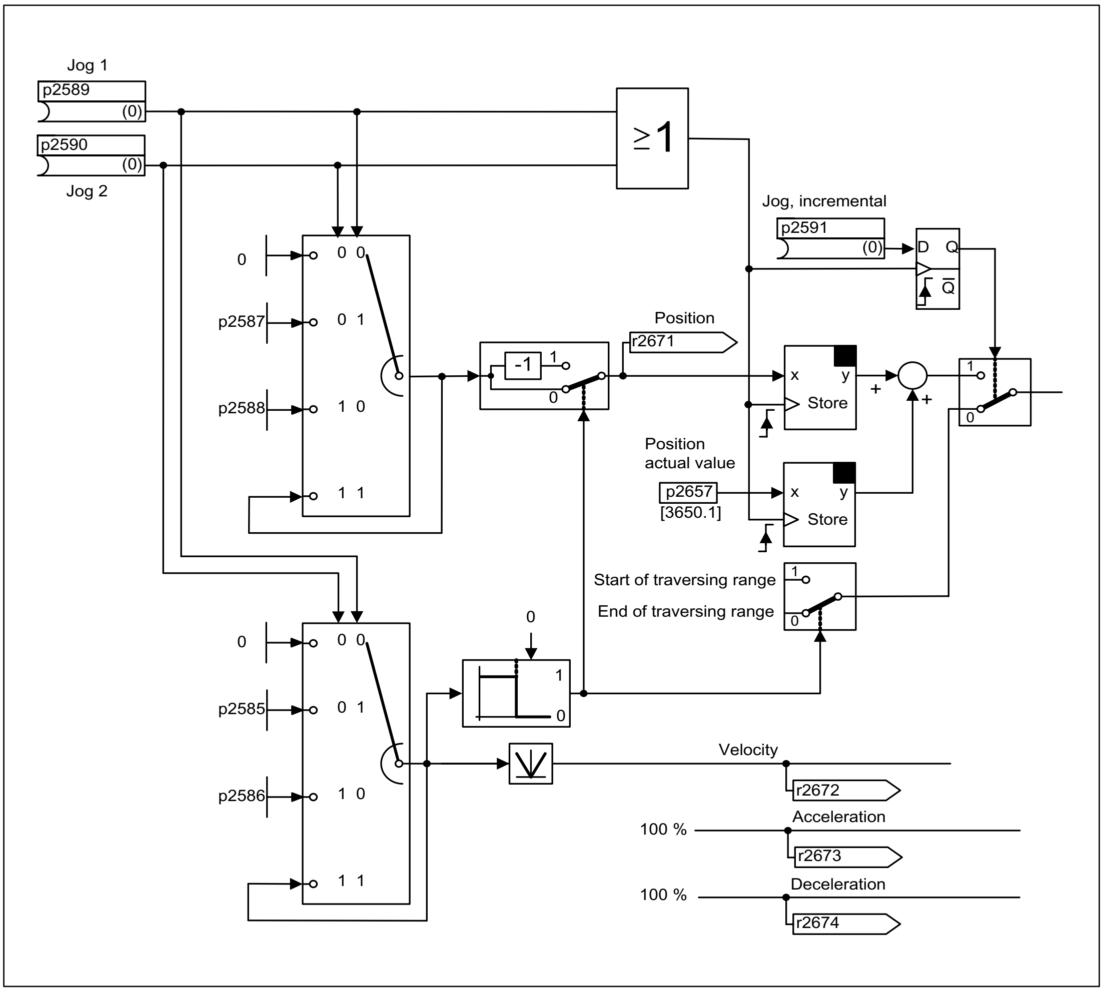


Figure 7-20 Jog mode

Function diagrams (see SINAMICS S List Manual)

- 3610 EPOS - jog mode

Overview of key parameters (see SINAMICS S List Manual)

- p2585 EPOS jog 1 setpoint velocity
- p2586 EPOS jog 2 setpoint velocity
- p2587 EPOS jog 1 traversing distance
- p2588 EPOS jog 2 traversing distance
- p2589 BI: EPOS jog 1 signal source
- p2590 BI: EPOS jog 2 signal source
- p2591 BI: EPOS jog incremental

7.9.8 Status signals

The status signals relevant to positioning mode are described below.

Tracking mode active (r2683.0)

The "Follow-up active mode" status signal shows that follow-up mode has been activated which can be done by binector input p2655 (follow-up mode) or by a fault. In this status, the position setpoint follows the actual position value, i.e. position setpoint = actual position value.

Setpoint static (r2683.2)

The status signal "setpoint static" indicates that the setpoint velocity has a value of 0. The actual velocity can deviate from zero due to a following error. While the status word has a value of 0, a traversing task is being processed.

Traversing command active (r2684.15)

The status signal "traversing command active" indicates that a traversing command is active. A motion command should be understood to comprise all motions (including jog, setup etc.). Contrary to the status signal "setpoint static", the status signal remains active - e.g. if a traversing command was stopped by a velocity override or intermediate stop.

SW limit switch + reached (r2683.7)
SW limit switch - reached (r2683.6)

These status signals indicate that the parameterized negative p2578/p2580 or positive p2579/p2581 traversing range limit was reached or passed. If both status signals are 0, the drive is located within the traversing limits.

Stop cam minus active (r2684.13)
Stop cam plus active (r2684.14)

These status signals indicate that the stop cam minus p2569 or stop cam plus p2570 were reached or passed. The signals are reset if the cams are left in a directly opposing the approach direction.

Axis moves forwards (r2683.4)
Axis moves backwards (r2683.5)
Axis accelerates (r2684.4)
Drive decelerates (r2684.5)
Drive stationary (zero speed) (r2199.0)

These signals display the current motion status. If the actual absolute speed is less or equal to p2161, then the status signal "drive stationary" is set - otherwise it is deleted. The signals are appropriately set if jog mode, reference point approach or a traversing task is active.

Cam switching signal 1 (r2683.8)
Cam switching signal 2 (r2683.9)

The electronic cam function can be implemented using these signals. Cam switching signal 1 is 0 if the actual position is greater than p2547 - otherwise 1. Cam switching signal 2 is 0 if the actual position is greater than p2548 - otherwise 1. This means that the signal is deleted if the drive is located behind (after) the cam switching position. The position controller initiates these signals.

Direct output 1 (r2683.10)
Direct output 2 (r2683.11)

If a digital output is parameterized, the function "direct output 1" or "direct output 2", then it can be set by a corresponding command in the traversing task (SET_O) or reset (RESET_O).

Following error in tolerance (r2684.8)

When the axis is traversed, closed-loop position controlled, using a model, the permissible following error is determined from the instantaneous velocity and the selected Kv factor. Parameter p2546 defines a dynamic following error window that defines the permissible deviation from the calculated value. The status signal indicates as to whether the following error is within the window (status 1).

Target position reached (r2684.10)

The status signal "target position reached" indicates that the drive has reached its target position at the end of a traversing command. This signal is set as soon as the actual drive position is within the positioning window p2544 and is reset, if it leaves this window.

The status signal is not set, if

- Signal level 1 at binector input p2554 "signal traversing command active".
- Signal level 0 at binector input p2551 "signal setpoint static".

The status signal remains set, until

- Signal level 1 at binector input p2551 "signal setpoint static".

Reference point set (r2684.11)

The signal is set as soon as referencing has been successfully completed. It is deleted as soon as no reference is there or at the start of the reference point approach.

Acknowledgement, traversing block activated (r2684.12)

A positive edge is used to acknowledge that in the mode "traversing blocks" a new traversing task or setpoint was transferred (the same signal level as binector input p2631 activate traversing task). In the mode "direct setpoint input / MDI for setting-up/positioning" a positive edge is used to acknowledge that a new traversing task or setpoint was transferred (the same signal level as binector input p2650 "edge setpoint transfer", if the transfer type was selected using a signal edge (binector input p2649 "0" signal)).

Velocity limiting active (r2683.1)

If the actual setpoint velocity exceeds the maximum velocity p2571 - taking into account the velocity override - it is limited and the control signal is set.

7.10 DCC axial winder

Description

The "DCC axial winder" functionality covers a wide variety of winder applications.

With a suitable setup, the function enables a winder or unwinder for a wide variety of applications, such as film plants, printing machines, coating plants, coil winders for wire-drawing machines or textile machines.

An axial winder solution usually comprises a winder drive, a continuous web and possibly sensors. The axial winder serves to wind or unwind a continuous web with a defined tension. The winder diameter will change during the winding process. The product thickness increases or decreases during the winding or unwinding process. The drive system calculates the current diameter on the basis of system variables and influences the speed or torque, depending on the application, so that the tension and velocity of the web is maintained according to specifications. This requires the current velocity of the web and the rotational speed of the winder axis to be known.

Features

- Different winding and control methods can be applied, e.g. direct closed-loop tension control through
  speed correction or torque limiting and indirect closed-loop tension control
- Closed-loop control can be implemented through "Tension controller acting on torque limits" or
  "Tension controller acting on speed setpoint"

- Adaptation of tension controller and speed controller gain based on diameter or inertia
- Diameter-based winding tightness diagram
- Diameter calculation
- Acceleration-based torque pre-control
- Flexible sensor evaluation (e.g. dancer roll, load cell)

Note

Documentation for a standard application for the DCC axial winder is available on demand from your responsible SIEMENS distribution partner.

Function blocks

The "DCC axial winder" function involves the following DCBs (Drive Control Blocks), i.e. function blocks for drive control:

Note

Detailed information on the function blocks is contained in the "SINAMICS SIMOTION Function Manual DCC Block Description" as well as in the "SINAMICS SIMOTION Programming Manual DCC Editor".

1. TTCU block: Winding hardness diagram
   The block is applied for defining the tension setpoint as a function of the current winder diameter. The setpoint is adjusted according to a selectable characteristic curve.
2. DCA block: Diameter calculator:
   The DCA (Diameter Calculator) is used to determine the current diameter of an axial winder based on the path velocity and the motor speed. The calculated diameter is checked for plausibility.
3. INCO block: Dynamic calculation of the moment of inertia for torque pre-control and Kp adaptation of the speed controller
   (see figure "Axial winder setup", abbreviations refer to block description).
   The block calculates the mass moment of inertia of an axial winder, referred to the motor side. In addition to the diameter (from DCA), the block also contains information on the geometry and material properties of the winder and the winding product.
   The static mass moment of inertia referred to the motor side is passed to the DCC block via the parameter r1493. The result is fed back to the basic system via the scaling parameter p1497 (referred to the static moment of inertia).

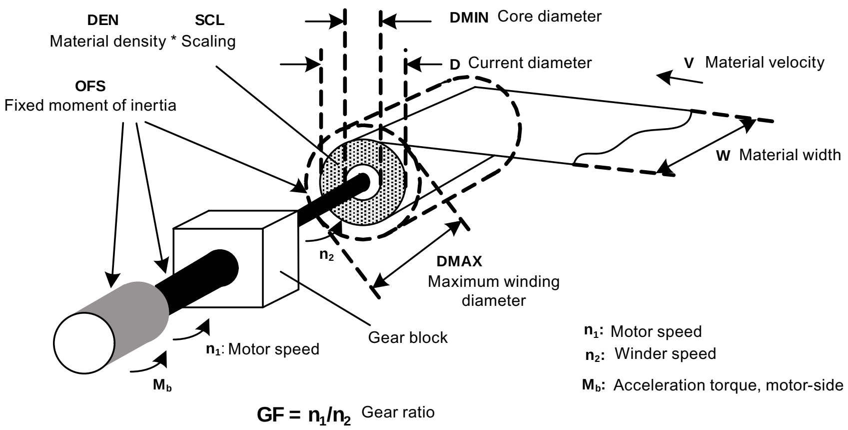


Figure 7-21 Axial winder setup

Functional principle

To maintain a constant tension of the continuous web, the drive moment is increased in a linear manner while the winding diameter increases, or decreased while the winding diameter decreases.

To protect the winding material during the winding process, the tension is reduced according to a characteristic curve when the winding diameter increases.

The calculation of the continuously changing moment of inertia permits a torque pre-control during a steady decrease or increase of the winder speed.

By using a sensor, a speed controlled operation of the winder is possible. The winder can be operated without an encoder by controlling the tension moment, with two scaling parameters p1552 and p1554 for tension moment limitation (see torque limitation).

Calculation of the moment of inertia for torque pre-control

The function diagram below shows the calculation flow for SERVO control with encoder [FP 5042] / without encoder [FP 5210]:

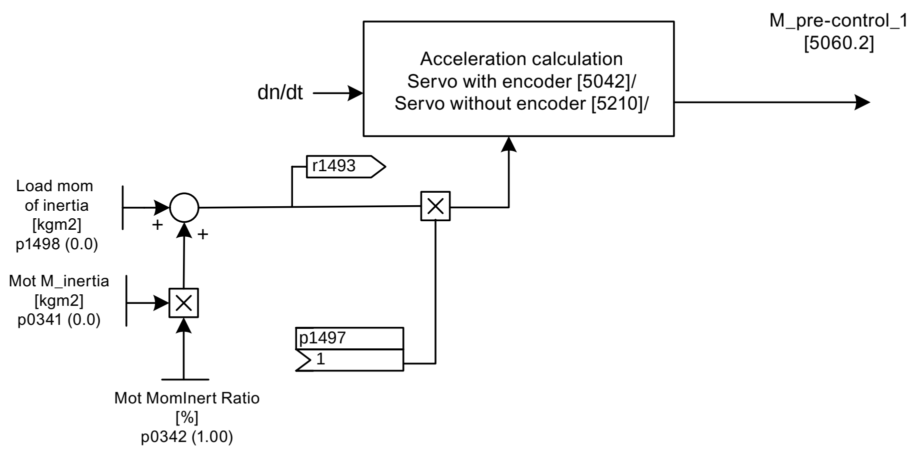


Figure 7-22 Torque pre-control for SERVO control

The function diagram below shows the calculation flow for VECTOR control [FP 6031]:

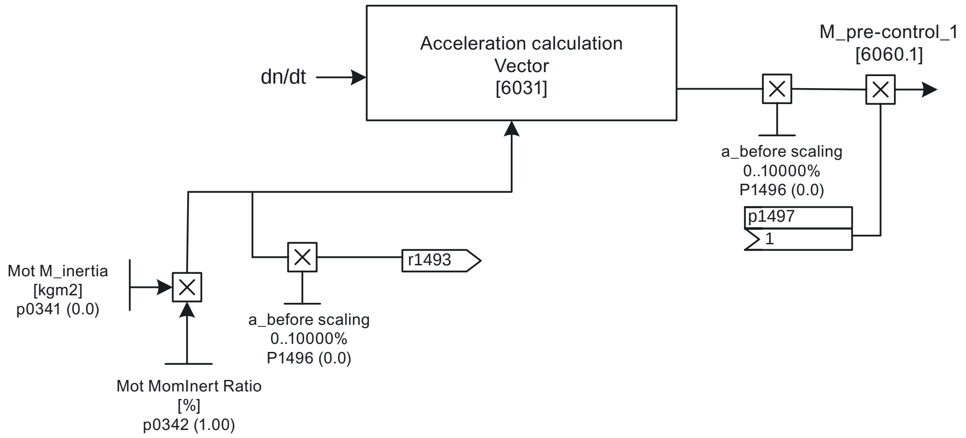


Figure 7-23 Torque pre-control for VECTOR control

Parameters for the function diagrams for torque pre-control

p0341[0...n] Motor moment of inertia / MotID M_mom inert

Setting of the motor moment of inertia (no load).
This parameter is automatically preset for motors from the motor list (p0301). When a motor from the list is selected, this parameter cannot be changed (write protection). To remove the write protection, the information in p0300 must be observed.

p0342[0...n] Ratio between the total moment of inertia and that of the motor

Sets the ratio between the total moment of inertia/mass (load + motor) and the intrinsic motor moment of inertia/mass (no load).

The product p0341 * p0342 is taken into account when automatically calculating the speed controller (VECTOR).

p1455[0...n] CI: Speed controller P gain adaptation signal / n_reg Adapt_sig Kp

Sets the source for the adaptation signal for additional adaptation of the speed controller P gain. A possible source is the relative moment of inertia of the INCO block.

r1493 Moment of inertia, total

Indication of the total moment of inertia before evaluation by scaling using p1497.

SERVO: r1493 = (p0341 * p0342) + p1498
VECTOR: r1493 = (p0341 * p0342) *p1496

p1496[0...n] Acceleration pre-control scaling / a_before scaling (VECTOR)

Sets the scaling for the acceleration pre-control of the speed/velocity controller.

p1497[0...n] CI: Moment of inertia, scaling / M_mom inert scal

Scaling factor of the static moment of inertia for the calculation of the current total moment of inertia (r1493 + portion of the moment of inertia of the winding product calculated by the INCO block).

p1498[0...n] Load moment of inertia / Load mom of inert (SERVO only)

Moment of inertia of the load without winding product

Limitation of the speed controller output with dynamic speed limits

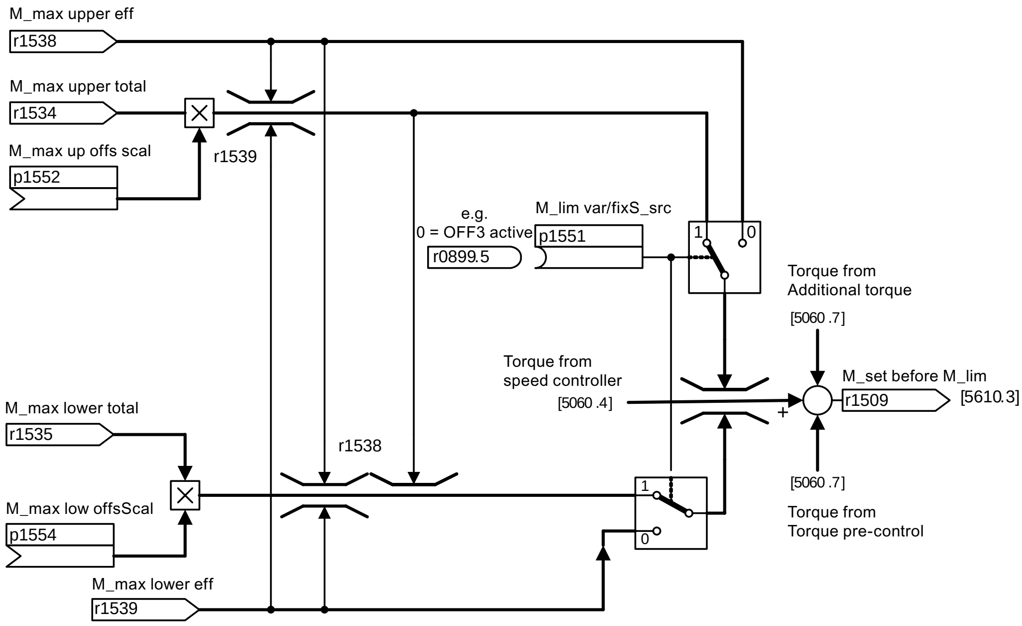


Figure 7-24 Limitation of the speed controller output with dynamic speed limits (example of SERVO) Application for the VECTOR case see FP 6060.

Parameters of the function diagram for torque limitation

r1538 Upper effective torque limit / M_max upper eff

Displays the currently effective upper torque limit.

r1539 Lower effective torque limit / M_max lower eff

Displays the currently effective lower torque limit.

p1551[0..n] Torque limit variable/fixed signal source / M_lim var/fixS_src

Sets the signal source for switching the torque limits between variable and fixed torque limit.

1 signal from BI: p1551:

A variable torque limit is effective (fixed torque limit + scaling).

0 signal from BI: p1551:

The fixed torque limit is effective.

p1552[0...n] Torque limit upper scaling without offset / M_max up offs scal

Sets the signal source for the scaling of the upper torque limit to limit the speed controller output without considering current and power limits. A possible source is the torque preset from the DCC diagram.

p1554[0...n] Torque limit lower scaling without offset / M_max low offsScal

Sets the signal source for the scaling of the lower torque limit to limit the speed controller output without considering current and power limits. A possible source is the torque preset from the DCC diagram.

Adaptation of the torque limits by means of tension controller

This method is often used in winder applications to prevent the winder from running away if the web breaks.

For this purpose, the drive is operated with speed controller override, with the speed setpoint being calculated as a function of diameter (see DCA block). The control signal of the tension controller is set to the torque limits, which causes the drive to operate at the torque limit in normal mode. In case of a web break, this prevents the tension controller from actively building torque. The winder speed is limited by the speed setpoint.

Function diagrams (see SINAMICS S List Manual)

- 5042 Servo control, Speed controller, torque/speed pre-control with encoder
- 5060 Servo control, torque setpoint
- 5210 Servo control, speed controller without encoder
- 5610 Torque limiting/reduction/interpolator
- 5620 Motor/generator torque limit
- 6031 Vector control, pre-control balancing
- 6060 Servo control, torque setpoint

7.11 Parallel connection of chassis power units (vector)

7.11.1 Features

SINAMICS supports the parallel connection of power units on the motor and infeed side to extend the power spectrum of the SINAMICS.

The main characteristics of the parallel connection are:

- Parallel connection of up to four power units on one motor
  - With parallel connection of several power units to one motor with separate winding systems (p7003 = 1)

    Note:
    Motors with separate winding systems are recommended.
  - – Connecting several power units in parallel to a motor with a single winding system (p7003 = 0)

⚠ CAUTION
Additional information and instructions in the Equipment Manual must be carefully taken into consideration.

- Parallel connection of up to four power units on the infeed side (closed/open loop)
- A CU320 can implement a maximum of one parallel connection on the mains connection and one parallel connection on the infeed side.
- Simple commissioning, because no special parameterization is necessary.
- The power units connected in parallel must be connected to the same Control Unit.
- Individual power units can be diagnosed (troubleshooting) using p7000 ff

7.11.2 Integration

Overview of key parameters (see SINAMICS S List Manual)

- p0120 Power unit data sets (PDS) number
- p0121 Power unit component number
- p0602 Power unit temperature sensor with parallel connection
- r7000 Parallel circuit configuration, number of active power units
- r7001 Parallel circuit configuration, enable power units
- r7002 Parallel circuit configuration, status power units
- p7003 Parallel circuit configuration, winding system
- p7010 Parallel circuit configuration, current asymmetry alarm threshold
- p7011 Parallel circuit configuration, DC link voltage asymmetry alarm threshold

- ...
- p7322 Parallel circuit configuration, VSM line filter capacitance, phaseW

7.11.3 Description

Switching power units in parallel is a simple method of extending the power spectrum of drives beyond the power of the individual power units.

7.11.4 Application examples

Parallel connection of two Motor Modules to one motor with double winding system

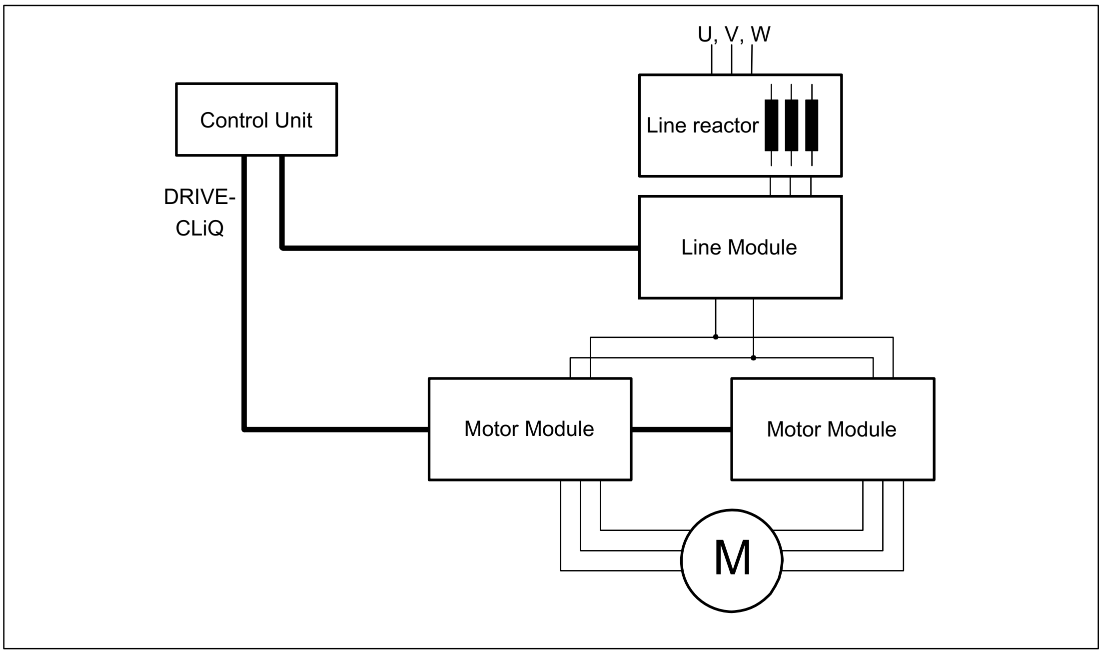


Figure 7-25 Example 1: parallel connection

Parallel connection of two Active Line Modules and two Motor Modules on a motor with a single winding system

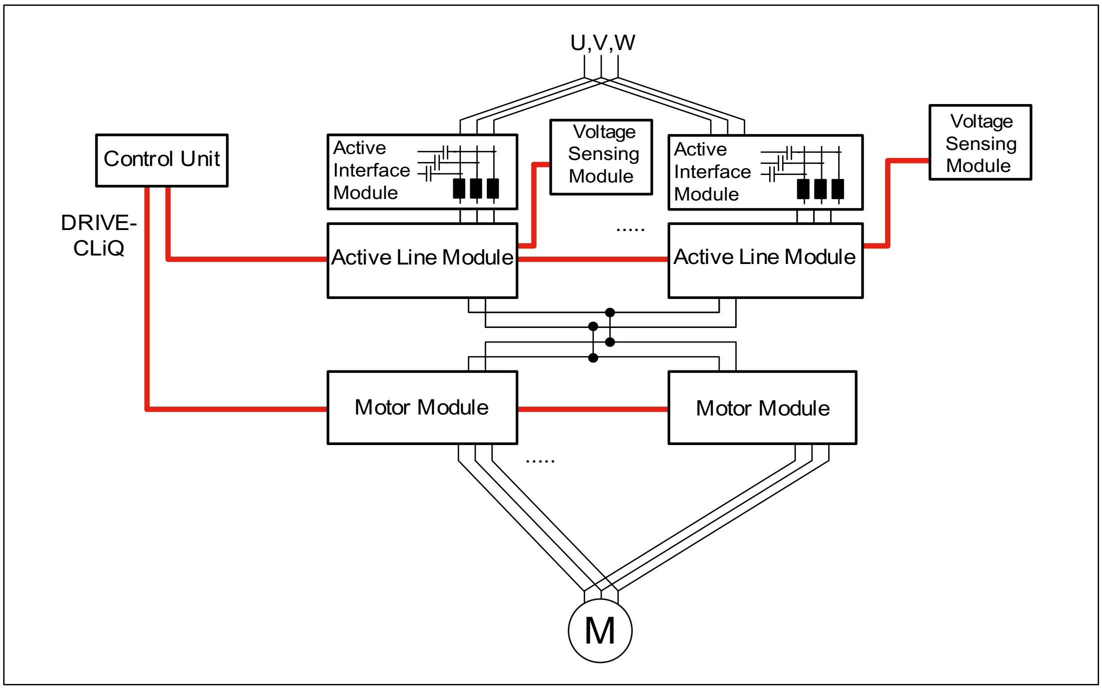


Figure 7-26 Example 2: parallel connection

7.11.5 Commissioning

During commissioning, power units connected in parallel are treated like a power unit on the line or motor side. With parallel connection, the parameter display for the actual values changes only slightly. Instead, suitable "total values" are derived from the individual values for the power units.

In STARTER, parallel connection (Line Modules and Motor Modules) is activated via the Wizard. You can also select parallel connection when choosing the power unit. You then have to specify the number of power units to be connected in parallel.

8 Monitoring and protective functions

8.1 Power unit protection, general

Description

SINAMICS power units offer comprehensive functions for protecting power components.

Table 8-1 General protection for power units

Protection against:	Precautions	Responses
Overcurrent 1)	Monitoring with two thresholds: • First threshold exceeded	A30031, A30032, A30033 Current limiting of a phase has responded. The pulsing in the phase involved is inhibited. If it is too frequently exceeded F30017 –> OFF2
	• Second threshold exceeded	F30001 "Overcurrent" –> OFF2
Overvoltage 1)	Comparison of DC link voltage with hardware shutdown threshold	F30002 "Overvoltage" –> OFF2
Undervoltage 1)	Comparison of DC link voltage with hardware shutdown threshold	F30003 "Undervoltage" –> OFF2
Short-circuit 1)	• Second monitoring threshold checked for overcurrent	F30001 "Overcurrent" –> OFF2
	• Uce monitoring of IGBT modules (chassis only)	F30022 "Uce monitoring" –> OFF2 (chassis only)
Ground fault	Monitoring the sum of all phase currents	After threshold in p0287 is exceeded: F30021 "Power unit: ground fault" --> OFF2 Note: The sum of all phase currents is displayed in r0069[6]. For operation, the value in p0287[1] must be greater than the sum of the phase currents when the insulation is intact.
Line phase failure detection 1)		F30011 "Line phase-failure in main circuit" –> OFF2
1) The monitoring thresholds are permanently defined in the converter and cannot be changed.		

8.2 Thermal monitoring and overload responses

Description

The priority of thermal monitoring for power unit is to identify critical situations. If alarm thresholds are exceeded, the user can set parameterizable response options that enable continued operation (e.g. with reduced power) and prevent immediate shutdown. The parameterization options, however, only enable intervention below the shutdown thresholds, which cannot be changed by the user.

The following thermal monitoring options are available:

- I^2t monitoring - A07805 - F30005

  I^2t monitoring is used to protect components that have a high thermal time constant compared with semi-conductors. An overload with regard to I^2t is present when the converter load r0036 is greater than 100% (load in % in relation to rated operation).

- Heat-sink temperature - A05000 – F30004

  Monitoring of the heat-sink temperature (r0037) of the power semi-conductor (IGBT)

- Chip temperature - A05001 - F30025

  Significant temperature differences can occur between the IGBT barrier junction and the heat sink. These differences are taken into account and monitored by the chip temperature (r0037).

If an overload occurs with respect to any of these three monitoring functions, an alarm is first output. The alarm threshold p0294 (I^2t monitoring) can be parameterized relative to the shutdown (trip) values.

Example

The factory setting for the alarm threshold for chip temperature monitoring is 15 Kelvin (K). Temperature monitoring for the heat sink and inlet air is set to 5 K, that is, the "Overtemperature, overload" alarm is triggered at 15 K or 5 K below the shutdown threshold.

The parameterized responses are induced via p0290 simultaneously when the alarm is output. Possible responses include:

- Reducing the pulse frequency (p0290 = 2, 3)

  This is a highly effective method of reducing losses in the power unit, since switching losses account for a high proportion of overall losses. In many applications, a temporary reduction in pulse frequency is tolerable in order to maintain the process.

  Disadvantage:

  Reducing the pulse frequency increases the current ripple which, in turn, can increase the torque ripple on the motor shaft (with low inertia load), thereby increasing the noise level. Reducing the pulse frequency does not affect the dynamic response of the current control circuit, since the sampling time for the current control circuit remains constant.

- Reducing the output frequency (p0290 = 0,2)

This variant is recommended when you do not need to reduce the pulse frequency or the pulse frequency has already been set to the lowest level. Further, the load should also have a characteristic similar to the fan, that is, a quadratic torque characteristic with falling speed.

Reducing the output frequency has the effect of significantly reducing the converter output current which, in turn, reduces losses in the power unit.

- No reduction (p0290 = 1)

You should choose this option if it is neither possible to reduce the pulse frequency nor reduce the output current. The converter does not change its operating point once an alarm threshold has been overshot, which means that the drive can be operated until it reaches its shutdown values. Once it reaches its shutdown threshold, the converter switches itself off and the "Overtemperature, overload" fault is output. The time until shutdown, however, is not defined and depends on the degree of overload.

To ensure that an alarm can be output earlier or that the user can intervene, if necessary, in the drive process (e.g. reduce load/ambient temperature), only the alarm threshold can be changed.

Function diagrams (see SINAMICS S List Manual)

- 8014 Thermal monitoring, power unit

Overview of key parameters (see SINAMICS S List Manual)

- r0036 Power unit overload
- r0037 Power unit temperatures
- p0290 Power unit overload response
- p0294 Alarm threshold I^2t overload power unit

8.3 Block protection

Description

The error message "Motor blocked" is only triggered if the speed of the drive is below the variable speed threshold set in p2175. With vector control, it must also be ensured that the speed controller is at the limit. With V/f control, the current limit must already have been reached.

Once the ON delay (p2177) has elapsed, the message "Motor blocked" and fault F7900 are generated.

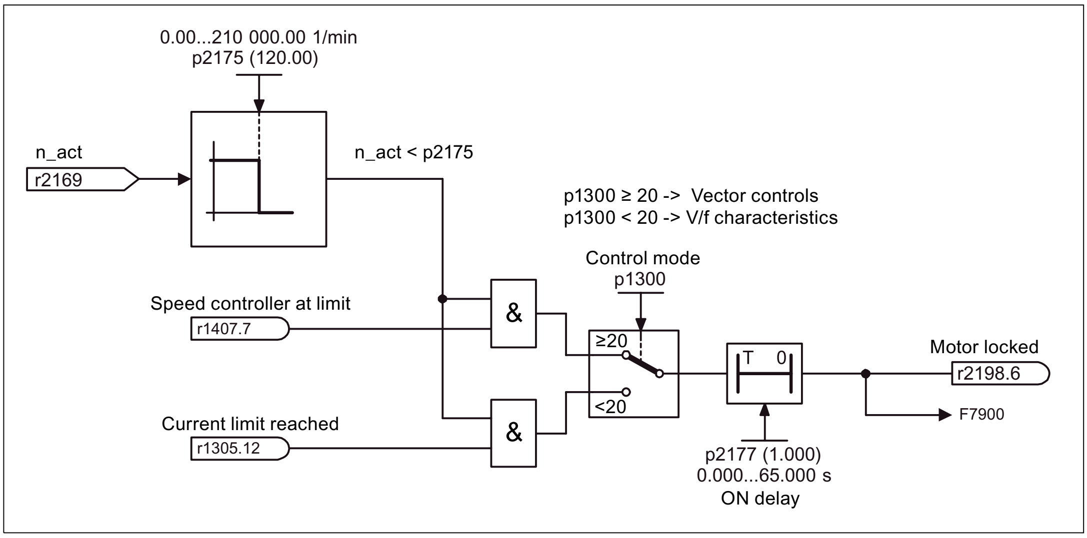


Figure 8-1 Block protection

Function diagrams (see SINAMICS S List Manual)

- 8012 Torque messages, motor blocked/stalled

Overview of key parameters (see SINAMICS S List Manual)

- p2175 Motor blocked speed threshold
- p2177 Motor blocked delay time

8.4 Stall protection (only for vector control)

Description

If, for closed-loop speed control with encoder, the speed threshold set in p1744 for stall detection is exceeded, then r1408.11 (speed adaptation, speed deviation) is set.

If, in the low speed range (less than p1755 * p1756), the fault threshold value, set in p1745 is exceeded, then r1408.12 is set (motor stalled).

If one of the two signals is set, then after the delay time in p2178, fault F7902 (motor stalled) is output.

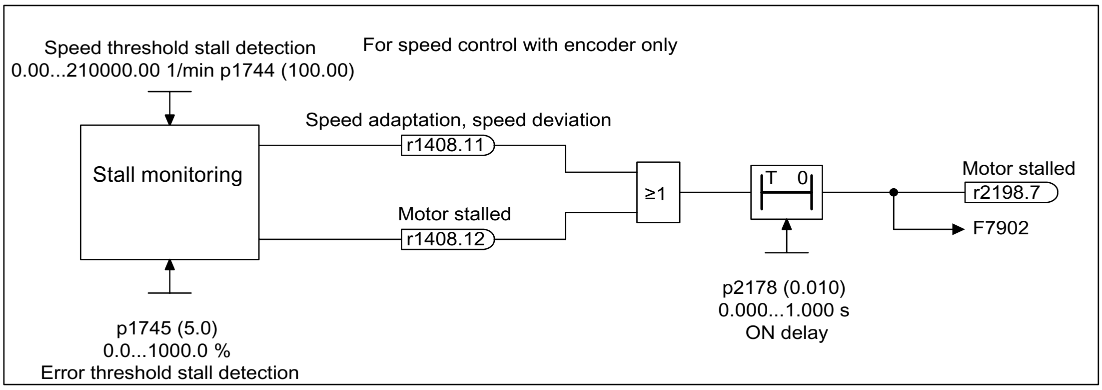


Figure 8-2 Stall protection

Function diagrams (see SINAMICS S List Manual)

- 6730 Current control
- 8012 Torque messages, motor blocked/stalled

Overview of key parameters (see SINAMICS S List Manual)

- r1408 CO/BO: Control status word 3
- p1744 Motor model speed threshold stall detection
- p1745 Motor model fault threshold value stall detection
- p1755 Motor model without encoder, changeover speed
- p1756 Motor model changeover speed hysteresis
- p2178 Motor stalled delay time

8.5 Thermal motor protection

Description

The priority of thermal motor protection is to identify critical situations. If alarm thresholds are exceeded, the user can set parameterizable response options (p0610) that enable continued operation (e.g. with reduced power) and prevent immediate shutdown.

- Effective protection is also possible without a temperature sensor (p4100 = 0). The temperatures of different motor components (stators, core, rotors) can be determined indirectly using a temperature model.
- Connecting temperature sensors allows the motor temperature to be determined directly. In this way, accurate start temperatures are available immediately when the motor is switched on again or after a power failure.

Temperature measurement via KTY

The device is connected to terminals X522:7 (anode) and X522:8 (cathode) at the customer terminal block (TM31) in the diode conducting direction. The measured temperature is limited to between -48 °C and +248°C and is made available for further evaluation.

- Set the KTY temperature sensor type: p0601 = 2
- Activate motor temperature measurement via the external sensor: p0600 = 10
- When the alarm threshold is reached (set via p0604; factory setting: 120°C), alarm A7910 is triggered.

  Parameter p0610 can be used to set how the drive responds to the alarm triggered:

  – 0: No response, only alarm, no reduction of I_max

  – 1: Alarm and reduction of I_max and fault (F07011)

  – 2: Alarm and fault (F07011), no reduction of I_max
- When the fault threshold is reached (set via p0605), fault F07011 is triggered in conjunction with the setting in p0610.

Temperature measurement via PTC

The device is connected to terminal X522:7/8 on the Terminal Module (TM31). The threshold for switching to an alarm or fault is 1650 Ω. If the threshold is exceeded, the system switches internally from an artificially-generated temperature value of -50 °C to +250°C and makes it available for further evaluation.

- Set the PTC temperature sensor type: p0601 = 1
- Activate motor temperature measurement via the external sensor: p0600 = 10
- Alarm A07910 is triggered once the PTC responds.
- Fault F07011 is triggered once the waiting time defined in p0606 has elapsed.

Sensor monitoring for cable breakage / short-circuit

If the temperature of the motor temperature monitor is outside the range -50°C to +250°C, the sensor cable is broken or has short-circuited. Alarm A07915 ("Alarm: temperature sensor fault") is triggered. Fault F07016 (“Fault: temperature sensor fault”) is triggered once the waiting time defined in p0607 has elapsed.

Fault F07016 can be suppressed by p0607 = 0. If an induction motor is connected, the drive continues operating with the data calculated in the thermal motor model.

If the system detects that the motor temperature sensor set in p0600 is not connected, alarm A07820 ("Temperature sensor not connected") is triggered.

Function diagrams for thermal motor protection

- 8016 Thermal monitoring motor
- 9576 Temperature evaluation KTY/PTC
- 9577 Sensor monitoring KTY/PTC

Parameters for thermal motor protection

- p0600 Motor temperature sensor for monitoring
- p0601 Motor temperature sensor type
- p0604 Motor overtemperature alarm threshold
- p0605 Motor overtemperature fault threshold
- p0606 Motor over temperature timer
- p0607 Temperature sensor fault timer
- p0610 Response to motor overtemperature condition

Safety Integrated basic functions 9

9.1 General information

Note

This manual describes the Safety Integrated Basic Functions.

The Safety Integrated Extended Functions are described in the following documentation:

Reference: /FHS/ SINAMICS S120 Function Manual Safety Integrated.

9.1.1 Explanations, standards, and terminology

Safety Integrated

The "Safety Integrated" functions, which have been prototype tested, provide highly-effective application-oriented protection for personnel and machinery.

This innovate safety technology offers the following benefits:

- Increased safety
- More economic operation
- Greater flexibility
- Higher level of plant availability

Standards and Directives

Various standards and guidelines for safety technology must be observed.

Guidelines are binding for both the manufacturer and operator of machines.

Standards generally reflect the state of the art and act as a basis for implementing safety concepts. Unlike guidelines, however, they are not binding.

Below is a list of standards and guidelines for safety technology.

- EC 98/37/EG machinery directive

  This guideline defines basic protection measures for safety technology.

- EN 292-1

  Basic terminology and general principles for design

- EN 954-1

  Safety-related parts of control systems
- EN 1050

  Risk assessment
- IEC 60204-1

  Safety of machinery - Electrical equipment of machines - Part 1: General

  Requirements for the electrical equipment of machines
- IEC 61508

  Functional reliability of electrical and electronic systems

  This standard defines "safety integrity levels" (SIL), which not only describe a certain degree of integrity with regard to safety-oriented software but also defined, quantitative error probability ranges with regard to the hardware.

  Note

  In conjunction with certified components, the safety functions of the SINAMICS S120 drive system fulfill the following requirements:
  - Category 3 to EN 954-1.
  - Safety integrity level 2 (SIL 2) to IEC 61508.

  A list of certified components is available on request from your local Siemens office.

  Note

  When operated in proper condition and in dry operating areas, SINAMICS devices with three-phase motors conform to Low-Voltage Directive 73/23/EEC.
- IEC 61800-5-2

  Adjustable-speed electrical power drive systems, Part 5-2: Requirements

  for safety - Functional requirements

Two-channel monitoring structure

All the main hardware and software functions for Safety Integrated are implemented in two independent monitoring channels (e.g. switch-off signal paths, data management, data comparison).

The two drive monitoring channels are implemented using the following components:

- Control Unit
- The Motor Module/Power Module belonging to a drive.

The monitoring functions in each monitoring channel work on the principle that a defined status must prevail before each action is carried out and a specific acknowledgement must be made after each action.

If these expectations of a monitoring channel are not fulfilled, the drive coasts to a standstill (two-channel) and an appropriate message is output.

Switch-off signal paths

Two independent switch-off signal paths are available. All switch-off signal paths are low active, thereby ensuring that the system is always switched to a safe state if a component fails or in the event of an open circuit.

If a fault is discovered in the switch-off signal paths, the "Safe Torque Off" function is activated and a system restart inhibited.

Monitoring cycle

The safety-relevant drive functions are executed cyclically in the monitoring clock cycle.

The safety monitoring clock cycle lasts a minimum of 4 ms. Increasing the basic DRIVE-CLiQ sampling time (p0110) also increases the safety monitoring clock cycle.

Crosswise data comparison

A cyclic cross-check of the safety-related data in the two monitoring channels is carried out.

If any data is inconsistent, a stop response is triggered with any Safety function.

Parameter overview (see SINAMICS S List Manual)

- r9780 SI monitoring clock cycle (Control Unit)
- r9880 SI monitoring clock cycle (Motor Module)

Comparison of function names

Table 9-1 Comparison of safety function names old <-> new

old		new according to IEC 61800-5-2	
Abbreviation	Name	New abbreviation	New name
SH	Safe standstill	STO	Safe Torque Off
SGA	Safety-related output	F-DO	Failsafe Digital Output
SGE	Safety-related input	F-DI	Failsafe Digital Input

9.1.2 Supported functions

Supported functions:

The functions mentioned here are in compliance with IEC 61800-5-2.

The following Safety Integrated (SI) functions are available:

- Safety Integrated basic functions

  These functions are part of the standard scope of the drive.

- Safe torque off (STO)

  STO is a safety function that prevents the drive from restarting unexpectedly, in accordance with EN 60204-1, Section 5.4.

  Note

  When a drive object that has Safety Integrated functions released is switched to "Parking" mode, the Safety Integrated software responds by activating STOP without generating a separate message.

- Safe Stop 1 (SS1, time controlled)

  Safe Stop 1 is based on the "Safe Torque Off" function. This means that a Category 1 stop in accordance with EN 60204-1 can be implemented.

- Safe Brake Control (SBC)

  The SBC function permits the safe control of a holding brake.

  SBC is not supported by chassis components. Power Modules Blocksize also require a Safe Brake Relay for this function.

- Safety Integrated extended functions
  - Safe Stop 1 (SS1, time and acceleration controlled)

    The SS1 function is based on the “Safe Torque Off” function. This means that a Category 1 stop in accordance with EN 60204-1 can be implemented.

  - Safe Stop 2 (SS2)

    The SS2 function brakes the motor safely with a subsequent transition to "Safe Operational Stop" (SOS).

  - Safe Operational Stop (SOS)

    "Safe Operational Stop" (SOS) protects against unintentional movements. The drive is in closed-loop control mode and is not disconnected from the power supply.

  - Safely Limited Speed (SLS)

    The "Safely Limited Speed" (SLS) protects against excessively high drive speeds.

  - Safe Speed Monitor (SSM)

    The SSM function reliably monitors the speed limit and issues a safe output signal, but without a response function.

Prerequisites for the extended functions

- An appropriate license
- Activation via PROFIsafe or TM54F

NOTICE
Per single Control Unit, either control via PROFIsafe or TM54F is permitted. Mixed operation is not permitted.

- SINAMICS S120: FW version from 2.5 SP1

- SIMOTION D4x5: FW version from V4.1.1 (SINAMICS S120 with FW version from V2.5 SP1 integrated)
- Safe actual value acquisition (see chapter "Safe actual value acquisition")
- An activated speed controller in the drive
- Overview of hardware components that support the Extended Functions:
  - Control Unit CU310 from order no.: 6SL3040-0LA00-0AA1/6SL3040-0LA01-0AA1
  - Control Unit CU320 from order no.: 6SL3040-...-0AA1 and version C
  - SIMOTION CPU: D4x5 V4.1.1 (SINAMICS S120 with FW V2.5 SP1 integrated)
D425 from 6AU1 425-0AA00-0AA0 HW release D
D435 from 6AU1 435-0AA00-0AA1 HW release D
D445 from 6AU1 445-0AA00-0AA0 HW release B
  - Motor Modules booksize from order no.: ...A3 or higher
  - Power Modules Blocksize
  - Control Unit Adapter 31 from order no.: 6SL3040-0PA00-0AA1

9.1.3 Parameter, Checksum, Version, Password

Properties of Safety Integrated parameters

The following applies to Safety Integrated parameters:

- They are kept separate for each monitoring channel.
- During startup, a checksum (Cyclic Redundancy Check, CRC) over the safety parameters is generated and checked. The display parameters are not contained in the CRC.
- Data storage: The parameters are stored on the non-volatile CompactFlash card.
- Factory settings for safety parameters

  A reset of the safety parameters to the factory setting on a drive-specific basis using p0970 or p3900 and p0010 = 30 is only possible when the safety functions are not enabled (p9301 = p9501 = p9601 = p9801 = p10010 = 0).

  A complete reset of all parameters to the factory settings (p0976 = 1 and p0009 = 30 on the Control Unit) is possible even when the safety functions are enabled (p9301 = p9501 = p9601 = p9801 = p10010 ≠ 0).
- They are password-protected against accidental or unauthorized changes.

NOTICE
The following safety parameters are not protected by the safety password: • p9370 SI Motion acceptance test mode (Motor Module) • p9570 SI Motion acceptance test mode (Control Unit) • p9510 SI Motion isochronous PROFIBUS Master • p9533 SI Motion SLS Setpoint speed limitation • p9705 BI: SI Motion Test stop signal source

Checking the checksum

For each monitoring channel, the safety parameters include one parameter for the actual checksum for the safety parameters that have undergone a checksum check.

During commissioning, the actual checksum must be transferred to the corresponding parameter for the specified checksum. This can be done for all checksums of a drive object at the same time with parameter p9701.

Basic functions

- r9798 SI actual checksum SI parameters (Control Unit)
- p9799 SI reference checksum SI parameters (Control Unit)
- r9898 SI actual checksum SI parameters (Motor Module)
- p9899 SI reference checksum SI parameters (Motor Module)

Extended Functions

- r9398[0...1] SI Motion actual checksum SI parameters (Motor Module)
- r9399[0...1] SI Motion specified checksum SI parameters (Motor Module)
- r9728[0...1] SI Motion actual checksum SI parameters
- r9729[0...1] SI Motion specified checksum SI parameters

During each ramp-up procedure, the actual checksum is calculated via the safety parameters and then compared with the specified checksum.

If the actual and specified checksums are different, fault F01650/F30650 or F01680/F30680 is output and an acceptance test requested.

Safety Integrated versions

The safety software has a separate version ID for the Control Unit and Motor Module.

For the basic functions

- r9770 SI version, drive-autonomous safety functions (Control Unit)
- r9870 SI version (Motor Module)

For the extended functions

- r9590 SI Motion Version secure movement monitoring (Control Unit)
- r9390 SI Motion Version secure movement monitoring (Motor Module)
- r9890 SI version (Sensor Module)
- r10090 SI Version TM54F

> ⚠ WARNING
>
> **From FW2.5 the following applies:**
>
> The upgrade/downgrade of DRIVE-CLiQ components is carried out automatically by the system if there is a difference between the firmware version on the components and the components firmware version on the CF card.
> This automatic upgrade/downgrade must not be disabled when Safety Integrated is used.

Password

The safety password protects the safety parameters against unauthorized write access.

In commissioning mode for Safety Integrated (p0010 = 95), you cannot change safety parameters until you have entered the valid safety password in p9761 for the drives or p10061 for the TM54F.

- When Safety Integrated is commissioned for the first time, the following applies:
  - Safety password = 0
  - Default setting for p9761 = 0

  In other words:
  The safety password does not need to be set during initial commissioning.
- In the case of a series commissioning of Safety or in the case of spare part installation, the following applies:
  - The safety password is retained on the CF card and in the STARTER project.
  - No safety password is required in the case of spare part installation.
- Change password for the drives
  - p0010 = 95 Commissioning mode
  - p9761 = Enter "old safety password".
  - p9762 = Enter "new password".
  - p9763 = Confirm "new password".
  - The new and confirmed safety password is valid immediately.
- Change password for the TM54F
  - p0010 = 95 Commissioning mode
  - p10061 = Enter "Old TM54F Safety Password" (factory setting "0")
  - p10062 = Enter "new password"
  - p10063 = Acknowledge "new password"
  - The new and acknowledged safety password is valid immediately.

If you need to change safety parameters but you do not know the safety password, proceed as follows:

1. Set the entire drive unit (Control Unit with all connected drives/components) to the factory setting.
2. Recommission the drive unit and drives.
3. Recommission Safety Integrated.

Parameter overview for password (see SINAMICS S List Manual)

- p9761 SI password input
- p9762 SI password new
- p9763 SI password acknowledgement
- p10061 SI password input TM54F

- p10062 SI password new TM54F
- p10063 SI password acknowledgement TM54F

9.1.4 Forced dormant error detection

Forced dormant error detection or test for the switch-off signal paths

Forced dormant error detection for the switch-off signal paths is used for detecting errors in the software/hardware of the two monitoring channels as quickly as possible and is carried out automatically when the "Safe Torque Off" function is activated/deactivated.

To fulfill the requirements of EN 954-1 regarding timely error detection, the two switch-off signal paths must be tested at least once within a defined time to ensure that they are functioning properly. For this purpose, forced dormant error detection must be triggered manually or is automatically initiated by the process.

A timer ensures that forced dormant error detection is carried out as quickly as possible.

- p9659 SI timer for the forced dormant error detection

Forced dormant error detection must be carried out at least once during the time set in this parameter.

Once this time has elapsed, an alarm is output and remains present until forced dormant error detection is carried out.

The timer returns to the set value each time the STO function is deactivated.

When the appropriate safety devices are implemented (e.g. protective doors), it can be assumed that running machinery will not pose any risk to personnel. For this reason, only an alarm is output to inform the user that a forced dormant error detection run is due and request that this be carried out at the next available opportunity. This alarm does not affect machine operation.

The user must set the time interval for carrying out forced dormant error detection to between 0.00 and 9000.00 hours depending on the application (factory setting: 8.00 hours).

When to carry out forced dormant error detection:

- When the drives are at a standstill after the system has been switched on.
- When the protective door is opened.
- At defined intervals (e.g. every 8 hours).
- In automatic mode (time and event dependent)

NOTICE
If, while the Extended Functions are used, the associated forced dormant error detection is performed, the time of the Basic Functions will also be reset. The respective alarm of the Basic Functions is not generated. While STO is selected through the Extended Functions, the terminals for the selection of the Basic Functions are not checked for any discrepancy. This means that the test stop of the Basic Functions must always be performed without the simultaneous selection of STO or SS1 by the Extended Functions. Otherwise it is impossible to check the correct control through the terminals.

9.2 Safety instructions

Safety instructions

⚠ WARNING
After hardware and/or software components have been modified or replaced, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel may not be in the hazardous area. Depending on the change made or what has been replaced, it may be necessary to carry out a partial or complete acceptance test (see chapter "Acceptance test"). Before persons may re-enter the hazardous area, the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/–). **Please note the following during switch-on:** The safety-related functions are only available and can be activated after the system has completely started up.

⚠ WARNING
The Category 0 stop function according to EN 60204-1 (defined as STO in Safety Integrated) means that the drives are not braked to zero speed, but coast to a stop (this may take some time depending on the level of kinetic energy involved). This must be included in the protective door locking mechanism logic e.g. with the logic operation SSM (n<nx).

⚠ WARNING
Safety Integrated is not capable of detecting parameterization errors made by the machine manufacturer. The required level of safety can only be assured by careful acceptance testing.

⚠ WARNING
The automatic FW update via p7826 = 1 (upgrade and downgrade), which is available from version V2.5, must not be deactivated when Safety Integrated is used.

⚠ CAUTION
If two power transistors in the power unit (one in the upper and one offset in the lower inverter bridge) fail at the same time, this can cause a momentary movement. The maximum movement can be: Synchronous rotary motors: Max. movement = 180 ° / pole pair count Synchronous linear motors: Max. movement = pole width

⚠ CAUTION

The "automatic restart" function may not be used together with the safety functions STO/SBC and SS1. The reason for this is that EN 60204 Part 1 (1998) in chapter 9.2.5.4.2 does not permit this (merely de-selecting a safety shutdown function must not cause the machine to restart).

NOTICE

Components cannot be deactivated via p0105, for example, with activated Safety functions.

9.3 Safe Torque Off (STO)

General description

In conjunction with a machine function or in the event of a fault, the "Safe Torque Off (STO)" function is used to safely disconnect the torque-generating motor power supply.

When the function is selected, the drive unit is in a "safe status". The power-on disable function prevents the drive unit from being restarted.

The two-channel pulse inhibit integrated in the Motor Modules / Power Modules is a basis for this function.

Functional features of "Safe Torque Off"

- This function is integrated in the drive; this means that a higher-level controller is not required.
- The function is drive specific, that is, it must be commissioned individually on a drive-by-drive basis.
- Enable of the function using parameters required.
- When the "Safe Torque Off" function is selected:
  - The motor cannot be started accidentally.
  - The pulse disable safely disconnects the torque-generating motor power supply.
  - The power unit and motor are not electrically isolated.

⚠ WARNING

Appropriate measures must be taken to ensure that the motor does not move once the motor power supply has been disconnected ("coast down") (e.g. enable the "Safe Brake Control" function with a vertical axis).

⚠ CAUTION
If two power transistors in the power unit (one in the upper and one offset in the lower inverter bridge) fail at the same time, this can cause a momentary movement. The maximum movement can be: Synchronous rotary motors: max. movement = 180° / no. of pole pairs Synchronous linear motors: max. movement = pole width

- The status of the "Safe Torque Off" function is displayed using parameters.

Enabling the "Safe Torque Off (STO)" function

The "Safe Torque Off" function is enabled via the following parameters:

NOTICE
It is not possible to activate the control via TM54F and PROFIsafe at the same time.

- STO via terminals:
  - p9601.0 = 1, p9801.0 = 1
- STO via TM54F (only with "Extended Functions" option):
  - p9601.2 = 1, p9801.2 = 1
  - p9601.3 = 0, p9801.3 = 0
- STO via PROFIsafe (only with "Extended Functions" option):
  - p9601.2 = 1, p9801.2 = 1
  - p9601.3 = 1, p9801.3 = 1

Selecting/deselecting "Safe Torque Off"

The following occurs when "Safe Torque Off" is selected:

- Each monitoring channel triggers safe pulse suppression via its switch-off signal path.
- A motor holding brake is applied (if connected and configured).

The following occurs when "Safe Torque Off" is de-selected:

- Each monitoring channel cancels safe pulse suppression via its switch-off signal path.
- The safety prompt "Apply motor holding brake" is canceled.
- Any pending STOP F or STOP A commands are canceled (see r9772/r9872).

Note

If "Safe Torque Off" is de-selected and selected again through one channel within the time in p9650/p9850, the pulses are canceled but a signal is not output.

If you want a message to be displayed in this case, however, you have to reconfigure N01620/N30620 via p2118 and p2119 as an alarm or fault.

Restart after the "Safe Torque Off" function has been selected

1. Deselect the function in each monitoring channel via the input terminals.
2. Issue drive enable signals.
3. Revoke the closing lockout and switch the drive back on.
   – 1/0 edge at input signal "ON/OFF1" (cancel power-on inhibit)
   – 0/1 edge at input signal "ON/OFF1" (switch on drive)
4. Run the drives again.

Status for "Safe Torque Off"

The status of the "Safe Torque Off (STO)" function is displayed using the following parameters:

Parameter overview (see List Manual)

- r9772 CO/BO: SI status (Control Unit)
- r9872 CO/BO: SI status (Motor Module)
- r9773 CO/BO: SI status (Control Unit + Motor Module)
- r9774 CO/BO: SI status (Safe Torque Off group)

As an alternative, the status of the functions can be displayed using the configurable messages N01620 and N30620 (configured using p2118 and p2119).

Response time with the "Safe Torque Off" function

The following values can be specified for the response times when the function is selected/deselected via input terminals:

- Typical response time

  2 x Safety monitoring cycle CU (r9780) + inputs/outputs sampling time (p0799)
- Max. response time in the event of a fault

  4 x Safety monitoring cycle CU (r9780) + inputs/outputs sampling time (p0799)

Examples, Booksize:

Assumption:

Safety monitoring clock cycle time CU (r9780) = 4 ms and
inputs/outputs sampling time (r0799) = 4 ms

t_{R_typ} = 2 x r9780 (4 ms) + r0799 (4 ms) = 12 ms

t_{R_max} = 4 x r9780 (4 ms) + r0799 (4 ms) = 20 ms

Parameter overview (see List Manual)

- p0799 CU inputs/outputs sampling times
- r9780 SI monitoring clock cycle (Control Unit)
- r9880 SI monitoring clock cycle (Motor Module)

9.4 Safe Stop 1 (SS1, time controlled)

General description

The "Safe Stop 1" function can be used to stop the drive in accordance with EN 60204-1, stop category 1. After "Safe Stop 1" has been selected, the drive brakes with the OFF3 ramp (p1135), and after the delay time set in p9652/p9852, changes to the status Safe Torque Off (STO).

CAUTION
When the SS1 (time-controlled) function has been activated through the parameterization of a delay in p9652/p9852, it is no longer possible to select STO via terminals.

Functional features of "Safe Stop 1"

SS1 is activated by p9652 and p9852 (delay time) not equal to "0"

- The function can only be activated in conjunction with "Safe Torque Off".
- When SS1 is selected, the drive is braked along the OFF3 ramp (p1135) and STO/SBC is automatically initiated after the delay time has expired (p9652/p9852).

  After the function has been activated the delay time runs - even if the function is de-selected during this time. In this case, after the delay time has expired, the STO/SBC function is selected and then again de-selected immediately.
- The selection is realized through two channels - however braking along the OFF3 ramp, only through one channel.

Release of the SS1 function

The function is enabled by entering the delay time in p9652 and p9852.

Prerequisite

The "Safe Torque Off" function must be enabled.

In order that the drive can brake down to a standstill even when selected through one channel, the time in p9652/p9852 must be shorter than the sum of the parameters for the crosswise data comparison (p9650/p9850 and p9658/p9858).

The time in p9652/9852 must be dimensioned so that after selection, the drive brakes down to a standstill.

Status for "Safe Stop 1"

The status of the "Safe Stop 1" function is displayed using the following parameters:

- r9772 CO/BO: SI status (Control Unit)
- r9773 CO/BO: SI status (Control Unit + Motor Module)
- r9774 CO/BO: SI status (Safe Torque Off group)
- r9872 CO/BO: SI status (Motor Module)

Alternatively, the status of the functions can be displayed using the configurable messages N01621 and N30621 (configured using p2118 and p2119).

Overview of key parameters (see SINAMICS S List Manual)

- see "Safe Torque Off" function
- p1135 OFF3 ramp-down time
- p9652 SI Safe Stop 1 delay time (Control Unit)
- p9852 SI Safe Stop 1 delay time (Motor Module)

9.5 Safe Brake Control (SBC)

Description

Safe brake control is used to activate holding brakes that function according to the standby current principle (e.g. motor holding brake).

The command for releasing or applying the brake is transmitted to the Motor Module/Power Module via DRIVE-CLiQ. he Motor Module/Safe Brake Relay then carries out the action and activates the outputs for the brake.

Brake activation via the brake connection on the Motor Module/Safe Brake Relay is carried out using a safe, two-channel method.

Note

Chassis components do not support this function.

Note

To ensure that this function can be used for Power Modules Blocksize, a Safe Brake Relay must be used (for more information, see the Equipment Manual).

When the Power Module is configured automatically, the Safe Brake Relay is detected and the motor holding brake type is defaulted (p1278 = 0).

⚠ WARNING

"Safe Brake Control" does not detect faults in the brake itself, such as brake winding short-circuit, worn brakes, etc.

If a cable breaks, this is only recognized by the "Safe Brake Control" function when the status changes, i.e. when the brake is applied/released.

Functional features of "Safe Brake Control" (SBC)

- When "Safe Torque Off" is selected or when safety monitors are triggered, "SBC" is performed with safe pulse cancellation.
- Unlike conventional brake control, SBC is executed via p1215 through two channels.
- SBC is executed regardless of the brake control or mode set in p1215. SBC is not recommended, however, when 1215 = 0 or 3.
- The function must be enabled via parameter.
- Each time "Safe Torque Off" is selected, the holding brake is applied immediately with forced dormant error detection.

Enabling the "Safe Brake Control (SBC)" function

The "Safe Brake Control" function is enabled via the following parameters:

- p9602 SI enable safe brake control (Control Unit)
- p9802 SI enable safe brake control (Motor Module)

The "Safe Brake Control" function is not active until at least one safety monitoring function has been enabled (i.e. p9601 = p9801 ≠ 0).

Two-channel brake control

The brake is controlled from the Control Unit. Two signal paths are available for applying the brake.

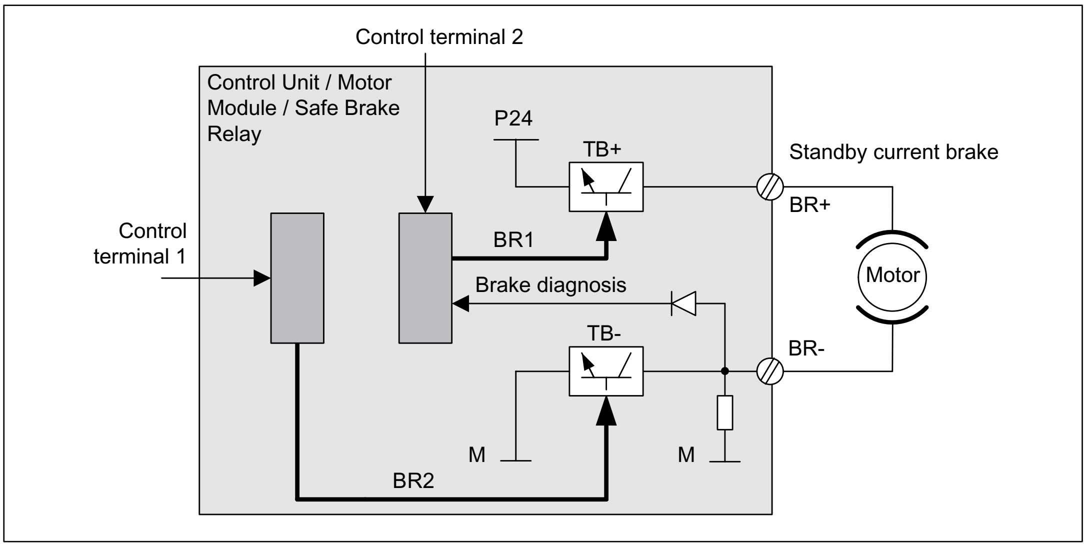


Figure 9-1 Two-channel brake control, booksize

The Motor Module carries out a check to ensure that the "Safe Brake Control" function is working properly and ensures that, if the Control Unit fails or is faulty, the brake current is interrupted and the brake applied.

The brake diagnosis can only reliably detect a malfunction in either of the switches (TB+, TB-) when the status changes (when the brake is released or applied).

If the Motor Module or Control Unit detects a fault, the brake current is switched off and the safe status is reached.

Response time with the "Safe Brake Control" function

The following values can be specified for the response times when the function is selected/deselected via input terminals:

- Typical response time

  4 x Safety monitoring cycle CU (r9780) + inputs/outputs sampling time (p0799)
- Max. response time in the event of a fault

  8 x Safety monitoring cycle CU (r9780) + inputs/outputs sampling time (p0799)

Examples:

Assumption:

Safety monitoring clock cycle time CU (r9780) = 4 ms and
inputs/outputs sampling time (r0799) = 4 ms

t_{R_typ} = 4 x r9780 (4 ms) + r0799 (4 ms) = 20 ms

t_{R_max} = 8 x r9780 (4 ms) + r0799 (4 ms) = 36 ms

Parameter overview (see SINAMICS S List Manual)

- p0799 CU inputs/outputs sampling times
- r9780 SI monitoring clock cycle (Control Unit)
- r9880 SI monitoring clock cycle (Motor Module)

9.6 Control via terminals on the Control Unit and the power unit

Features

- Only for the STO, SS1 (time-controlled) and SBC functions
- Dual-channel structure via two digital inputs (Control Unit/power unit)
- Different terminal strips depending on design
- Automatic ANDing of up to 8 digital inputs (p9620[0...7]) on the Control Unit with parallel configuration of chassis type power units

Overview of the safety function terminals for SINAMICS S120

The different power unit formats of SINAMICS S120 have different terminal designations for the inputs of the safety functions. These are shown in the following table.

Table 9-2 Inputs for safety functions

	1. Switch-off signal path (p9620[0])	2. Switch-off signal path
Control Unit CU320	X122.1....4 / X132.1...4 (on the CU320) digital input 0 to 7	(see Motor Modules / Power Modules)
Single Motor Module Booksize	(see CU320)	X21.3 and X21.4 (on the Motor Module)
Single Motor Module Chassis	(see CU320)	X41.1 and X41.2 (on the CIB)
Double Motor Module Booksize	(see CU320)	X21.3 and X21.4 (motor connection X1)/X22.3 and X22.4 (motor connection X2) (on the Motor Module)
Power Module Blocksize with CUA31	(see CU320)	X210.3 and X210.4 (on the CUA31)
Power Module Blocksize with CU310	X121.1...4 (on the CU310) digital input 0 to 3	X120.7 and X120.8 (on the CU310)
Power Module Chassis with CU310	X121.1...4 (on the CU310) digital input 0 to 3	X41.1 and X41.2 (on the CIB)
For further information about the terminals, see the Equipment Manuals.		

Terminals for STO, SS1 (time-controlled), SBC

The functions are separately selected/deselected for each drive using two terminals.

- 1. Switch-off signal path (CU310/CU320)

  The desired input terminal is selected via BICO interconnection (BI: p9620[0]).

- 2. Switch-off signal path (Motor Module/Power Module/CUA31)

  The input terminal is the "EP" ("Enable Pulses") terminal.

Both terminals must be operated simultaneously, otherwise a fault will be issued.

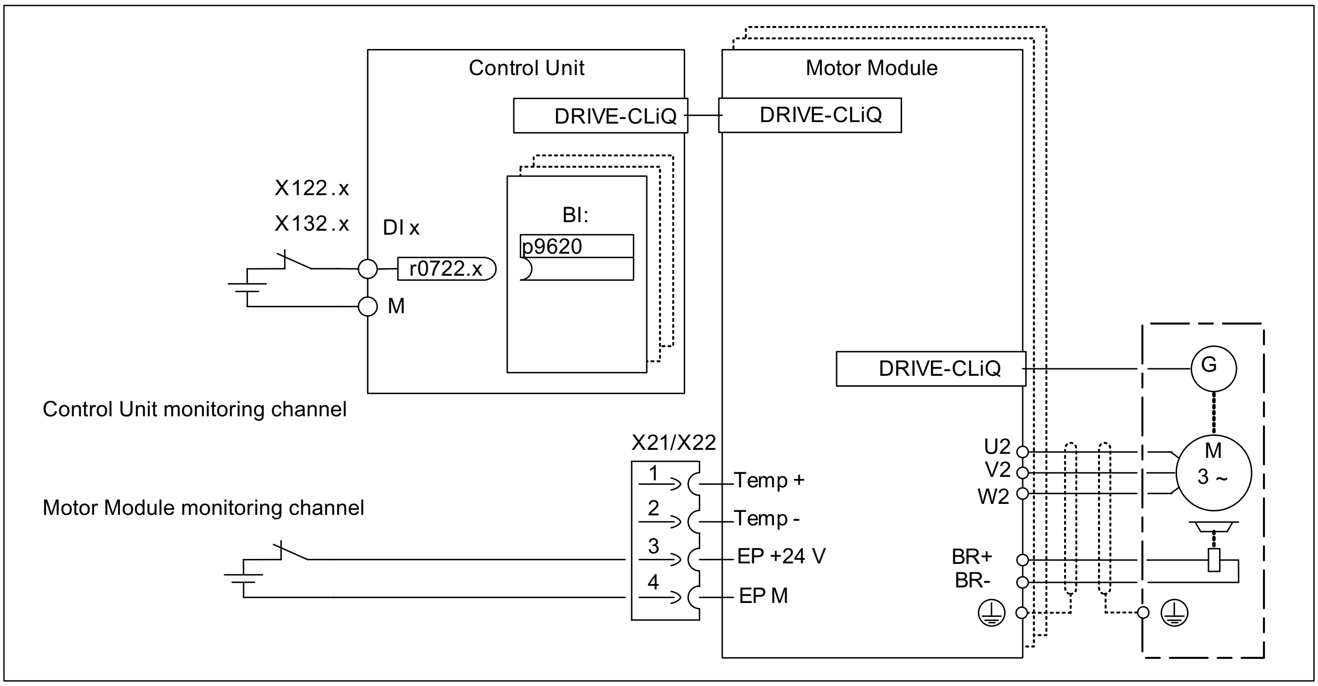


Figure 9-2 Terminals for "Safe Torque Off", example for Motor Modules Booksize and CU320

Grouping drives (not for CU310)

To ensure that the function works for more than one drive at the same time, the terminals for the corresponding drives must be grouped together as follows:

- 1. Switch-off signal path (CU320)

  By connecting the binector input to the joint input terminal on the drives in one group.

- 2. Switch-off signal path (Motor Module/CUA31)

  By appropriately connecting-up the terminals for the individual Motor Modules/Power Modules belonging to the group with CUA31.

Note

The grouping must be identical in both monitoring channels.

If a fault in a drive results in a "Safe Torque Off (STO)", this does not automatically mean that the other drives in the same group also switch to "Safe Torque Off (STO)".

The assignment is checked during the test for the switch-off signal paths, The operator selects "Safe Torque Off" for each group. The check is drive-specific.

Example: Terminal groups

It must be possible to select/deselect "Safe Torque Off" separately for group 1 (drive 1 and 2) and group 2 (drive 3 and 4).

For this purpose, the same grouping for "Safe Torque Off" must be performed on both the Control Unit and the Motor Modules.

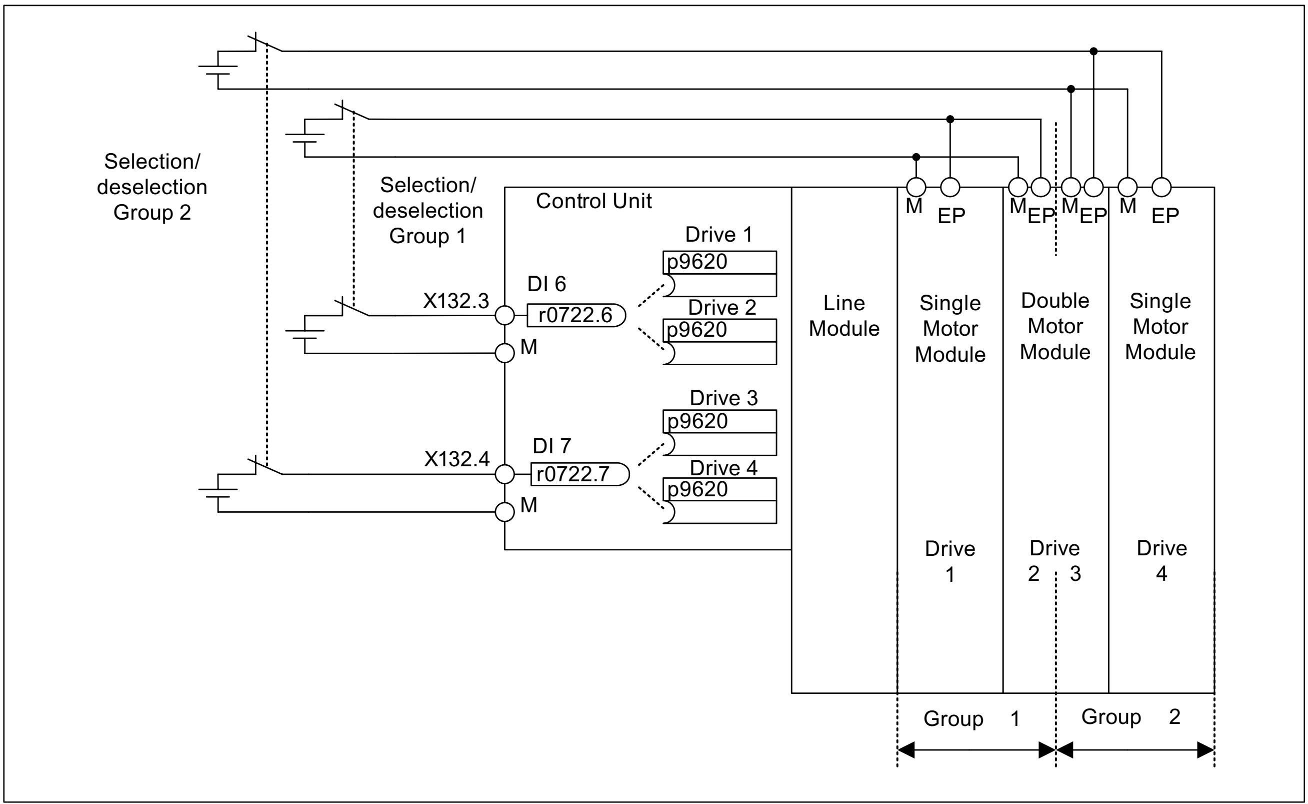


Figure 9-3 Grouping terminals with Motor Modules Booksize and CU320

Information on the parallel connection of chassis type Motor Modules

When Motor Modules of chassis type are connected in parallel, a safe AND element is created on the parallel drive object. The number of indexes in p9620 corresponds to the number of parallel chassis components in p0120.

Simultaneity and tolerance time of the two monitoring channels

The "Safe Torque Off" function must be selected/deselected simultaneously in both monitoring channels using the input terminals and is only effective for the associated drive.

1 signal: Deselecting the function

0 signal: Selecting the function

"Simultaneously" means:

The changeover must be complete in both monitoring channels within the parameterized tolerance time.

- p9650 SI tolerance time F-DI changeover (Control Unit)
- p9850 SI tolerance time F-DI changeover (Motor Module)

If the "Safe Torque Off" function is not selected/deselected within the tolerance time, this is detected by the crosswise comparison, and fault F01611 or F30611 (STOP F) is output. In this case, the pulses have already been canceled as a result of the selection of "Safe Torque Off" on one channel.

9.7 Commissioning the "STO", "SBC" and "SS1" functions

9.7.1 General information about commissioning safety functions

Commissioning notes

NOTICE
For safety reasons, safety functions cannot be commissioned offline with the STARTER commissioning tool (or SCOUT).

Note

- The "STO", "SBC" and "SS1" functions are drive specific, that is, the functions must be commissioned individually for each drive.
- To support the "STO" and "SBC" functions, the following (minimum) safety versions are required:
  Control Unit: V02.01.01 (r9770[0...2])
  Motor Module: V02.01.01 (r9870[0...2])
- To support the "SS1" functions, the following (minimum) safety version is required:
  Control Unit: V02.04.01 (r9770[0...2])
  Motor Module: V02.04.01 (r9870[0...2])
- If the version in the Motor Module is incompatible, the Control Unit responds as follows during the switchover to safety commissioning mode (p0010 = 95):
  - Fault F01655 (SI CU: Align the monitoring functions) is output. The fault triggers fault reaction OFF2.
    The fault cannot be acknowledged until safety commissioning mode (p0010 ≠ 95) is exited.
  - The Control Unit triggers a safe pulse suppression via its own safety switch-off signal path.
  - If parameterized (p1215), the motor holding brake is applied.
  - The safety functions cannot be enabled (p9601/p9801 and p9602/p9802).

Prerequisites for commissioning the safety functions

1. Commissioning of the drives must be complete.
2. Non-safe pulse disable must be present (e.g. via OFF1 = "0" or OFF2 = "0")

   If the motor holding brake is connected and parameterized, the holding brake is applied.
3. The terminals for "Safe torque off" must be wired.
4. For operation with SBC, the following applies:

   A motor with motor holding brake must be connected to the appropriate terminal of the Motor Module.

Standard commissioning of the safety functions

1. A project that has been commissioned and uploaded to STARTER can be transferred to another drive unit without losing the safety parameterization.
2. If the source and target devices have different software versions, it may be necessary to adapt the reference checksums (p9799, p9899). This is indicated by the faults F01650 (fault value: 1000) and F30650 (fault value: 1000).
3. Once the project has been downloaded to the target device, a short acceptance must be carried out (see table 7-10). This is indicated by fault F01650 (fault value: 2004).

NOTICE
Once a project has been downloaded, it must be stored on the non-volatile CompactFlash card (copy from RAM to ROM).

Replacing Motor Modules with the current FW release

1. After a Motor Module fails, a more recent firmware release can be installed on the new Motor Module.
2. If the old and new devices have different software versions, it may be necessary to adjust the reference checksums (p9899) (see Table 7-2). This is indicated by F30650 (fault value: 1000).

Table 9-3 Adapting the reference checksum (p9899)

no.	Parameter	Description/comments
1	p0010 = 95	Safety Integrated: set commissioning mode.
2	p9761 = "Value"	Set the safety password.
3	p9899 = "r9898"	Adapt the reference checksum on the Motor Module
4	p0010 = Value not equal to 95	Safety Integrated: exit commissioning mode
5	POWER ON	Carry-out a POWER ON.

Adapt the reference checksum with the safety screens of STARTER:

Change settings -> Enter password -> Activate settings

After the settings have been activated, the checksums are automatically adapted.

9.7.2 Procedure for commissioning "STO", "SBC" and "SS1"

To commission the "STO", "SBC" and "SS1" functions, carry out the following steps:

Table 9-4 Commissioning the "STO", "SBC" and "SS1" functions

No.	Parameter	Description/comments
1	p0010 = 95	**Safety Integrated: set commissioning mode.** • The following alarms and faults are output: – A01698 (SI CU: Commissioning mode active) During first commissioning only: – F01650 (SI CU: acceptance test required) with fault value = 130 (no safety parameters exist for the Motor Module). – F30650 (SI MM: acceptance test required) with fault value = 130 (no safety parameters exist for the Motor Module). Acceptance test and acceptance certificate: see step 14. • The pulses are safely canceled and monitored by the Control Unit and Motor Module. • The safety sign-of-life is monitored by the Control Unit and Motor Module. • The function for exchanging fault reactions between the Control Unit and Motor Module is active. • An existing and parameterized motor holding brake has already been applied. • In this mode, fault F01650 or F30650 with fault value = 2003 is output after a safety parameter is changed for the first time. This behavior applies for the entire duration of safety commissioning, that is, the "STO" function cannot be selected/deselected while safety commissioning mode is active because this would constantly force safe pulse suppression.
2	p9761 = "Value"	**Set the safety password.** When Safety Integrated is commissioned for the first time, the following applies: • Safety password = 0 • Default setting for p9761 = 0 This means that the safety password does not need to be set during initial commissioning.
3	 p9601.0 p9801.0	**Enable "Safe torque off" function** STO via Control Unit terminals STO via Motor Module terminals • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • Both parameters are included in the crosswise data comparison and must, therefore, be identical.
4	 p9602 = 1 p9802 = 1	**Enable the "Safe brake control" function.** Enable "SBC" on the Control Unit Enable "SBC" on the Motor Module • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • Both parameters are included in the crosswise data comparison and must, therefore, be identical. • The "safe brake control" function is not activated until at least one safety monitoring function has been enabled (i.e. p9601 = p9801 ≠ 0).

No.	Parameter	Description/comments
5	 p9652 > 0 p9852 > 0	**Enable "Safe Stop 1" function.** Enable "SS1" on the Control Unit Enable "SS1" on the Motor Module • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • Both parameters are included in the crosswise data comparison and must, therefore, be identical. • The "Safe Stop 1" function is not activated until at least one safety monitoring function has been enabled (i.e. p9601 = p9801 ≠ 0).
6	 p9620 = "Value" Terminal "EP"	**Set terminals for "Safe torque off (STO)".** Set the signal source for STO on the Control Unit. Wire terminal "EP" (enable pulses) on the Motor Module. • Control Unit monitoring channel: By appropriately interconnecting BI: p9620 for the individual drives, the following is possible: – Selecting/deselecting the STO – Grouping the terminals for STO • Motor Module monitoring channel: By wiring the "EP" terminal accordingly on the individual Motor Modules, the following is possible: – Selecting/deselecting the STO – Grouping the terminals for STO **Note:** The STO terminals must be grouped identically in both monitoring channels.
7	 p9650 = "Value" p9850 = "Value"	**Set F-DI changeover tolerance time.** F-DI changeover tolerance time on Control Unit F-DI changeover tolerance time on Motor Module • The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set). • Due to the different runtimes in the two monitoring channels, an F-DI changeover (e.g., selection/deselection of STO) does not take immediate effect. After an F-DI changeover, dynamic data is not subject to a data cross-check during this tolerance time. • Both parameters are included in the crosswise data comparison and must, therefore, be identical. A difference of one safety monitoring clock cycle is tolerated for the values.

<table>
<tr><th>No.</th><th>Parameter</th><th>Description/comments</th></tr>
<tr><td>8</td><td>
p9658 = "Value"
p9858 = "Value"</td><td>Set transition period from STOP F to STOP A.
Transitional period from STOP F to STOP A on Control Unit
Transitional period from STOP F to STOP A on Motor Module
• The parameters are not changed until safety commissioning mode has been exited (i.e. when p0010 ≠ 95 is set).
• STOP F is the fault reaction that is initiated when the data cross-check is violated as a result of fault F01611 or F30611 (SI: defect in a monitoring channel). STOP F normally triggers "No fault reaction".
• After the parameterized time has expired, STOP A (immediate safety pulse inhibit) is triggered by the fault F01600 or F30600 (SI: STOP A triggered).
The default setting for p9658 and p9858 is 0 (i.e., STOP F immediately results in STOP A).
• Both parameters are included in the crosswise data comparison and must, therefore, be identical. A difference of one safety monitoring clock cycle is tolerated for the values.</td></tr>
<tr><td>9</td><td>p9659 = "Value"</td><td>Time for carrying out forced dormant error detection and testing the safety switch-off paths.
• After this time has expired, the user is requested to test the switch-off paths as a result of alarm A01699 (SI CU: Necessary to test the switch-off signal paths) (i.e. select/de-select STO).
• The commissioning engineer can change the time required for carrying out the forced dormant error detection and testing the safety switch-off paths.</td></tr>
<tr><td>10</td><td>
p9799 = "r9798"
p9899 = "r9898"</td><td>Adjust specified checksums.
Specified checksum on the Control Unit
Specified checksum on the Motor Module
The current checksums for the Safety parameters that have undergone a checksum check are displayed as follows:
• Actual checksum on the Control Unit: r9798
• Actual checksum on the Motor Module: r9898
By setting the actual checksum in the parameter for the specified checksum, the commissioning engineer confirms the Safety parameters in each monitoring channel.
This procedure is performed automatically when STARTER and the commissioning Wizard for SINAMICS Safety Integrated are used.</td></tr>
<tr><td>11</td><td>
p9762 = "Value"
p9763 = "Value"</td><td>Set the new Safety password.
Enter a new password.
Confirm the new password.
• The new password is not valid until it has been entered in p9762 and confirmed in p9763.
• As of now, you must enter the new password in p9761 so that you can change Safety parameters.
• Changing the Safety password does not mean that you have to change the checksums in p9799 and p9899.</td></tr>
</table>

No.	Parameter	Description/comments
12	p0010 = Value not equal to 95	**Safety Integrated: exit commissioning mode** • If at least one safety monitoring function is enabled (p9601 = p9801 ≠ 0), the checksums are checked: If the target checksum on the Control Unit has not been correctly adapted, then fault F01650 (SI CU: Acceptance test required) is output with fault code 2000 and it is not possible to exit the safety commissioning mode. If the target checksum on Motor Modules has not been correctly adapted, then fault F01650 (SI CU: Acceptance test required) is output with fault code 2001 and it is not possible to exit the safety commissioning mode. • If a safety monitoring function has not been enabled (p9601 = p9801 = 0), safety commissioning mode is exited without the checksums being checked. When safety commissioning mode is exited, the following is carried out: • The new safety parameters are active on the Control Unit and Motor Module.
13		All drive parameters (entire drive group or only single axis) must be manually saved from RAM to ROM. These data are not saved automatically!
14	POWER ON	Carry-out a POWER ON. After commissioning, a POWER ON reset must be carried out.
15	-	**Carry out acceptance test and create test certificate.** Once safety commissioning is complete, the commissioning engineer must carry out an acceptance test for the enabled safety monitoring functions. The results of the acceptance test must be documented in an acceptance certificate.

9.7.3 Safety faults

Stop response

When Safety Integrated faults occur, the following stop responses can be triggered:

Table 9-5 Safety Integrated stop responses

<table>
<tr><th>Stop response</th><th>Action</th><th>Effect</th><th>Triggered ...</th></tr>
<tr><td>STOP A cannot be acknowledged</td><td rowspan="2">Trigger safe pulse suppression via the switch-off signal path for the relevant monitoring channel.
During operation with SBC: apply motor holding brake.</td><td rowspan="2">The motor coasts to a standstill or is braked by the holding brake.</td><td>For all non-acknowledgeable Safety faults with pulse disable.</td></tr>
<tr><td>STOP A</td><td>For all acknowledgeable safety faults with pulse disable.
As a follow-up reaction of STOP F.</td></tr>
</table>

Stop response	Action	Effect	Triggered ...
	STOP A is identical to stop Category 0 to EN 60204-1. With STOP A, the motor is switched directly to zero torque via the "Safe torque off (STO)" function. A motor at standstill cannot be started again accidentally. A moving motor coasts to standstill. This can be prevented by using external braking mechanisms (e.g. armature short-circuiting, holding or operational brake). When STOP A is present, "Safe torque off (STO)" is effective.		
STOP F	Transition to STOP A.	None1)	If an error occurs in the crosswise data comparison.
	STOP F is permanently assigned to the crosswise data comparison (CDC). In this way, errors are detected in the monitoring channels. After STOP F, STOP A is triggered. When STOP A is present, "Safe torque off (STO)" is effective.		
1) If STOP F is output by the crosswise data comparison of the two input signals when the "Safe torque off" function is selected, this means that the pulses have already been canceled when "Safe torque off" was selected on one channel.			

WARNING

With a vertical axis or pulling load, there is a risk of uncontrolled axis movements when STOP A/F is triggered. This can be prevented by using "Safe brake control (SBC)" and a holding brake with sufficient retention force (non-safe).

Acknowledging the safety faults

Safety Integrated faults must be acknowledged as follows:

1. Remove the cause of the fault.
2. Deselect "Safe Torque Off (STO)".
3. Acknowledge the fault.

If safety commissioning mode is exited when the safety functions are switched off (p0010 = value not equal to 95 when p9601 = p9801 = 0), all the safety faults can be acknowledged.

Once safety commissioning mode has been reset (p0010 = 95), all the faults that were previously present reappear.

NOTICE

The safety faults can also be acknowledged (as with all other faults) by switching the drive unit off and then on again (POWER ON).

If this action has not eliminated the fault cause, the fault is displayed again immediately after power up.

Description of faults and alarms

Note

The faults and alarms for SINAMICS Safety Integrated are described in the following documentation:

References: /LH1/ SINAMICS S List Manual

9.8 Acceptance test and certificate

9.8.1 General information about acceptance

Acceptance test

The machine manufacturer must carry out an acceptance test for the activated Safety Integrated functions (SI functions) on the machine.

During the acceptance test, all the limit values entered for the enabled SI functions must be exceeded to check and verify that the functions are working properly.

NOTICE
The acceptance test must only be carried out after the safety functions have been commissioned and POWER ON reset.

Authorized person, acceptance report

Each SI function must be tested and the results documented and signed in the acceptance certificate by an authorized person. The acceptance certificate must be stored in the machine logbook.

Authorized in this sense refers to a person who has the necessary technical training and knowledge of the safety functions and is authorized by the machine manufacturer to carry out the test.

Note

- The information and descriptions regarding commissioning must be carefully observed.
- If any parameters are altered by SI functions, the acceptance test must be carried out again and documented in the acceptance certificate.
- Template for the acceptance certificate
  A printed form is available in this manual as an example/suggestion.

Scope of a complete acceptance test

Documentation

Machine documentation (including the SI functions)

1. Machine description and overview diagram
2. SI functions for each drive
3. Description of safety equipment

Functional test

Check the individual SI functions used

1. "Safe torque off" function, part 1
2. "Safe torque off" function, part 2
3. "Safe Stop 1" function
4. "Safe brake control" function

Completion of certificate

Record the commissioning procedure and provide countersignatures.

1. Check the Safety parameters
2. Record the checksums
3. Verify the data backups
4. Countersignatures

Appendix

Measurement records for function test parts 1 and 2.

- Alarm logs
- Trace recordings

9.8.2 Documentation

Table 9-6 Machine description and overview diagram

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Electrical axes	

Other axes	
Spindles	
Overview diagram of machine	

Table 9-7 Values from relevant machine data

Parameter Control Unit		FW version	-
		r0018 =	-
Parameter Motor Modules	**Drive number**	**FW version**	**SI version**
		-	r9770 =
		r0128 =	r9870 =
		r0128 =	r9870 =
		r0128 =	r9870 =
		r0128 =	r9870 =
		r0128 =	r9870 =
		r0128 =	r9870 =
	Drive number	**SI monitoring clock cycle Control Unit**	**SI monitoring clock cycle Motor Module**
Parameter Motor Modules		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =
		r9780 =	r9880 =

Table 9-8 SI functions for each drive

Drive number	SI function

Table 9-9 Description of safety equipment

Examples: Wiring of STO terminals (protective door, emergency OFF), grouping of STO terminals, holding brake for vertical axis, etc.

9.8.3 Acceptance test for Safe Torque Off (STO)

"Safe Torque Off" (STO) function

This test comprises the following steps:

Table 9-10 "Safe Torque Off" (STO) function

No.	Description	Status
1.	Initial state	
	Drive in "Ready" status (p0010 = 0)	
	STO function enabled (p9601.0 = 1, p9801.0 = 1)	
	No safety faults and alarms (r0945, r2122, r2132)	
	r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	When terminals are grouped for "Safe Torque Off": r9774.0 = r9774.1 = 0 (STO de-selected and inactive - group)	
2.	Run the drive	
3.	Ensure that the correct drive is running	
4.	Select STO when issuing the traversing command	
Note: The acceptance test must be carried out for each configured control, which may be via terminals, via the TM54F or via PROFIsafe.		
5.	Check the following:	
	• The drive coasts to a standstill or is braked and stopped by the mechanical brake (if available and configured (p1215, p9602, p9802)).	
	• No safety faults and alarms (r0945, r2122, r2132)	
	• r9772.0 = r9772.1 = 1 (STO selected and active – CU)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• When terminals are grouped for "Safe torque off": r9774.0 = r9774.1 = 1 (STO selected and active - group)	
6.	Deselect STO	
7.	Check the following:	
	• No safety faults and alarms (r0945, r2122, r2132)	
	• r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	• When terminals are grouped for "Safe Torque Off": r9774.0 = r9774.1 = 0 (STO de-selected and inactive - group)	
	• r0046.0 = 1 (drive in "Power-on inhibit" state)	
8.	Acknowledge "Power-on inhibit" and run the drive	
9.	Ensure that the correct drive is running	

No.	Description	Status
	The following is tested: • Correct DRIVE-CLiQ wiring between Control Unit and Motor Modules • Correct assignment of drive No. – Motor Module – motor • The hardware is functioning properly • The switch-off signal paths are wired correctly • Correct assignment of the terminals for STO on the Control Unit • Correct STO grouping (if available) • Correct parameterization of the STO function • Routine for forced dormant error detection of the switch-off signal paths	

9.8.4 Acceptance test for Safe Stop 1, time controlled (SS1)

"Safe Stop 1" function (SS1, time-controlled)

This test comprises the following steps:

Table 9-11 "Safe Stop 1" function (SS1)

No.	Description	Status
1.	Initial state	
	Drive in "Ready" status (p0010 = 0)	
	STO function enabled (p9601.0 = 1, p9801.0 = 1)	
	Enable SS1 function (p9652 > 0, p9852 > 0)	
	No safety faults and alarms (r0945, r2122, r2132)	
	r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	r9772.2 = r9872.2 = 0 (SS1 not requested – CU and MM)	
	When terminals are grouped for "Safe Torque Off": r9774.0 = r9774.1 = 0 (STO de-selected and inactive - group)	
2.	Run the drive	
3.	Ensure that the correct drive is running	
4.	Select SS1 when issuing the traversing command	
Note: The acceptance test must be carried out for each configured control, which may be via terminals, via the TM54F or via PROFIsafe.		
5.	Check the following:	
	• The drive is braked along the OFF3 ramp (p1135).	
	Before the SS1 delay time (p9652, p9852) expires, the following applies:	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive - CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9772.2 = r9872.2 = 1 (SS1 active – CU and MM)	

No.	Description	Status
	• r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	• r9773.2 = 1 (SS1 active – drive)	
	STO is initiated after the SS1 delay time expires (p9652, p9852).	
	• No safety faults and alarms (r0945, r2122, r2132)	
	• r9722.0 = r9772.1 = 1 (STO selected and active – CU)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – MM)	
	• r9772.2 = r9872.2 = 0 (SS1 inactive – CU and MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9773.2 = 0 (SS1 inactive – drive)	
6.	Deselect SS1	
7.	Check the following:	
	• No safety faults and alarms (r0945, r2122, r2132)	
	• r9722.0 = r9772.1 = 0 (STO de-selected and inactive - CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9772.2 = r9872.2 = 0 (SS1 inactive – CU and MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9773.2 = 0 (SS1 inactive – drive)	
	• r0046.0 = 1 (drive in "Power-on inhibit" state)	
8.	Acknowledge "Power-on inhibit" and run the drive	
9.	Ensure that the correct drive is running	
	The following is tested: • Correct parameterization of the SS1 function	

9.8.5 Acceptance test for "Safe Brake Control" (SBC)

"Safe Brake Control" function (SBC)

This test comprises the following steps:

Table 9-12 "Safe brake control" (SBC) function

No.	Description	Status
1.	Initial state	
	• Drive in "Ready" status (p0010 = 0)	
	• STO function enabled (p9601.0 = 1, p9801.0 = 1)	
	• Enable SBC function (p9602 = 1, p9802 = 1)	
	• Vertical axis: Brake as in sequential control (p1215 = 1) • No vertical axis: Brake always released (p1215 = 2)	

No.	Description	Status
	• Vertical axis: Mechanical brake is applied • No vertical axis: Mechanical brake is released	
	• No safety faults or alarms (r0945, r2122)	
	• r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	• r9772.4 = r9872.4 = 0 (SBC not requested – CU and MM)	
2.	Run drive (applied brake is released)	
3.	Ensure that the correct drive is running	
4.	Select STO/SS1 when issuing the traversing command	
Note: The acceptance test must be carried out for each configured control, which may be via terminals, via the TM54F or via PROFIsafe.		
5.	Check the following: • Drive is braked and stopped by the mechanical brake. • No safety faults or alarms (r0945, r2122) • r9772.0 = r9772.1 = 1 (STO selected and active – CU) • r9872.0 = r9872.1 = 1 (STO selected and active – MM) • r9773.0 = r9773.1 = 1 (STO selected and active – drive) • r9772.4 = r9872.4 = 1 (SBC requested – CU and MM)	
6.	Deselect STO	
7.	Check the following:	
	• Vertical axis: Mechanical brake remains applied • No vertical axis: Mechanical brake is released • No safety faults or alarms (r0945, r2122)	
	• r9772.0 = r9772.1 = 0 (STO de-selected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO de-selected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO de-selected and inactive – drive)	
	• r9772.4 = r9872.4 = 0 (SBC not requested – CU and MM)	
	• r0046.0 = 1 (drive in "Power-on inhibit" state)	
8.	Acknowledge "Power-on inhibit" and run the drive (vertical axis: mechanical brake is released)	
9.	Ensure that the correct drive is running	
	The following is tested: • The brake is connected properly • The hardware is functioning properly • The SBC is parameterized correctly • Routine for the forced dormant error detection of the brake control	

9.8.6 Completion of certificate

SI parameters

	Specified values checked?	
	Yes	No
Control Unit		
Motor Module		

Checksums

Drive		Checksum (8 hex)	
Name	Drive number	Control Unit (p9798)	Motor Module (p9898)

Data backup

	Storage medium			Storage location
	Type	Designation	Date	
Parameter				
PLC program				
Circuit diagrams				

Countersignatures

Commissioning engineer

This confirms that the tests and checks have been carried out properly.

Date	Name	Company/dept.	Signature

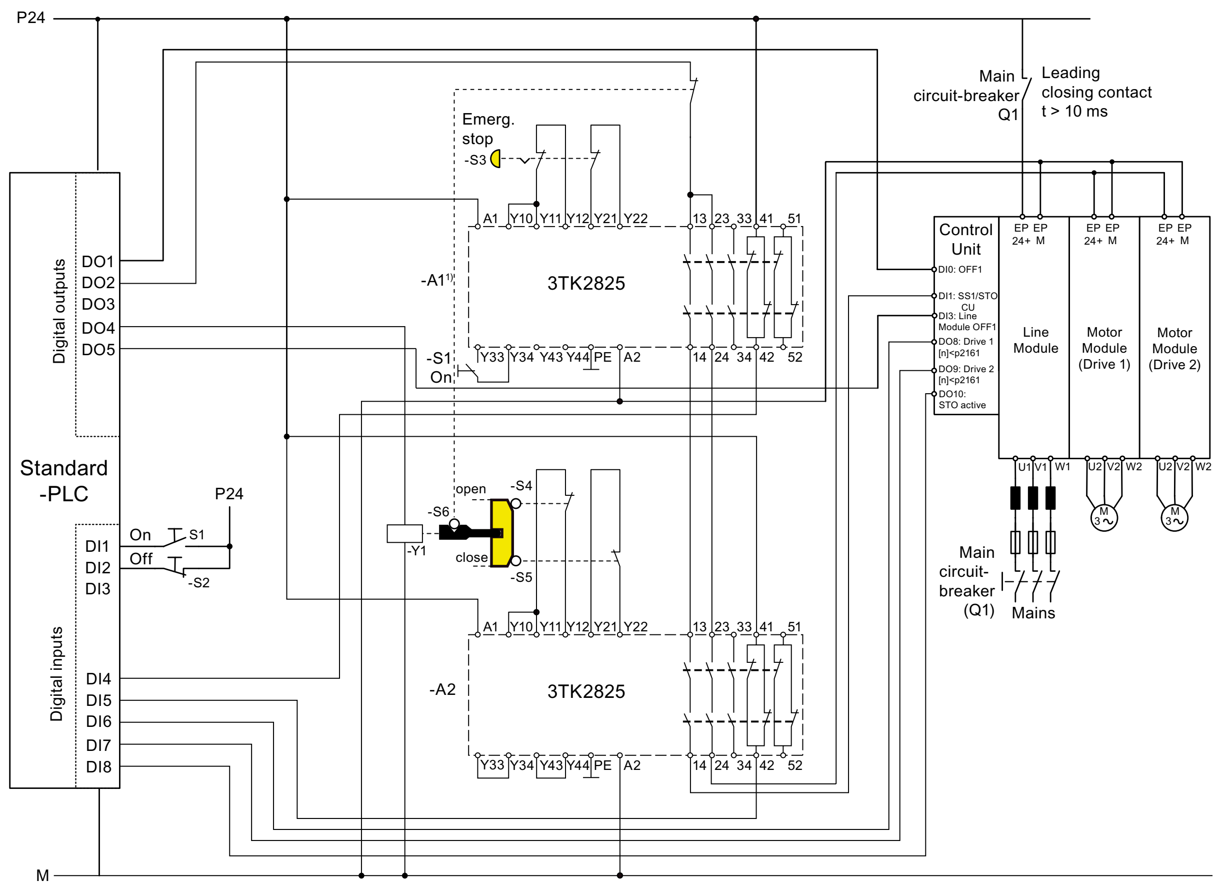
Machine manufacturer

This confirms that the parameters recorded above are correct.

Date	Name	Company/dept.	Signature

9.9 Application examples

9.9.1 Safe Stop 1 (SS1, time-controlled) when protective door is locked, emergency stop switch-off



1) Y43 - Y44 must be open, otherwise no switch-on monitoring of S1 (Y33/34).

Figure 9-4 Application example

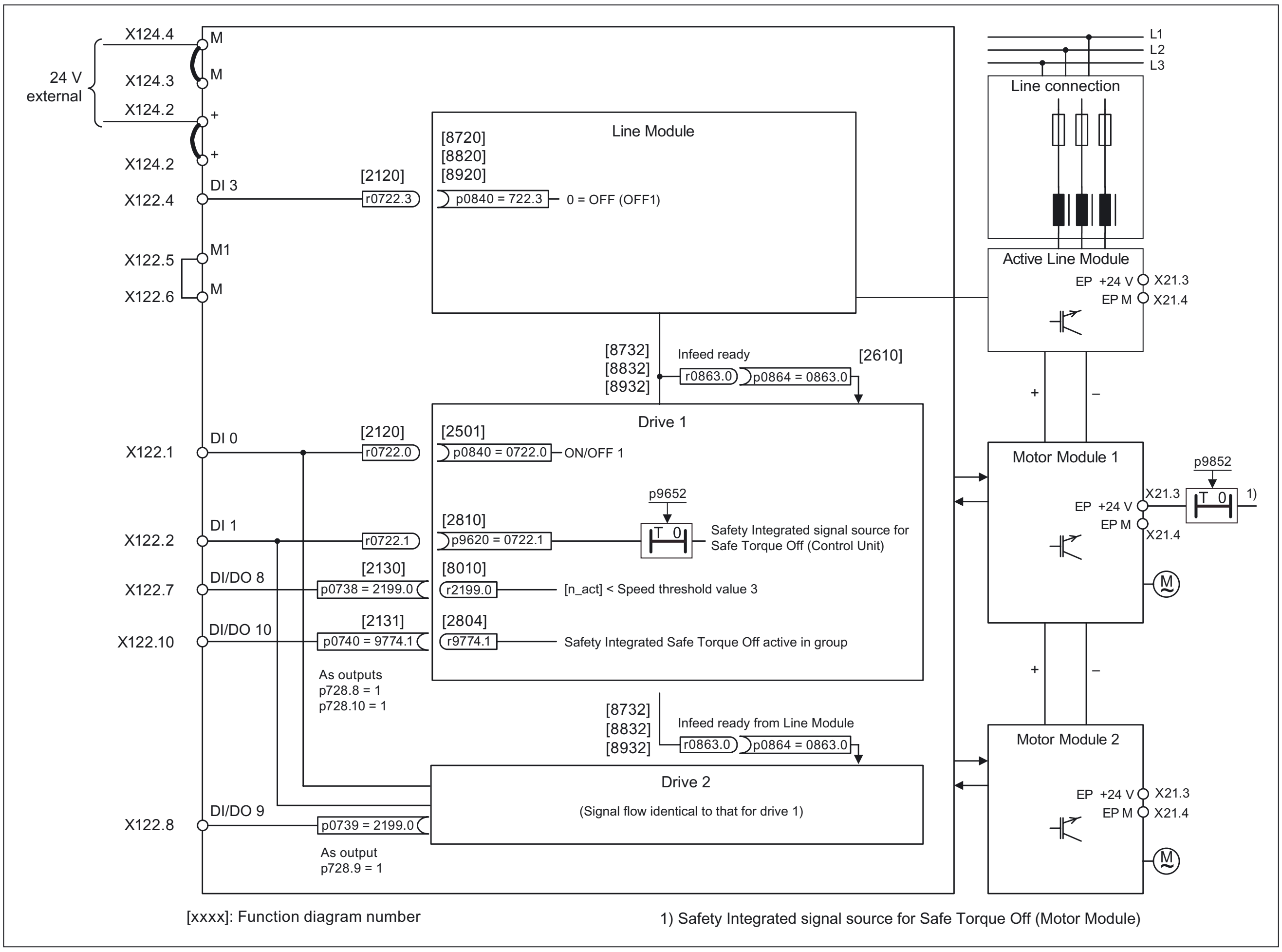


Figure 9-5 Safety Integrated signal flow application example

Note

This example illustrates implementation options. The solution required for the machine must be suitable for the machine function, which means that parameters and control commands are defined individually.

NOTICE
The fault responses and output functions (e.g. inversion or simulation) must not be changed or activated with respect to the factory setting.

Description of functions

With two SIGUARD safety combinations for emergency stop and the protective door, as well as a standard PLC, the system can be configured according to EN 954-1, category 3, and EN1037. The drives are brought to a standstill in accordance with stop category 1 to EN 60204-1.

- The "Safe Torque Off" safety function, which is integrated in the drive, complies with category 3 to EN 954-1 and SIL 2 to IEC 61508. The non-safe message "Safe Torque Off active" is sufficient.
- Safety combinations for emergency stop and protective door monitoring comply with category 4 (instantaneous enable circuits).
- The electric circuits for emergency stop and protective door monitoring are monitored for cross-circuits on two channels.
- Switches S4, S5, and S6 are positively-opening position switches corresponding to EN 1088.
- Being a higher-level circuit with contacts, the "Safe Stop 1 (SS1)" function also works if the PLC malfunctions or fails.
- I/O communication via the digital interface between the drive and PLC can also be replaced by non-safe standard communication (e.g. PROFIBUS).
- This application example is based on the basic functions "Safe Torque Off" (STO) and "Safe Stop 1" (SS1).
  The speed ramps and speed thresholds are monitored in non-safe mode.

Note

In order to implement the Emergency Stop function (stopping in an emergency - emergency stop) it is not absolutely necessary to electrically isolate the drive converter from the line supply using electromechanical switching devices according to EN 60204-1 (1998) and IEC60204-1 (2005). When work is carried-out on the motor or drive converter, the voltage must be disconnected via a main circuit-breaker (that can be locked-out). Other Standards (e.g. NFPA79-2002 / USA) specify additional requirements regarding the EMERGENCY STOP function. For the EMERGENCY SWITCHING-OFF function (switching-off in an emergency) according to EN 60204-1 (1998) and IEC 60204-1 (2005), the supply voltage to the equipment must be disconnected through an electromechanical switching device. The risk analysis to be carried-out by the machinery construction OEM must determine which emergency functions (emergency operations) are actually required for a specific application.

Behavior for Emergency Stop

An emergency stop is triggered by the S3 button ("Emergency stop"). The drive is brought to a standstill in accordance with stop category 1 of EN 60204-1.

- Open the safe enable contacts of the safety combination A1. This activates the "Safe Stop 1" drive function on two channels via terminal X122.2 (DI 1) on the Control Unit and terminals X21.3 (EP +24 V) and X21.4 (EP M) on the Motor Module. "Safe Torque Off" is selected after the set SS1 delay time (p9852, p9652) has elapsed. When all the grouped drives have reached the "Safe Torque Off active" status, this is signaled back via terminal X122.10 (DO 10: STO group active).
- The confirmation from the safety combination and the drive is monitored in the PLC to ensure that it is plausible.

Behavior when the protective door is opened

To issue a request to open the protective door, press the S2 button ("OFF"). The drive is brought to a standstill in accordance with stop category 1 of EN 60204-1.

- Resetting the PLC output DO 2 will trigger an SS1 at terminal X122.2 on the CU (DI 1) and at the EP terminals of the Motor Modules. The drives are immediately braked via the speed ramp (p1135). The speed ramp is not monitored for SS1. The pulses are safely canceled after the safe SS1 delay time (p9852, p9652) has elapsed.
- When all drives have executed the safe pulse cancelation, the feedback "STO in group active" (DO 10) is issued from the CU to the PLC. In addition, a request is made via the PLC (PLC: DI 7 and DI 8) if the drives have fallen below the preset speed threshold (D0 8 and DO 9: |n|<p2161).
  Only when these conditions are met, solenoid Y1 (PLC output DO 4) is energized and the lock of the protective door opened.
- When the protective doors are opened, the protective door safety circuit is interrupted and safety combination A2 opens its safety circuits.

Note

The position of the protective door interlock is monitored by S6! If a fault on the PLC causes the lock of the protective door to open, an SS1 is initiated via S6 at terminal X122.2 (DI 1) of the Control Unit and at the EP terminals of the Motor Modules. The drives are immediately braked via the speed ramp (p1135), and the pulses canceled after the SS1 delay time has elapsed. When the protective door is opened, the "Safe Stop 1" function is safely selected.

Switching on the drives

The drives can be started when the protective door is shut and emergency STOP pushbutton S3 is released. The emergency STOP pushbutton S3 must be unlocked before pushbutton S1 ("ON") is actuated. With the safety combination, the ON circuit Y33, Y34 is checked for a short-circuit when terminals Y43 , Y44 are open (i.e. if Y33 and Y34 are closed before emergency stop pushbutton S3 is closed, this is identified as a fault). The Line Module must be switched on via PLC output DO 5 on the PLC by means of an edge from "0" to "1".

- Once you have pressed button S1 ("ON"), safety combination A1 switches to "ready for operation". When PLC output DO 4 is reset, the coil of tumbler Y1 is no longer energized and the protective door is locked. Safety combination A2 is also ready for operation.
- By setting the PLC output DO 2, the SS1 and STO safety function is de-selected on two channels via terminal DI 1 X122.2 on the Control Unit and terminals X21.3 (EP +24 V) and X21.4 (EP M) on the Motor Modules.
- Due to a rising edge at PLC output DO1, the drives can be switched back to "operation" mode via terminal X122.1 (DI 0: OFF1).

9.10 Overview of parameters and function diagrams

Parameter overview (see SINAMICS S List Manual)

Table 9-13 Parameters for Safety Integrated

No. of Control Unit (CU)	No. of Motor Module (MM)	Name	Changeable to
p9601	p9801	SI enable safety functions	Safety Integrated commissioning (p0010 = 95)
p9602	p9802	SI enable safe brake control	
p9620	-	SI signal source for Safe torque off	
p9650	p9850	SI SGE changeover, tolerance time (Motor Module)	
p9652	p9852	SI Safe Stop 1 delay time	
p9658	p9858	SI transition time STOP F to STOP A	
p9659	-	SI timer for the forced dormant error detection	
p9761	-	SI password input	In every operating mode
p9762	-	SI password new	Safety Integrated commissioning (p0010 = 95)
p9763	-	SI password acknowledgment	
r9770[0...2]	r9870[0...2]	SI version safety function integrated in the drive	-
r9771	r9871	SI shared functions	-
r9772	r9872	SI CO/BO: Status	-
r9773	-	SI CO/BO: Status (Control Unit + Motor Module)	-
r9774	-	SI CO/BO: Status (Safe torque off group)	-
r9780	r9880	SI monitoring clock cycle	-
r9794	r9894	SI crosswise comparison list	-
r9795	r9895	SI diagnostics for STOP F	-
r9798	r9898	SI actual checksum SI parameters	-
p9799	p9899	SI target checksum SI parameters	Safety Integrated commissioning (p0010 = 95)

Description of the parameters

Note

The SINAMICS Safety Integrated parameters are described in the following documentation:

References: /LH1/ SINAMICS S List Manual - Section 1.2

Function diagram overview (see SINAMICS S List Manual)

- 2800 Parameter manager
- 2802 Monitoring and faults/alarms
- 2804 Status words
- 2810 Safe torque off (STO)
- 2814 Safe brake control (SBC)

Communication PROFIBUS DP/PROFINET IO 10

10.1 Communications according to PROFIdrive

10.1.1 General information about PROFIdrive for SINAMICS

General information

PROFIdrive V4.1 is the PROFIBUS and PROFINET profile for drive technology with a wide range of applications in production and process automation systems.

PROFIdrive is independent of the bus system used (PROFIBUS, PROFINET).

Note

PROFIdrive for drive technology is standardized and described in the following document:

References: /P5/ PROFIdrive Profile Drive Technology

Controller, Supervisor, and Drive Unit

- Features of the Controller, Supervisor, and Drive Unit

Table 10-1 Features of the Controller, Supervisor, and Drive Unit

Features	Controller, Supervisor	Drive Unit
As bus node	Active	Passive
Send messages	Permitted without external request	Only possible on request by master
Receive messages	Possible with no restrictions	Only receive and acknowledge permitted

- Controller (PROFIBUS: Master Class 1, PROFINET IO: IO Controller)

  This is typically a higher-level control in which the automation program runs.

  Example: SIMATIC S7 and SIMOTION
- Supervisor (PROFIBUS: Master Class 2, PROFINET IO: IO Supervisor)

  Devices for configuration, commissioning, operator control and monitoring during bus operation. Devices that only non-cyclically exchange data with Drive Units and Controllers.

Examples: Programming devices, human machine interfaces

- Drive Unit (PROFIBUS: Slave, PROFINET IO: IO Device)

  The SINAMICS drive unit is with reference to PROFIdrive, a Drive Unit.

Interface IF1 and IF2

The Control Unit can communicate via two different interfaces (IF1 and IF2).

These interfaces have the following basic characteristics:

- IF1:

  PROFIdrive, standard telegrams, cycle synchronization, all DO types, can be used by PROFINET IO and PROFIBUS

- IF2:

  No PROFIdrive, no standard telegrams, no clock synchronization, servo, vector and infeed, reduced number of transferable data (16 PZDs max.), can be used by CANopen

---

Note

For further information about the interfaces IF1 and IF2 see chapter "Parallel operation of communication interfaces for CU320" in this manual.

10.1.2 Application classes

Description

There are different application classes for PROFIdrive, depending on the scope and type of the application processes. There are a total of 6 application classes in PROFIdrive, of which 4 are discussed here.

Application class 1 (Standard drive)

In the most basic case, the drive is controlled via a speed setpoint by means of PROFIBUS/PROFINET. In this case, speed control is fully handled in the drive controller. Typical application examples are basic frequency converters. Pump and fan control.

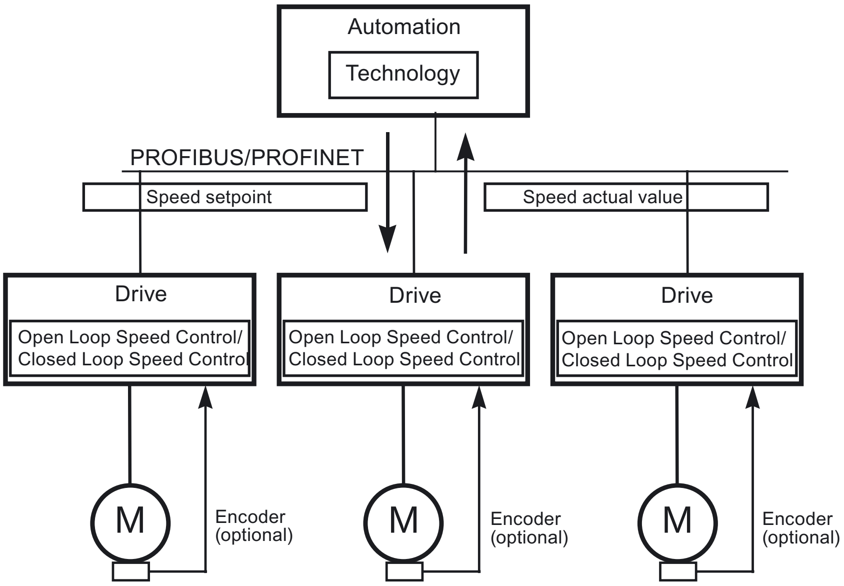


Figure 10-1 Application class 1

Application class 2 (Standard drive with technology function)

The total process is subdivided into a number of small subprocesses and distributed among the drives. This means that the automation functions no longer reside exclusively in the central automation device but are also distributed in the drive controllers.
Of course, this distribution assumes that communication is possible in every direction, i.e. also cross-communication between the technology functions of the individual drive controllers. Specific applications include e.g. setpoint cascades, winders and speed synchronization applications for continuous processes with a continuous web.

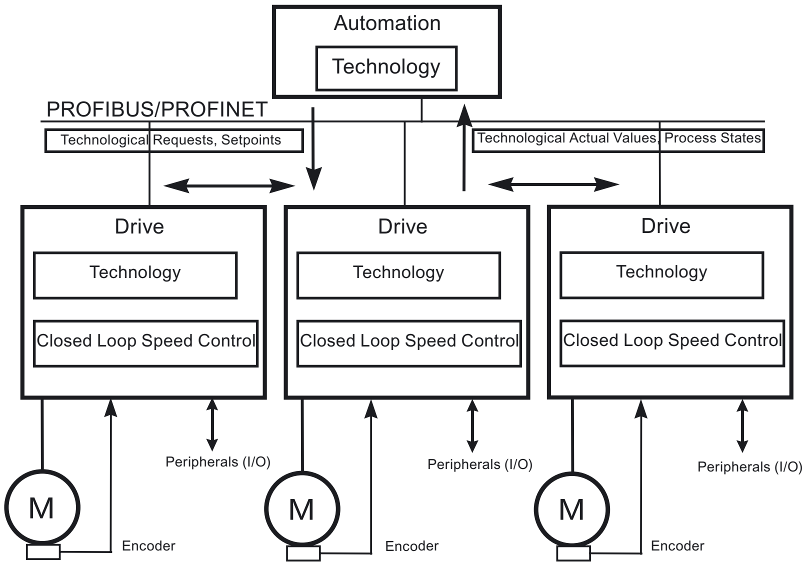


Figure 10-2 Application class 2

Application class 3 (positioning drive)

In addition to the drive control, the drive also includes a positioning control, so that the drive operates as a self-contained single-axis positioning drive while the higher-level technological processes are executed on the controller. Positioning requests are transmitted to the drive controller via PROFIBUS/PROFINET and launched. Positioning drives have a very wide range of applications, e.g. the screwing and unscrewing of caps in a bottle filling plant or the positioning of cutters on a film cutting machine.

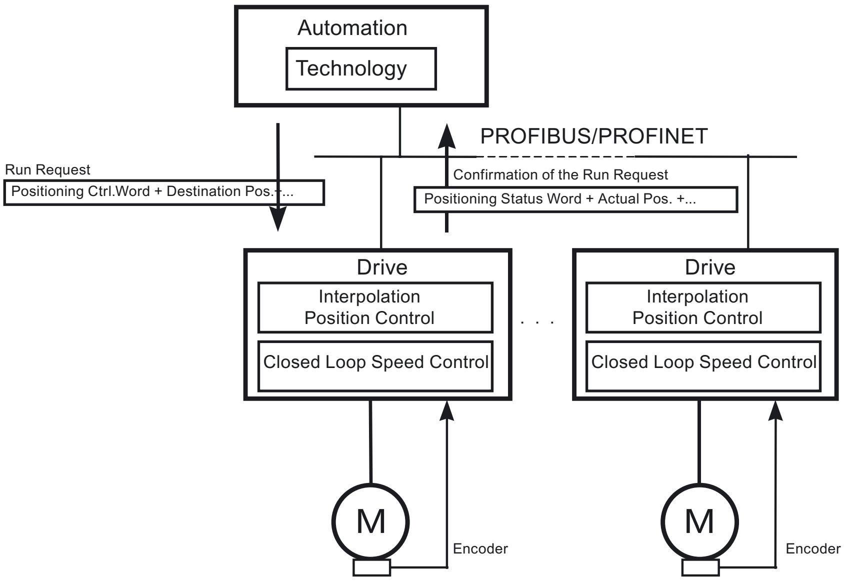


Figure 10-3 Application class 3

Application class 4 (central motion control)

This application class defines a speed setpoint interface with execution of the speed control on the drive and of the positioning control in the controller, such as is required for robotics and machine tool applications with coordinated motions on multiple drives.

Motion control is primarily implemented by means of a central numerical controller (CNC). The position control loop is closed via the bus. The synchronization of the position control cycles in the control and in the closed-loop controllers in the drive requires a clock synchronization of the kind that is provided by PROFIBUS DP and PROFINET IO with IRT.

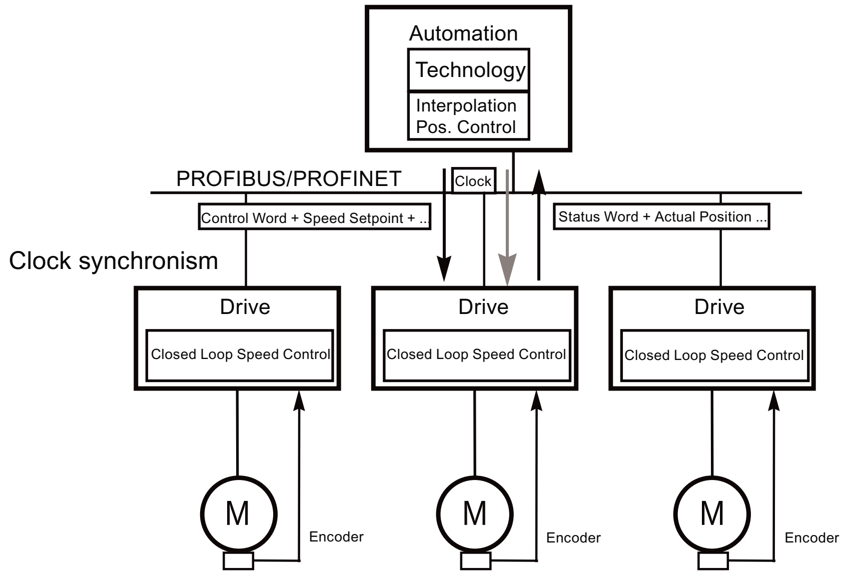


Figure 10-4 Application class 4

Dynamic Servo Control (DSC)

The PFOFIdrive profile contains the "Dynamic Servo Control" control concept. This can be used to significantly increase the dynamic stability of the position control loop in application class 4 with simple means.

For this purpose, the deadtime that is typical for a speed setpoint interface is minimized by an additional measure (see also chapter "Dynamic Servo Control").

Selection of telegrams as a function of the application class

The telegrams listed in the table below (see also chapter "Telegrams and process data") can be used in the following application classes:

Table 10-2 Selection of telegrams as a function of the application class

Telegram (p0922 = x)	Description	Class 1	Class 2	Class 3	Class 4
1	Speed control, 2 words	x	x		
2	Speed control, 4 words	x	x		
3	Speed control, 1 position encoder		x		x
4	Speed control, 2 position encoder				x
5	DSC, 1 position encoders				x
6	DSC, 2 position encoders				x
7	Basic positioner			x	
9	Basic positioner with MDI			x	
20	Speed control, VIK-NAMUR	x	x		
102	Speed control with torque reduction, 1 position controller				x
103	Speed control with torque reduction, 2 position controllers				x
105	DSC with torque reduction, 1 position encoder				x
106	DSC with torque reduction, 2 position encoder				x
110	Basic positioners with MDI, override and XistP			x	
116	DSC with torque reduction, 2 position encoder				x
352	Speed control, PCS7	x	x		
370	Telegram for infeed	x	x	x	x
390	Telegram for Control Unit (drive object 1, DO1), digital inputs/outputs	x	x	x	x
391	Telegram for Control Unit (drive object 1, DO1), digital inputs/outputs and 2 measuring probes	x	x	x	x
392	Telegram for Control Unit (drive object 1, DO1), digital inputs/outputs and 6 measuring probes	x	x	x	x
999	Free telegrams	x	x	x	x

10.1.3 Cyclic communication

Cyclic communication is used to exchange time-critical process data.

10.1.3.1 Telegrams and process data

General information

The selection of a telegram via p0922 determines, on the drive unit side (Control Unit) which process data is transferred.

From the perspective of the drive unit, 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

What telegrams are available?

1. 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.

   The following standard telegrams can be set via p0922:

   – 1 speed control, 2 words
   – 2 speed control, 4 words
   – 3 speed control, 1 position encoder
   – 4 speed control, 2 position encoder
   – 5 DSC, 1 position encoder
   – 6 DSC, 2 position encoder
   – 7 basic positioner
   – 9 basic positioners with MDI
   – 20 speed control, VIK-NAMUR

2. 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.

   The following vendor-specific telegrams can be set via p0922:

   – 102 speed control with torque reduction, 1 position encoder
   – 103 speed control with torque reduction, 2 position encoder
   – 105 DSC with torque reduction, 1 position encoder
   – 106 DSC with torque reduction, 2 position encoder
   – 110 basic positioners with MDI, override and XistP
   – 116 DSC with torque reduction, 2 position encoder
   – 352 speed control, PCS7
   – 370 Telegram for the infeed
   – 390 Telegram for Control Unit (drive object 1, DO1), digital inputs/outputs
   – 391 Telegram for Control Unit (drive object 1, DO1), digital inputs/outputs and 2 measuring probes
   – 392 Telegram for Control Unit (drive object 1, DO1), digital inputs/outputs and 6 measuring probes

3. Free telegrams (p0922 = 999)

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

	SERVO, TM41	VECTOR	CU_S	A_INF, B_INF, S_INF, TB30, TM31, TM15DI/DO
Receive process data				
DWORD connector output	r2060[0 ... 14]	r2060[0 ... 30]	-	
WORD connector output	r2050[0 ... 15]	r2050[0 ... 31]	r2050[0 ... 4]	
Binector output	r2090.0 ... 15 r2091.0 ... 15 r2092.0 ... 15 r2093.0 ... 15		r2090.0 ... 15 r2091.0 ... 15	
Free binector-connector converter	p2080[0 ... 15], p2081[0 ... 15], p2082[0 ... 15], p2083[0 ... 15] / r2089[0 ... 3]			
Send process data				
DWORD connector input	p2061[0 ... 14]	p2061[0 ... 30]	-	
WORD connector input	p2051[0 ... 18]	p2061[0 ... 31]	p2051[0 ... 14]	p2051[0 ... 4]
Free connector-binector converter	p2099[0 ... 1] / r2094.0 ... 15, r2095.0 ... 15			

Telegram interconnections

When you change p0922 = 999 (factory setting) to p0922 ≠ 999, the telegrams are interconnected and blocked automatically.

Note

Telegrams 20, 352 are the exceptions. Here, PZD06 in the transmit telegram and PZD03 to PZD06 in the receive telegram can be interconnected as required.

When you change p0922 ≠ 999 to p0922 = 999, the previous telegram interconnection is retained and can be changed.

Note

If p0922 = 999, a telegram can be selected in p2079. A telegram interconnection is automatically made and blocked. The telegram can also be extended.

This is an easy method of creating extended telegram interconnections on the basis of existing telegrams.

The telegram structure

The parameter p0978 contains the sequence of DOs that use a cyclic PZD exchange. A zero delimits the DOs that do not exchange any PZDs.

If the value 255 is written to p0978, the drive unit emulates an empty drive object that is visible to the PROFIdrive controller. This permits cyclic communication of a PROFIdrive controller

- with unchanged configuration to drive units that have a different number of drive objects.
- with deactivated DOs without having to change the project.

Note

- The following must apply to ensure conformity with the PROFIdrive profile:
  - Interconnect PZD receive word 1 as control word 1 (STW1).
  - Interconnect PZD send word 1 as status word 1 (STW1).
    Use WORD format for PZD1.
- One PZD = one word.
  Only one of the interconnection parameters (p2051 or p2061) can have the value ≠ 0 for a PZD word.
- Physical word and double word values are inserted in the telegram as referenced variables.
  p200x are relevant as reference values (telegram contents = 4000 hex or
  4000 0000 hex for double words if the input variable has a value of p200x).

Structure of the telegrams

Telegram	1		2		3		4		5		6		7		9		20	
Appl. class	1		1		1, 4		1, 4		4 DSC		4 DSC		3		3		1	
PZD 1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1
PZD 2	NSOLL_A	NIST_A	NSOLL_B	NIST_B	NSOLL_B	NIST_B	NSOLL_B	NIST_B	NSOLL_B	NIST_B	NSOLL_B	NIST_B	BLCKSEL	ACTBLCK	BLCKSEL	ACTBLCK	NSOLL_A	NIST_A_GL
PZD 3	Telegram received from PROFIBUS/PROFINET	Telegram sent to PROFIBUS/PROFINET													CTW2	STW2		IAACT_S
PZD 4			CTW2	STW2	CTW2	STW2	CTW2	STW2	CTW2	STW2	CTW2	STW2			MDIPos	XIST_A		MACT_S
PZD 5					E1_CTW	G1_STW	G1_CTW	G1_STW	G1_CTW	G1_STW	G1_CTW	G1_STW						PACT_S
PZD 6						G1_XIST1	G2_CTW	G1_XIST1	XERR	G1_XIST1	G2_CTW	G1_XIST1			MDIVel			<1>
PZD 7											XERR							
PZD 8						G1_XIST2		G1_XIST2	KPC	G1_XIST2		G1_XIST2			MDIAcc			
PZD 9											KPC				MDIDec			
PZD 10								G2_STW				G2_STW			MDIMod			
PZD 11								G2_XIST1				G2_XIST1						
PZD 12																		
PZD 13								G2_XIST2				G2_XIST2						
PZD 14																		
PZD 15																		

<1>Can be interconnected in any way (default: MELD_NAMUR).

Figure 10-5 Overview of standard telegrams and process data

Telegram	102		103		105		106		110		116		352	
Appl. class	1, 4		1, 4		4 DSC		4 DSC		3		4 DSC		1	
PZD 1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1	CTW1	STW1
PZD 2	NSOLL_B	NIST_B	NSOLL_B	NIST_B	NSOLL_B	NIST_B	NSOLL_B	NIST_B	BLCKSEL	ACTBLCK	NSOLL_B	NIST_B	NSOLL_A	NIST_A_GLATT
PZD 3									PosCTW	PosSTW			<1>	IAACT_SM
PZD 4	CTW2	STW2	CTW2	STW2	CTW2	STW2	CTW2	STW2	CTW2	STW2	CTW2	STW2	<1>	MACT_SM
PZD 5	TORQRED	MESSW	TORQRED	MESSW	TORQRED	MESSW	TORQRED	MESSW	Over	MESSW	TORQRED	MESSW	<1>	WARN_CODE
PZD 6	E1_CTW	E1_STW	E1_CTW	E1_STW	E1_CTW	E1_STW	E1_CTW	E1_STW	MDIPos	XistP	G1_CTW	G1_STW	<1>	FAULT_CODE
PZD 7		E1_XIST1	E2_CTW	E1_XIST1	XERR	E1_XIST1	E2_CTW	E1_XIST1			E2_CTW	E1_XIST1		
PZD 8							XERR		MDIVel		XERR			
PZD 9		E1_XIST2		E1_XIST2	KPC	E1_XIST2		E1_XIST2				E1_XIST2		
PZD 10							KPC		MDIAcc		KPC			
PZD 11				E2_STW				E2_STW	MDIDec			E2_STW		
PZD 12				E2_XIST1				E2_XIST1	MDIMode			E2_XIST1		
PZD 13														
PZD 14				E2_XIST2				E2_XIST2				E2_XIST2		
PZD 15														
PZD 16												AACT_SM		
PZD 17												MSET_SM		
PZD 18												PACT_SM		
PZD 19												ITACT_SM		

<1>Can be interconnected in any way.

Figure 10-6 Overview of manufacturer-specific telegrams and process data, part 1/2

Telegram	370		390		391		392		999	
Appl. class	-		-		-		-		-	
PZD 1	I_CTW1	I_STW1	CU_CTW	CU_STW	CU_CTW	CU_STW	CU_CTW	CU_STW	CTW1 <1>	STW1 <1>
PZD 2			O_DIGITAL	I_DIGITAL	O_DIGITAL	I_DIGITAL	O_DIGITAL	I_DIGITAL	You are free to select the receiving telegram length using central PROFIdrive configuration in the master <2>	You are free to select the sending telegram length using central PROFIdrive configuration in the master <2>
PZD 3					PR_CTW	PR_STW	PR_CTW	PR_STW		
PZD 4						PR1_TS_F		PR1_TS_F		
PZD 5						PR1_TS_R		PR1_TS_R		
PZD 6						PR2_TS_F		PR2_TS_F		
PZD 7						PR2_TS_R		PR2_TS_R		
PZD 8								PR3_TS_F		
PZD 9								PR3_TS_R		
PZD 10								PR4_TS_F		
PZD 11								PR4_TS_R		
PZD 12								PR5_TS_F		
PZD 13								PR5_TS_R		
PZD 14								PR6_TS_F		
PZD 15								PR6_TS_R		
PZD 16										
PZD 17										
PZD 18										
PZD 19										
PZD 20										

<1>PZD1 must be used as control word 1 (CTW1) or status word 1 (STW1) to comply with the PROFIdrive profile.
If CTW1 is not transferred to the PROFIdrive profile with PZD1, then set p2037 = 2.

<2>The maximum PZD number depends on the drive object type.

= position encoder signal

Figure 10-7 Overview of manufacturer-specific telegrams and process data, part 2/2

Depending on the drive object, only certain telegrams can be used:

Drive object	Telegrams (p0922)
A_INF	370, 999
B_INF	370, 999
S_INF	370, 999
SERVO	1, 2, 3, 4, 5, 6, 102, 103, 105, 106, 116, 999
SERVO (EPOS)	7, 9, 110, 999
VECTOR	1, 2, 3, 4, 20, 352, 999
VECTOR (EPOS)	7, 9, 110, 999
TM15DI/DO	No predefined telegram.

Drive object	Telegrams (p0922)
TM31	No predefined telegram.
TM41	3, 999
TB30	No predefined telegram.
CU_S	390, 391, 392, 999

Depending on the drive object, the following maximum number of process data items can be transmitted for user-defined telegram structures:

Drive object	Max. number of PZD for sending / receiving
• A_INF	Send 8, receive 5
• B_INF	Send 8, receive 5
• S_INF	Send 8, receive 5
• SERVO	Send 19, receive 16
• VECTOR	32
• TM15DI/DO	5
• TM31	5
• TM41	Send 19, receive 16
• TB30	5
• CU	Send 15, receive 5

Interface Mode

Interface Mode is used for adjusting the assignment of the control and status words in line with other drive systems and standardized interfaces.

The mode can be set as follows:

Value	Interface Mode
p2038 = 0	SINAMICS (factory setting)
p2038 = 1	SIMODRIVE 611 universal
p2038 = 2	VIK-NAMUR

Procedure:

1. Set p0922 ≠ 999.
2. p2038 = set required interface mode.

When you set a telegram from the range between 100 and 199, Interface Mode is set by default (p2038 = 1) and cannot be changed.

Interface Mode defines the setting of the standard telegram 20 (p2038 = 2). The assignment cannot be modified.

When a telegram that specifies the Interface Mode (e.g. p0922 = 102) is changed to a different telegram (e.g. p0922 = 3), the setting in p2038 is retained.

Function diagrams (see SINAMICS S List Manual)

- 2410 PROFIBUS address, diagnostic
- ...
- 2483 Send telegram, free interconnection via BICO (p0922 = 999)

10.1.3.2 Monitoring: telegram failure

Description

After a telegram failure and a monitoring time has elapsed (p2047), bit r2043.0 is set to "1" and alarm A01920 is output. Binector output r2043.0 can be used for an emergency stop, for example.

After a delay time has elapsed (p2044), fault F01910 is output. Fault F01910 triggers fault response OFF2 (pulse inhibit) for the supply and fault response OFF3 (emergency stop) for SERVO/VECTOR. If no OFF response is to be triggered, the fault response can be reparameterized accordingly.

Fault F01910 can be acknowledged immediately. The drive can then be operated even without PROFIdrive.

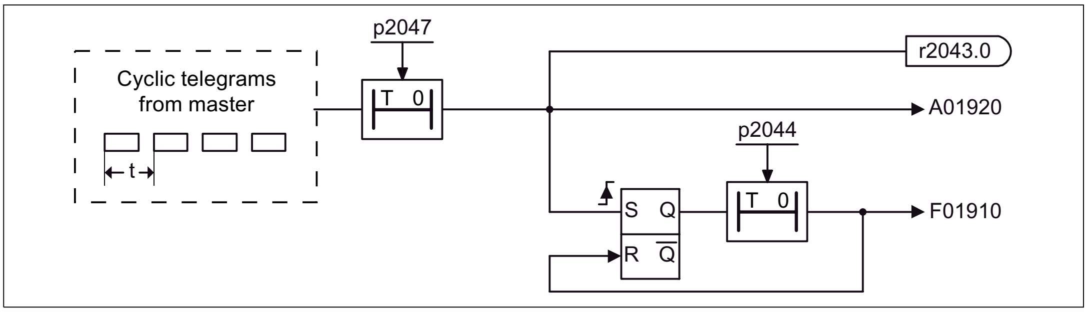


Figure 10-8 Monitoring: telegram failure

Example: emergency stop with telegram failure

Assumption:

- A drive unit with an Active Line Module and a Single Motor Module.
- VECTOR mode is activated.
- After the ramp-down time has elapsed (p1135), the drive is at a standstill.

Settings:

- CU p2047 = 20 ms
- A_INF p2044 = 2 ms
- VECTOR p2044 = 0 ms

Sequence:

After a telegram failure and the monitoring time has elapsed (p2047), binector output r2043.0 of drive object CU switches to "1". At the same time, alarm A01920 is output for the A_INF drive objects and alarm A01920 and fault F01910 are output for VECTOR. When F01910 is output, an OFF3 is triggered for the drive. After a delay time (p2044) of two seconds has elapsed, fault F01910 is output on the infeed and triggers OFF2.

10.1.3.3 Description of control words and setpoints

Note

This chapter describes the assignment and meaning of the process data in SINAMICS interface mode (p2038 = 0).

The reference parameter is also specified for the relevant process data. The process data is generally normalized in accordance with parameters p2000 to r2004.

The following scalings apply:

A temperature of 100°C = 100% and 0°C = 0%

An electrical angle of 90° = 100 % and 0° = 0%.

Overview of control words and setpoints

Table 10-3 Overview of control words and setpoints

Abbreviation	Name	Signal number	Data type [1)]	Interconnection parameters
STW1	Control word 1	1	U16	(bit serial)[2)]
STW2	Control word 2	3	U16	(bit serial)[2)]
NSOLL_A	Speed setpoint A (16-bit)	5	I16	p1155 p1070(ext. setpoint.)
NSOLL_B	Speed setpoint B (32-bit)	7	I32	p1155 p1070(ext. setpoint.) p1430(DSC)
G1_STW	Encoder 1 control word	9	U16	p0480[0]
G2_STW	Encoder 2 control word	13	U16	p0480[1]
G3_STW	Encoder 3 control word	17	U16	p0480[2]
A_DIGITAL	Digital outputs	22	U16	(bit serial)
XERR	Position deviation	25	I32	p1190
KPC	Position controller gain factor	26	I32	p1191
TORQUERED	Torque reduction	101	I16	p1542
MT_STW	Control word for probe	130	U16	p0682
SATZANW	Pos block selection	201	U16	(bit serial)
PosSTW	Pos control word	203	U16	(bit serial)
Over	Pos velocity override	205	I16	p2646
MDIPos	Pos MDI position	221	I32	p2642
MDIVel	Pos MDI velocity	223	I32	p2643

Abbreviation	Name	Signal number	Data type 1)	Interconnection parameters
MDIAcc	Pos MDI acceleration override	225	I16	p2644
MDIDec	Pos MDI deceleration override	227	I16	p2645
MDIMode	Pos MDI mode	229	U16	p2654
E_STW1	Control word for INFEED	320	U16	(bit serial)2)
CU_STW	Control word for Control Unit (CU)	500	U16	(bit serial)

1. 1) Data type according to PROFIdrive profile V4:
   I16 = Integer16, I32 = Integer32, U16 = Unsigned16, U32 = Unsigned32
2. 2) Bit-serial interconnection: refer to the following pages

CTW1 (control word 1)

See function diagram [2442]

Table 10-4 Description of CTW1 (control word 1)

Bit	Meaning	Comments		BICO
0	ON/OFF1	0/1	ON Pulse enable possible	BI: p0840
		0	OFF1 Braking with the ramp-function generator, then pulse cancellation and power-on inhibit.	
1	OFF2	1	No OFF2 Enable possible	BI: p0844
		0	Immediate pulse cancellation and power-on inhibit	
	Note: Control signal OFF2 is generated by ANDing BI: p0844 and BI: p0845.			
2	OFF3	1	No OFF3 Enable possible	BI: p0848
		0	Emergency stop (OFF3) Braking with OFF3 ramp p1135, then pulse cancellation and power-on inhibit.	
	Note: Control signal OFF3 is generated by ANDing BI: p0848 and BI: p0849.			
3	Enable operation	1	Enable operation Pulse enable possible	BI: p0852
		0	Disable operation Cancel pulses	
4	Enable ramp-function generator	1	Operating condition Ramp-function generator enable possible	BI: p1140
		0	Inhibit ramp-function generator Set ramp-function generator output to zero	
5		1	Start ramp-function generator	BI: p1141
		0	Freeze ramp-function generator	

Bit	Meaning	Comments		BICO
	Note: The ramp-function generator cannot be frozen via p1141 in jog mode (r0046.31 = 1).			
6	Enable speed setpoint	1	Enable setpoint	BI: p1142
		0	Inhibit setpoint Set ramp-function generator input to zero	
7	Acknowledge fault	0/1	Acknowledge fault	BI: p2103
		0	No effect	
	Note: Faults are acknowledged at a 0/1 edge via BI: p2103 or BI: p2104 or BI: p2105.			
8	reserved	-	-	-
9	reserved	-	-	-
10	Master ctrl by PLC	1	Master ctrl by PLC This signal must be set so that the process data transferred via PROFIdrive is accepted and becomes effective.	BI: p0854
		0	PLC has no master control Process data transferred via PROFIdrive is rejected - i.e. it is assumed to be zero.	
	Note: This bit should not be set to "1" until the PROFIdrive has returned an appropriate status via STW1.9 = "1"..			
11	Direction reversal	1	Direction reversal	BI: p1113
		0	No direction reversal	
12	Reserved			
13	Motorized potentiometer, setpoint, raise	1	Motorized potentiometer, setpoint, raise	BI: p1035
		0	Motorized potentiometer setpoint raise not selected	
14	Motorized potentiometer, lower setpoint	1	Motorized potentiometer, lower setpoint	BI: p1036
		0	Motorized potentiometer setpoint lower not selected	
	Note: If motorized potentiometer setpoint raise and lower are 0 or 1 simultaneously, the current setpoint is frozen.			
15	reserved	-	-	-

STW1 (control word 1), positioning mode, p0108.4 = 1

See function diagram [2475]

Table 10-5 Description of STW1 (control word 1), positioning mode

Bit	Meaning	Comments		BICO
0	ON/OFF1	0/1	ON Pulse enable possible	BI: p0840
		0	OFF1 Braking with the ramp-function generator, then pulse cancellation and power-on inhibit.	

Bit	Meaning	Comments		BICO
1	OFF2	1	No OFF2 Enable possible	BI: p0844
		0	OFF2 Immediate pulse cancellation and power-on inhibit	
	Note: Control signal OFF2 is generated by ANDing BI: p0844 and BI: p0845.			
2	OFF3	1	No OFF3 Enable possible	BI: p0848
		0	Emergency stop (OFF3) Braking with OFF3 ramp p1135, then pulse cancellation and power-on inhibit.	
	Note: Control signal OFF3 is generated by ANDing BI: p0848 and BI: p0849.			
3	Enable operation	1	Enable operation Pulse enable possible	BI: p0852
		0	Disable operation Cancel pulses	
4	Reject traversing task	1	Do not reject traversing task	BI: p1140
		0	Reject traversing task	
5	Intermediate stop	1	No intermediate stop	BI: p2640
		0	Intermediate stop	
6	Activate traversing task	0/1	Enable setpoint	BI: p2631, p2650
		0	No effect	
	Note: The interconnection p2649 = 0 is also made.			
7	Acknowledge fault	0/1	Acknowledge fault	BI: p2103
		0	No effect	
8	Jog 1	1	Jog 1 ON See also the SINAMICS S List Manual, function diagram 3610	BI: p2589
		0	No effect	
9	Jog 2	1	Jog 2 ON See also the SINAMICS S List Manual, function diagram 3610	BI: p2590
		0	No effect	
10	Master ctrl by PLC	1	Control via PLC This signal must be set so that the process data transferred via PROFIdrive is accepted and becomes effective.	BI: p0854
		0	No control via PLC Process data transferred via PROFIdrive is rejected - i.e. it is assumed to be zero.	
	Note: This bit should not be set to "1" until the PROFIdrive has returned an appropriate status via ZSW1.9 = "1".			
11	Start referencing	1	Start referencing	BI: p2595
		0	Stop reference	

Bit	Meaning	Comments		BICO
12	Reserved	-	-	-
13	External block change	0/1	External set change is initiated	BI: 2632
		0	No effect	
14	Reserved	-	-	-
15	Reserved	-	-	-

CTW2 (control word 2)

See function diagram [2444]

Table 10-6 Description of CTW2 (control word 2)

Bit	Meaning	Comments		BICO
0	Drive data set selection DDS bit 0	-	Drive data set selection (5 bit counter)	BI: p0820[0]
1	Drive data set selection DDS bit 1	-		BI: p0821[0]
2	Drive data set selection DDS bit 2	-		BI: p0822[0]
3	Drive data set selection DDS bit 3	-		BI: p0823[0]
4	Drive data set selection DDS bit 4	-		BI: p0824[0]
5...6	Reserved	-	-	-
7	Parking axis	1	Request parking axis (handshake with ZSW2 bit 7)	BI: p0897
		0	No request	
8	Travel to fixed endstop	1	Select "Travel to fixed stop" The signal must be set before the fixed stop is reached.	BI: p1545
		1/0	Deselect "Travel to fixed stop" The signal must be set before the fixed stop is reached	
9	Reserved	-	-	-
10	Reserved	-	-	-
11	Motor switchover	0/1	Motor switchover complete	BI: p0828[0]
		0	No effect	
12	Drive unit sign-of-life bit 0	-	User data integrity (4-bit counter)	CI: p2045
13	Drive unit sign-of-life bit 1	-		
14	Drive unit sign-of-life bit 2	-		
15	Drive unit sign-of-life bit 3	-		

E_CTW1 (control word for INFEED)

See function diagram [8920]

Table 10-7 Description of E_CTW1 (control word for INFEED)

Bit	Meaning	Comments		BICO
0	ON/OFF1	0/1	ON Pulse enable possible	BI: p0840
		0	OFF1 Reduce DC link voltage via ramp (p3566), pulse inhibit/line contactor open	
1	OFF2	1	No OFF2 Enable possible	BI: p0844
		0	OFF2 Immediate pulse cancellation and power-on inhibit	
	Note: Control signal OFF2 is generated by ANDing BI: p0844 and BI: p0845.			
2	Reserved	-	-	-
3	Enable operation	1	Enable operation Pulse enable is present	BI: p0852
		0	Disable operation Pulse inhibit is present	
4	Reserved	-	-	-
5	Inhibit motor operation	1	Inhibit motor operation Motoring operation as step-up converter is inhibited.	BI: p3532
		0	Enable motor operation Motoring operation as step-up converter is enabled.	
	Note: When "Inhibit motoring operation" is present, power can still be drawn from the DC link. The DC link voltage is then no longer controlled. The voltage level is the same as the rectified value of the current line voltage.			
6	Inhibit regenerating	1	Inhibit regenerative operation Regenerative operation is inhibited.	BI: p3533
		0	Enable regenerative operation Regenerative operation is enabled.	
	Note: If regenerative operation is inhibited and power is fed to the DC link (e.g. by braking the motor), the DC link voltage increases (F30002).			
7	Acknowledge error	0/1	Acknowledge error	BI: p2103
	Note: Faults are acknowledged at a 0/1 edge via BI: p2103 or BI: p2104 or BI: p2105.			
8	Reserved	-	-	-
9	Reserved	-	-	-
10	Master ctrl by PLC	1	Control via PLC This signal must be set so that the process data transferred via PROFIdrive is accepted and becomes effective.	BI: p0854
		0	No control via PLC Process data transferred via PROFIdrive is rejected - i.e. it is assumed to be zero.	

Bit	Meaning	Comments		BICO
	Note: This bit should not be set to "1" until the PROFIdrive has returned an appropriate status via STW1.9 = "1"..			
11	Reserved	-	-	-
12	Reserved	-	-	-
13	Reserved	-	-	-
14	Reserved	-	-	-
15	Reserved	-	-	-

SATZANW (positioning mode, p0108.4 =1)

See function diagram [2476]

Table 10-8 Description of BLOCKSEL (positioning mode, p0108.4 =1)

Bit	Meaning	Comments		BICO
0	1 = block selection, bit 0 (2^0)	Block selection Traversing block 0 to 63		BI: p2625
1	1 = block selection, bit 1 (2^1)			BI: p2626
2	1 = block selection, bit 2 (2^2)			BI: p2627
3	1 = block selection, bit 3 (2^3)			BI: p2628
4	1 = block selection, bit 4 (2^4)			BI: p2629
5	1 = block selection, bit 5 (2^5)			BI: p2630
6 ... 14	Reserved	-	-	-
15	Activate MDI	1	Activate MDI	p2647
		0	De-activate MDI	
Note: See also: SINAMICS S Function Manual, Function module "basic positioner"				

PosSTW (positioning mode, p0108.4 =1)

See function diagram [2477]

Table 10-9 Description of PosSTW (positioning mode, p0108.4 =1)

Bit	Meaning	Comments		BICO
0	Tracking mode	1	Activate tracking mode	BI: 2655
		0	Tracking mode de-activated	
1	Set reference point	1	Set reference point	BI: 2696
		0	Do not set reference point	
2	Reference cam	1	Reference cam active	BI: 2612
		0	Reference cam not active	
3	Fixed stop sensor active	1	The sensor for the fixed stop is active	BI: 2637

Bit	Meaning	Comments		BICO
		0	The sensor for the fixed stop is inactive	
4	Reserved	-	-	-
5	Jogging, incremental	1	Jogging incremental active	BI: 2591
		0	Jogging velocity active	
6 ... 15	Reserved	-	-	-
Note: See also: SINAMICS S Function Manual, Function module "basic positioner"				

NSOLL_A (speed setpoint A (16-bit))

- Speed setpoint with a 16-bit resolution with sign bit.
- Bit 15 determines the sign of the setpoint:
  - Bit = 0 --> positive setpoint
  - Bit = 1 --> negative setpoint
- The speed is normalized via p2000.

  NSOLL_A = 4000 hex or 16384 dec ≙ speed in p2000

NSOLL_B (speed setpoint B (32-bit))

- Speed setpoint with a 32-bit resolution with sign bit. .
- Bit 31 determines the sign of the setpoint:
  - Bit = 0 --> positive setpoint
  - Bit = 1 --> negative setpoint
- The speed is normalized via p2000.

  NSOLL_B = 4000 0000 hex or 1 073 741 824 dec ≙ speed in p2000

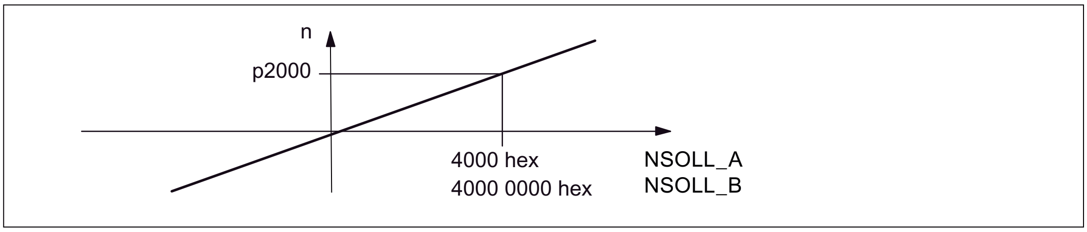


Figure 10-9 Normalization of speed

Gn_STW (encoder n control word)

This process data belongs to the encoder interface.

XERR (position deviation)

The position deviation for dynamic servo control (DSC) is transmitted via this setpoint.

The format of XERR is identical to the format of G1_XIST1.

KPC (position controller gain factor))

The position controller gain factor for dynamic servo control (DSC) is transmitted via this setpoint.

Transmission format: KPC is transmitted in the unit 0.001 1/s

Range of values: 0 to 4000.0

Special case: When KPC = 0, the "DSC" function is deactivated.

Example:

A2C2A hex ≙ 666666 dec ≙ KPC = 666.666 1/s ≙ KPC = 40 1000/min

MDIPos (pos MDI position)

This process data defines the position for MDI sets.

Normalization: 1 corresponds to 1 LU

MDIVel (pos MDI velocity)

This process data defines the velocity for MDI sets.

Normalization: 1 corresponds to 1000 LU/min

MDIAcc (pos MDI acceleration)

This process data defines the acceleration for MDI sets.

Normalization: 4000 hex (16384 dec) = 100 %

The value is restricted to 0.1 ... 100% (internally).

MDIDec (pos MDI deceleration override)

This process data defines the percentage for the deceleration override for MDI sets.

Normalization: 4000 hex (16384 dec) = 100 %

The value is restricted internally to 0.1 ... 100%

MDIMode (pos MDI mode)

This process data defines the mode for MDI sets.

Requirement: p2654 > 0
MDIMode = xx0x hex –> Absolute
MDIMode = xx1x hex –> Relative
MDIMode = xx2x hex –> Abs_pos (with modulo correction only)
MDIMode = xx3x hex –> Abs_neg (with modulo correction only)

Over (pos velocity override)

This process data defines the percentage for the velocity override.

Normalization: 4000 hex (16384 dec) = 100 %

Range of values: 0 ... 7FFF hex

Values outside this range are interpreted as 0%.

TORQUERED (torque reduction))

This setpoint can be used to reduce the torque limit currently active on the drive.

When you use manufacturer-specific PROFIdrive telegrams with the TORQUERED control word, the signal flow is automatically interconnected up to the point where the torque limit is scaled.

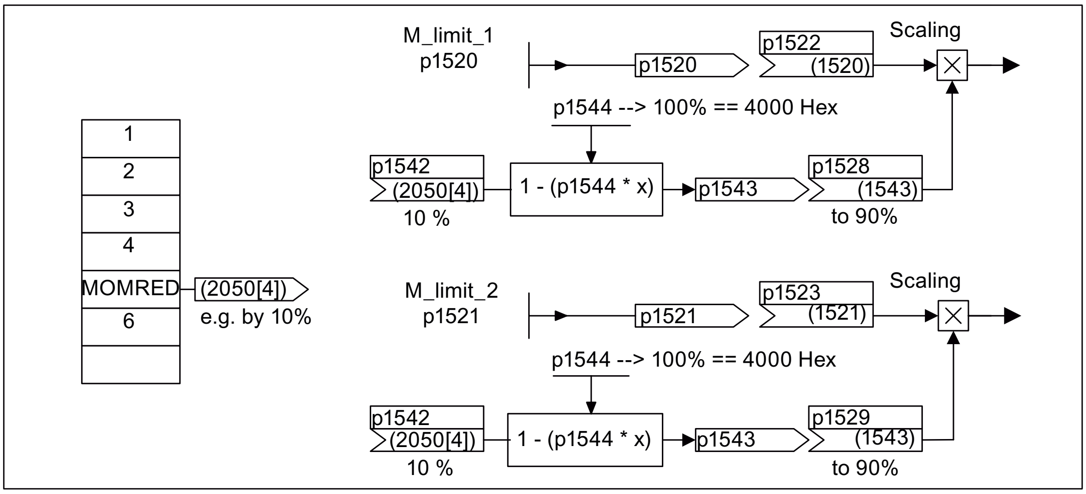


Figure 10-10 TORQUERED setpoint

TORQUERED specifies the percentage by which the torque limit is to be reduced. This value is converted internally to the amount by which the torque is to be reduced and normalized via p1544.

MT_STW
CU_STW
A_DIGITAL

This process data is part of the central process data.

10.1.3.4 Description of status words and actual values

Description of status words and actual values

Note

This chapter describes the assignment and meaning of the process data in SINAMICS interface mode (p2038 = 0).

The reference parameter is also specified for the relevant process data. The process data is generally normalized in accordance with parameters p2000 to r2004.

The following scalings apply:
a temperature of 100°C = 100%
an electrical angle 90° also = 100 %.

Overview of status words and actual values

Table 10-10 Overview of status words and actual values

Abbreviation	Name	Signal number	Data type 1)	Comment
STW1	Status word 1	2	U16	r2089[0] (bit serial)2)
STW2	Status word 2	4	U16	r2089[1] (bit serial)2)
NACT_A	Speed setpoint A (16 bit)	6	I16	r0063 (servo) r0063[0] (vector)
NACT_B	Speed setpoint B (32 bit)	8	I32	r0063 (servo) r0063[0] (vector)
G1_STW	Encoder 1 status word	10	U16	r0481[0]
G1_XIST1	Encoder 1 actual position value 1	11	U32	r0482[0]
G1_XACT2	Encoder 1 actual position value 2	12	U32	r0483[0]
G2_STW	Encoder 2 status word	14	U16	r0481[1]
G2_XIST1	Encoder 2 actual position value 1	15	U32	r0482[1]
G2_XACT2	Encoder 2 actual position value 2	16	U32	r0483[1]
G3_STW	Encoder 3 status word	18	U16	r0481[2]
G3_XIST1	Encoder 3 actual position value 1	19	U32	r0482[2]
G3_XACT2	Encoder 3 actual position value 2	20	U32	r0483[2]
E_DIGITAL	Digital inputs	21	U16	r2089[2]
IAIST_GLATT	Absolute actual current smoothed	51	I16	r0068[1]
ITIST_GLATT	Current actual value, torque-generating	52	I16	r0078[1]
MIST_GLATT	Actual torque smoothed	53	I16	r0080[1]
PIST_GLATT	Power factor, smoothed	54	I16	r0082[1]
NIST_A_GLATT	Actual speed smoothed	57	U16	r0063[1]
MELD_ NAMUR	VIK-NAMUR message bit bar	58	U16	r3113

Abbreviation	Name	Signal number	Data type 1)	Comment
MELDW	Message word	102	U16	r2089[2] (bit serial)2)
MSOLL_GLATT	Total speed setpoint	120	I16	r00079[1]
AIST_GLATT	Torque utilization	121	I16	r0081
MT_ZSW	Status word for probe	131	U16	r0688
MT1_ZS_F	Probe 1 measuring time, falling edge	132	U16	r0687[0]
MT1_ZS_S	Probe 1 measuring time, rising edge	133	U16	r0686[0]
MT2_ZS_F	Probe 1 measuring time, falling edge	134	U16	r0687[1]
MT2_ZS_S	Probe 2 measuring time, rising edge	135	U16	r0686[1]
AKTSATZ	Pos selected block	202	U16	r2670
PosZSW	Pos status word	204	U16	r2683
XistP	Pos position actual value	206	U16	r2521
FAULT_CODE	Fault code	301	U16	r2131
WARN_CODE	Alarm code	303	U16	r2132
E_ZSW1	Status word for INFEED	321	U16	r899, r2139 (bit serial)2)
CU_ZSW	Status word for Control Unit (CU)	501	U16	r2089[1]
1) Data type according to the PROFIdrive profile V4: I16 = Integer16, I32 = Integer32, U16 = Unsigned16, U32 = Unsigned32				
2) Bit-serial interconnection: Refer to the following pages, r2089 via binector-connector converter				

STW1 (status word 1)

See function diagram [2452]

Table 10-11 Description of STW1 (status word 1)

Bit	Meaning	Comments		BICO
0	Ready to power-up	1	Ready to start Power supply on, electronics initialized, line contactor released if necessary, pulses inhibited.	BO: r0899.0
		0	Not ready to start	
1	Ready to run	1	Ready to operate Voltage at Line Module (i.e. line contactor closed (if used)), field being built up.	BO: r0899.1
		0	Not ready to operate Reason: No ON command has been issued.	
2	Operation enabled	1	Operation enabled Enable electronics and pulses, then ramp up to active setpoint.	BO: r0899.2
		0	Operation inhibited	

Bit	Meaning	Comments		BICO
3	Fault active	1	Fault active The drive is faulty and, therefore, out of service. The drive switches to power-on inhibit once the fault has been acknowledged and the cause has been remedied. The active faults are stored in the fault buffer.	BO: r2193.3
		0	No fault present No active fault in the fault buffer.	
4	Coasting active (OFF2)	1	No OFF2 active	BO: r0899.4
		0	Coasting active (OFF2) An OFF2 command is present.	
5	Fast stop active (OFF3)	1	No OFF3 active	BO: r0899.5
		0	Fast stop active (OFF3) An OFF3 command is present.	
6	Power-on disable	1	Power-on disable A restart is only possible by means of OFF1 and then ON.	BO: r0899.6
		0	No power-up inhibit Power-up is possible.	
7	Alarm present	1	Alarm present The drive is operational again. No acknowledgement necessary. The active alarms are stored in the alarm buffer.	BO: r2139.7
		0	No alarm present No active alarm in the alarm buffer.	
8	Speed setpoint-actual value deviation within tolerance band	1	Setpoint-actual value monitoring within tolerance band Actual value within a tolerance band; dynamic overshoot or shortfall permitted for $t < t_{max}$ permissible, e.g. $n = n_{setp}\pm$ $f = f_{setp}\pm$, and, t_{max} can be parameterized	BO: r2197.7
		0	Setpoint/actual value monitoring not within tolerance band	
9	Control requested	1	Control required The PLC is requested to assume control. Condition for applications with isochronous mode: drive synchronized with PLC system.	BO: r0899.9
		0	Local operation Control only possible on device	
10	f or n comparison value reached or exceeded	1	f or n comparison value reached or exceeded.	BO: r2199.1
		0	f or n comparison value not reached.	
	Note: The message is parameterized as follows: p2141 Threshold value p2142 Hysteresis			
11	I, M or P limit reached or exceeded	1	I, M or P limit not reached	BO: r1407.7 (inverted)
		0	I, M or P limit reached or exceeded	

Bit	Meaning	Comments		BICO
12	Holding brake open	1	Holding brake open	BO: r0899.12
		0	Holding brake closed	
13	No motor overtemperature alarm	1	Motor overtemperature alarm not active	BO: r2135.14 (inverted)
		0	Motor overtemperature alarm active	
14	n_act >= 0	1	Actual speed > = 0	BO: r2197.3
		0	Actual speed < 0	
15	Alarm, drive converter thermal overload	1	No alarm present	BO: r2135.15 (inverted)
		0	Alarm, converter thermal overload The overtemperature alarm for the converter is active.	

STW1 (status word 1), positioning mode, p0108.4 = 1

See function diagram [2479]

Table 10-12 Description of STW1 (status word 1, positioning mode)

Bit	Meaning	Comments		BICO
0	Ready to power-up	1	Ready to start Power supply on, electronics initialized, line contactor released if necessary, pulses inhibited.	BO: r0899.0
		0	Not ready to start	
1	Ready to run	1	Ready to operate Voltage at Line Module (i.e. line contactor closed (if used)), field being built up.	BO: r0899.1
		0	Not ready to operate Reason: No ON command has been issued.	
2	Operation enabled	1	Operation enabled Enable electronics and pulses, then ramp up to active setpoint.	BO: r0899.2
		0	Operation inhibited	
3	Fault active	1	Fault active The drive is faulty and, therefore, out of service. The drive switches to Power-on inhibit once the fault has been acknowledged and the cause has been remedied. The active faults are stored in the fault buffer.	BO: r2193.3
		0	No fault present No active fault in the fault buffer.	
4	Coasting active (OFF2)	1	No OFF2 active	BO: r0899.4
		0	Coasting active (OFF2) An OFF2 command is present.	
5	Fast stop active (OFF3)	1	No OFF3 active	BO: r0899.5
		0	Fast stop active (OFF3) An OFF3 command is present.	

Bit	Meaning	Comments		BICO
6	Power-on disable	1	Power-on disable A restart is only possible by means of OFF1 and then ON.	BO: r0899.6
		0	No power-up inhibit Power-up is possible.	
7	Alarm present	1	Alarm present The drive is operational again. No acknowledgement necessary. The active alarms are stored in the alarm buffer.	BO: r2139.7
		0	No alarm present No active alarm in the alarm buffer.	
8	Following error within the tolerance range	1	Setpoint-actual value monitoring within tolerance band Actual value within a tolerance bandwidth; The tolerance bandwidth can be parameterized.	BO: r2684.8
		0	Setpoint/actual value monitoring not within tolerance band	
9	Control requested	1	Control required The PLC is requested to assume control. Condition for applications with isochronous mode: drive synchronized with PLC system.	BO: r0899.9
		0	Local operation Control only possible on device	
10	Target position reached	1	Target position reached	BO: r2684.10
		0	Target position not reached	
11	Reference point set	1	Reference point set	BO: r2684.11
		0	Reference point not set	
12	Acknowledgement, traversing block activated	0/1	Acknowledgement, traversing block	BO: r2684.12
		0	No effect	
13	Drive at standstill	1	Drive at standstill	BO: r2199.0
		0	Drive not at standstill	
14	Reserved	–	–	–
15	Reserved	–	–	–

STW2 (status word 2)

See function diagram [2454]

Table 10-13 Description of STW2 (status word 2)

Bit	Meaning	Comments		BICO
0	DDS eff., bit 0	–	Drive data set effective (5-bit counter)	BO: r0051.0
1	DDS eff., bit 1	–		BO: r0051.1
2	DDS eff., bit 2	–		BO: r0051.2
3	DDS eff., bit 3	–		BO: r0051.3

Bit	Meaning	Comments		BICO
4	DDS eff., bit 4	–		BO: r0051.4
5, 6	Reserved	–	–	–
7	Parking axis	1	Axis parking active	BO: r0896.0
		0	Axis parking not active	
8	Travel to fixed endstop	1	Travel to fixed endstop	BO: r1406.8
		0	No travel to fixed stop	
9, 10	Reserved	–	–	–
11	Data set changeover	1	Data record changeover active	BO: r0835.0
		0	No data set changeover active	
12	Drive unit sign-of-life bit 0	–	User data integrity (4-bit counter)	Implicitly interconnected
13	Drive unit sign-of-life bit 1	–		
14	Drive unit sign-of-life bit 2	–		
15	Drive unit sign-of-life bit 3	–		

NACT_A (Speed setpoint A (16 bit))

- Actual speed value with 16-bit resolution.
- The speed actual value is normalized in the same way as the setpoint (see NSOLL_A).

NACT_B (Speed setpoint B (32 bit))

- Actual speed value with 32-bit resolution.
- The speed actual value is normalized in the same way as the setpoint (see NSOLL_B).

Gn_ZSW (encoder n status word)
Gn_XIST1 (encoder n position actual value 1)
Gn_XIST2 (encoder n position actual value 2)

This process data belongs to the encoder interface.

ITIST_GLATT

The actual current value smoothed with p0045 is displayed.

MELDW (message word)

See function diagram [2456]

Table 10-14 Description of MELDW (message word)

Bit	Meaning	Comments		BICO
0	Ramp-up/ramp-down completed / ramp-function generator active	1	Ramp-up/ramp-down completed. • The ramp-up procedure is completed once the speed setpoint has been changed.	BO: r2199.5

<table>
<tr><th>Bit</th><th>Meaning</th><th colspan="2">Comments</th><th>BICO</th></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td>1/0</td><td>Ramp-up starts.
The start of the ramp-up procedure is detected as follows:
• The speed setpoint changes,
and
• the defined tolerance bandwidth (p2164) is exited.</td><td rowspan="3"></td></tr>
<tr><td>0</td><td>Ramp-function generator active
• The ramp-up procedure is still active once the speed setpoint has been changed.</td></tr>
<tr><td>0/1</td><td>Ramp-up ends.
The end of the ramp-up procedure is detected as follows:
• The speed setpoint is constant,
and
• The actual speed value is within the tolerance bandwidth and has reached the speed setpoint,
and
• The waiting time (p2166) has elapsed.</td></tr>
<tr><td rowspan="3">1</td><td rowspan="2">Torque utilization < p2194</td><td>1</td><td>Torque utilization < p2194
• The current torque utilization is less than the set torque utilization threshold (p2194),
or
• Ramp-up is not yet complete.</td><td rowspan="2">BO: r2199.11</td></tr>
<tr><td>0</td><td>Torque utilization > p2194
• The current torque utilization is greater than the set torque utilization threshold (p2194).</td></tr>
<tr><td colspan="4">Application:
This message indicates that the motor is overloaded and appropriate measures need to be taken to rectify the situation (e.g. stop the motor or reduce the load).</td></tr>
<tr><td rowspan="3">2</td><td rowspan="2">|n_act| t p2161</td><td>1</td><td>|n_act| < p2161
The actual speed value is less than the set threshold value (p2161).</td><td rowspan="2">BO: r2199.0</td></tr>
<tr><td>0</td><td>|n_act| ≥ p2161
The actual speed value is greater than or the same as the set threshold value (p2161).</td></tr>
<tr><td colspan="4">Note:
The message is parameterized as follows:
p2161 Threshold value
p2150 Hysteresis
Application:
To protect the mechanics, the gear stages are not switched mechanically until the speed is less than the set threshold value.</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">|n_act| v p2155</td><td>1</td><td>|n_act| ≤ p2155
The actual speed value is less than or the same as the set threshold value (p2155).</td><td rowspan="2">BO: r2197.1</td></tr>
<tr><td>0</td><td>|n_act| > p2155
The actual speed value is greater than the set threshold value (p2155).</td></tr>
</table>

Bit	Meaning		Comments	BICO
	Note: The message is parameterized as follows: p2155 Threshold value p2140 Hysteresis **Application:** Speed monitoring.			
4	Reserved	1	–	–
		0	-	
5	Reserved	1	–	-
		0	–	
6	No motor overtemperature alarm	1	No motor overtemperature alarm The temperature of the motor is within the permissible range.	BO: r2135.14 (inverted)
		0	Alarm, motor overtemperature The temperature of the motor is greater than the set motor temperature threshold (p0604).	
	Note: • When the motor temperature threshold is exceeded, only an alarm is output initially to warn you of this. The alarm is canceled automatically when the temperature no longer exceeds the alarm threshold. • If the overtemperature is present for longer than the value set via p0606, a fault is output to warn you of this. • Motor temperature monitoring can be switched-out via p0600 = 0. **Application:** The user can respond to this message by reducing the load. thereby preventing the motor from shutting down with the "Motor temperature exceeded" fault after the set time has elapsed.			
7	No thermal overload in power section alarm	1	No thermal overload in power unit alarm The temperature of the heat sink in the power section is within the permissible range.	BO: r2135.15 (inverted)
		0	Thermal overload in power unit alarm The temperature of the heat sink in the power unit is outside the permissible range. If the overtemperature remains, the drive switches itself off after approx. 20 s.	
8	Speed setp - act val deviation in tolerance t_on	1	The speed setpoint/actual value is **within** the tolerance p2163: The signal is switched on after the delay specified in p2167 has elapsed.	BO: r2199.4
		0	The speed setpoint/actual value is **outside** the tolerance.	
9... 12	Reserved	1	-	-
		0	-	
13	Pulses enabled	1	Pulses enabled The pulses for activating the motor are enabled.	BO: r0899.11
		0	Pulses inhibited	
	Application: Armature short-circuit protection must only be switched on when the pulses are inhibited. This signal can be evaluated as one of many conditions when armature short-circuit protection is activated.			
14	Reserved	1	-	-
15		0	-	

MSOLL_GLATT

The torque setpoint smoothed with p0045 is displayed.

AIST_GLATT

Torque utilization smoothed with p0045 is displayed.

E_DIGITAL
MT_STW
MT_n_ZS_F/MT_n_ZS_S
CU_ZSW

This process data is part of the central process data.

IAIST_GLATT

The actual current value smoothed with p0045 is displayed.

MIST_GLATT

The actual torque value smoothed with p0045 is displayed.

PIST_GLATT

The active power smoothed with p0045 is displayed.

MELD_NAMUR

Display of the NAMUR message bit bar

WARN_CODE

Display of the alarm code (see function diagram 8066)

FAULT_CODE

Display of the alarm code (see function diagram 8060)

E_STW1 (status word for INFEED)

See function diagram [8926]

Table 10-15 Description of E_STW1 (status word for E_INF)

Bit	Meaning	Comments		BICO
0	Ready to power-up	1	Ready to power-up	BO: r0899.0
		0	Not ready to start	

Bit	Meaning	Comments		BICO
1	Ready to run	1	Ready to run DC link pre-charged, pulses inhibited	BO: r0899.1
		0	Not ready	
2	Operation enabled	1	Operation enabled Vdc = Vdc_setp	BO: r0899.2
		0	Operation inhibited	
3	Fault active	1	Fault active	BO: r2139.3
		0	No fault	
4	No OFF2 active	1	No OFF2 active	BO: r0899.4
		0	OFF2 active	
5	Reserved	–	–	–
6	Power-on disable	1	Power-on disable Fault active	BO: r0899.6
		0	No power-up inhibit	
7	Alarm present	1	Alarm present	BO: r2139.7
		0	No alarm	
8	Reserved	–	–	–
9	Control requested	1	Control required The PLC is requested to assume control. Condition for applications with isochronous mode: drive synchronized with PLC system.	BO: r0899.9
		0	Local operation Control only possible on device	
10	Reserved	–	–	–
11	Bypass energized	1	Bypass energized Pre-charging is complete and the bypass relay for the pre-charging resistors is energized.	BO: r0899.11
		0	Bypass not energized Pre-charging not yet complete.	
12	Line contactor activated	1	Line contactor activated	BO: r0899.12
		0	Line contactor not energized	
13... 15	Reserved	–	–	–

PosZSW

See function diagram [3645]

Table 10-16 Description of PosZSW (status word, positioning mode)

Bit	Meaning	Comments		BICO
0	Tracking mode active	1	Tracking mode active	BO: r2683.0
		0	Tracking mode not active	
1	Speed limiting active	1	Active	BO: r2683.1
		0	Not active	

Bit	Meaning	Comments		BICO
2	Setpoint static	1	Setpoint static	BO: r2683.2
		0	Setpoint not static	
3	Reserved	–	–	–
4	Axis moves forwards	1	Axis moves forwards	BO: r2683.4
		0	Axis stationary or moving backwards	
5	Axis moving backwards	1	Axis moving backwards	BO: r2683.5
		0	Axis stationary or moving forwards	
6	Software limit switch minus approached	1	Software limit switch minus approached	BO: r2683.6
		0	Software limit switch minus not approached	
7	Software limit switch plus approached	1	Software limit switch plus approached	BO: r2683.7
		0	Software limit switch plus not approached	
8	Actual position value <= cam switching position 1	1	Actual position value <= cam switching position 1	BO: r2683.8
		0	Cam switching position 1 passed	
9	Actual position value <= cam switching position 2	1	Actual position value <= cam switching position 2	BO: r2683.9
		0	Cam switching position 2 passed	
10	Direct output 1 via the traversing block	1	Direct output 1 active	BO: r2683.10
		0	Direct output 1 not active	
11	Direct output 2 via the traversing block	1	Direct output 1 active	BO: r2683.11
		0	Direct output 1 not active	
12	Fixed stop reached	1	Fixed stop reached	BO: r2683.12
		0	Fixed stop is not reached	
13	Fixed stop, clamping torque reached	1	Fixed stop, clamping torque reached	BO: r2683.13
		0	Fixed stop, clamping torque is not reached	
14	Travel to fixed stop active	1	Travel to fixed stop active	BO: r2683.12
		0	Travel to fixed stop not active	
15	Reserved	–	–	–

AktSatz

See function diagram [3650]

Table 10-17 Description AktSatz (active traversing block/MDI active)

Bit	Meaning	Comments		BICO
0	Active traversing block, bit 0	–	Active traversing block (6-bit counter)	BO: r2670.0
1	Active traversing block, bit 1	–		BO: r2670.1
2	Active traversing block, bit 2	–		BO: r2670.2
3	Active traversing block, bit 3	–		BO: r2670.3
4	Active traversing block, bit 4	–		BO: r2670.4
5	Active traversing block, bit 5	–		BO: r2670.5
6..14	Reserved	–	–	–
15	MDI active	1	MDI active	BO: r2670.15
		0	MDI not active	

XistP

Actual position value is displayed

Normalization: 1 corresponds to 1 LU

10.1.3.5 Control and status words for encoder

Description

The process data for the encoders is available in various telegrams. For example, telegram 3 is provided for speed control with 1 position encoder and transmits the process data of encoder 1.

The following process data is available for the encoders:

- Gn_CTW encoder n control (n = 1, 2, 3)
- Gn_ZSW encoder n status word
- Gn_XIST1 encoder n act. pos. value 1
- Gn_XIST2 encoder n act. pos. value 2

Note

Encoder 1: Motor encoder

Encoder 2: Direct measuring system

Encoder 3: Additional measuring system
Encoder 3 can be connected via p2079 and extension of the standard telegrams.

Example of encoder interface

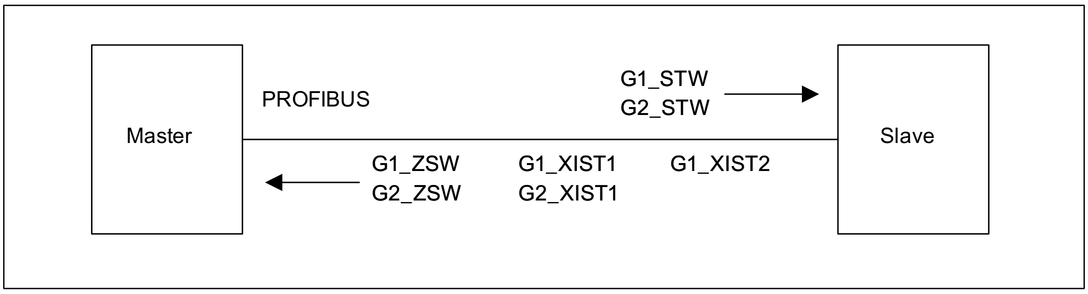


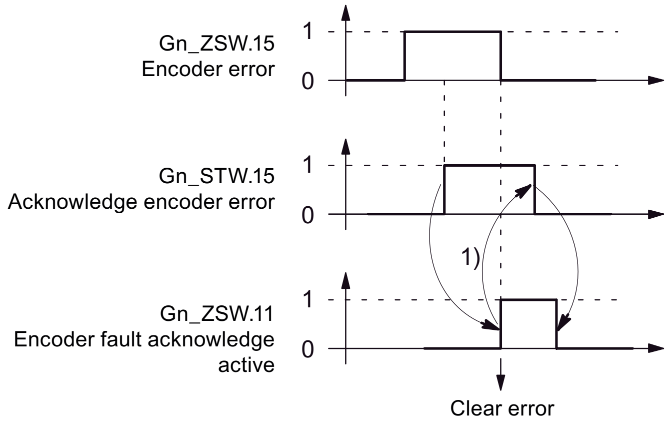
Figure 10-11 Example of encoder interface (encoder-1: two actual values, encoder -2: an actual value)

Encoder n control word (Gn_CTW, n = 1, 2, 3)

The encoder control word controls the encoder functions.

Table 10-18 Description of the individual signals in Gn_STW

Bit	Name		Signal status, description		
0 1 2 3	Find reference mark or flying measurement	Functions	If bit 7 = 0, then find reference mark request applies:		
			Bit	Meaning	
			0	Function 1	Reference mark 1
			1	Function 2	Reference mark 2
			2	Function 3	Reference mark 3
			3	Function 4	Reference mark 4
			If bit 7 = 1, then find flying measurement request applies:		
			0	Function 1	Probe 1 rising edge
			1	Function 2	Probe 2 falling edge
			2	Function 3	Probe 3 rising edge
			3	Function 4	Probe 4 falling edge
			Note:		
			• Bit x = 1 Bit x = 0		Request function Do not request function
			• The following applies if more than 1 function is activated: The values for all functions cannot be read until each activated function has terminated and this has been confirmed in the corresponding status bit (STW.0/.1/.2/.3 "0" signal again). • Find reference mark It is possible to search for a reference marker. • Equivalent zero mark • On-the-fly measurement Positive and negative edge can be activated simultaneously.		
4 5 6		Command	Bit 6, 5, 4		Meaning
			000		-
			001		Activate function x
			010		Read value x
			011		Terminate function
			(x: function selected via bit 0-3)		
7		Mode	1	Measurement on-the-fly (fine resolution via p0418)	
			0	Find reference marker (fine resolution via p0418)	
0... 12	Reserved		-		
13	Request cyclic absolute value		1	Request cyclic transmission of the absolute position actual value in Gn_XIST2. Used for (e.g.): • Additional measuring system monitoring • Synchronization during ramp-up	
			0	No request	
14	Parking encoder		1	Request parking encoder (handshake with Gn_ZSW bit 14)	
			0	No request	
15	Acknowledge encoder error		0/1	Request to reset encoder errors	

Bit	Name	Signal status, description	
			 1) Signal must be reset by user.
		0	No request

Example 1: Find reference mark

Assumptions for the example:

- Distance-coded reference mark
- Two reference markers (function 1/function 2)
- Position control with encoder 1

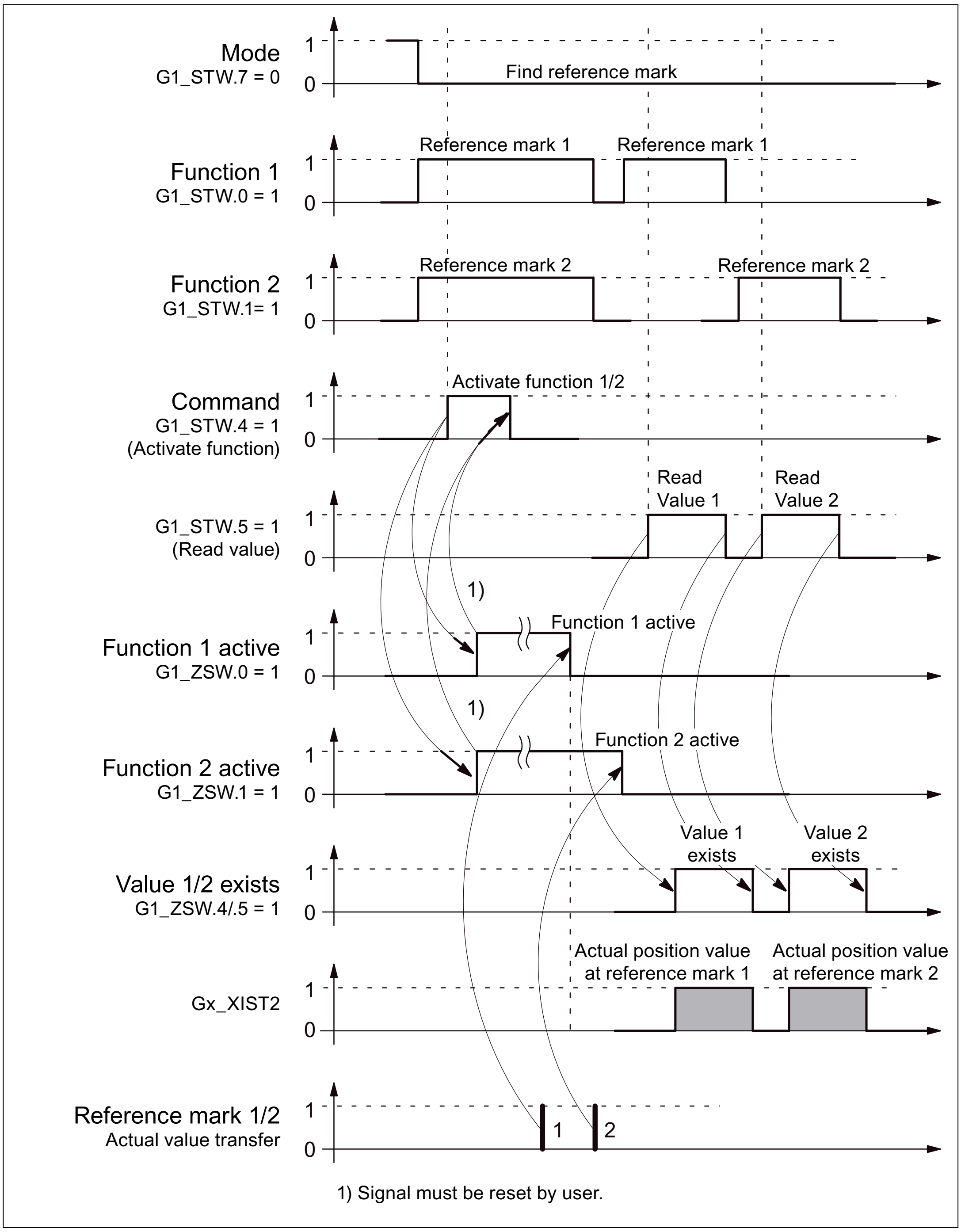


Figure 10-12 Flowchart for "find reference mark"

Example 2: Flying measurement

Assumptions for the example:

- Measuring probe with rising edge (function 1)
- Position control with encoder 1

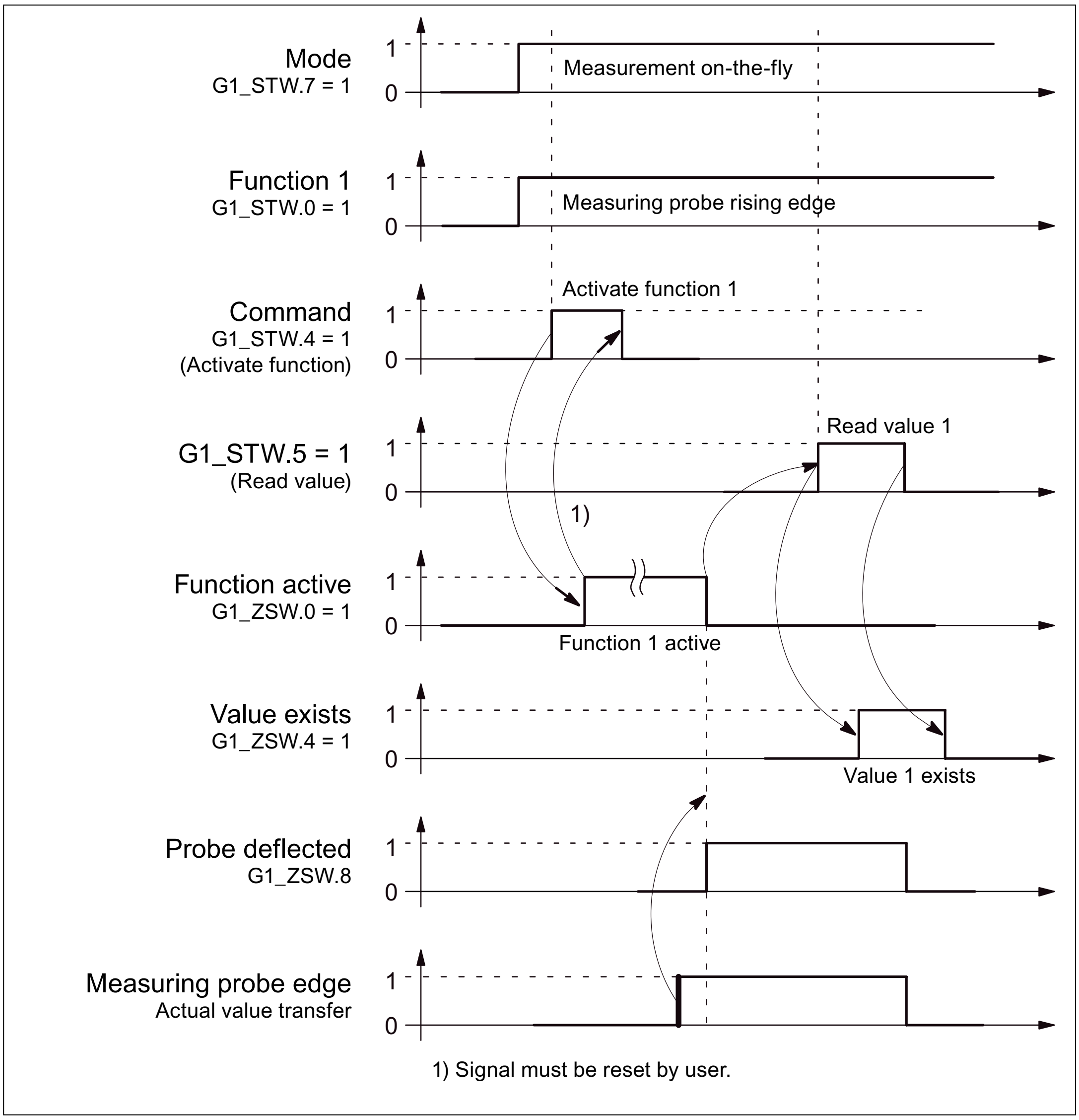


Figure 10-13 Function chart for "measurement on-the-fly"

Encoder 2 control word (G2_CTW)

- See G1_CTW (table 4-19)

Encoder 3 control word (G3_CTW)

- See G1_CTW (table 4-19)

Encoder n status word (Gn_STW, n = 1, 2, 3)

The encoder status word is used to display states, errors and acknowledgements.

Table 10-19 Description of the individual signals in Gn_STW

Bit	Name		Signal status, description		
0 1 2 3	Find reference mark or flying measurement	Status: Function 1 - 4 active	Valid for find reference marker and measurement on-the-fly.		
			Bit	Meaning	
			0	Function 1	Reference marker 1 Probe 1 rising edge
			1	Function 2	Reference marker 2 Probe 1 falling edge
			2	Function 3	Reference marker 3 Probe 2 rising edge
			3	Function 4	Reference marker 4 Probe 2 falling edge
			Note: • Bit x = 1 function active Bit x = 0 function inactive		
4 5 6 7		Status: Value 1 - 4 available	Valid for find reference marker and measurement on-the-fly.		
			Bit	Meaning	
			4	Value 1	Reference marker 1 Probe 1 rising edge
			5	Value 2	Probe 1 falling edge
			6	Value 3	Probe 2 rising edge
			7	Value 4	Probe 2 falling edge
			Note: • Bit x = 1 value available Bit x = 0 value not available • Only one value can be fetched at a time. Reason: There is only one common status word Gn_XIST2 to read the values. • The probe must be configured to a "high-speed input" DI/DO on the Control Unit.		
8		Probe 1 deflected	1	Probe deflected (high signal)	
			0	Probe not deflected (low signal)	
9	Probe 2 deflected		1	Probe deflected (high signal)	
			0	Probe not deflected (low signal)	
10	Reserved		-		
11	Encoder fault acknowledge active		1	Encoder fault acknowledge active **Note:** See under CTW.15 (acknowledge encoder error)	
			0	No acknowledgement active	
12	Reserved		-		
13	Transmit cyclic absolute value		1	Acknowledgement for Gn_STW.13 (request cyclic absolute value) **Note:** Cyclic transmission of the absolute value can be interrupted by a function with higher priority. • See Fig. 1-9 • See Gn_XACT2	
			0	No acknowledgement	
14	Parking encoder		1	Parking encoder active (i.e. parking encoder switched off)	

Bit	Name	Signal status, description	
		0	No active parking encoder
15	Encoder error	1	Error from encoder or actual-value sensing is active. **Note:** The error code is stored in Gn_XACT2.
		0	No error is active.

Encoder 1 actual position value 1 (G1_XACT1)

- Resolution: Encoder lines • 2n

  n: fine resolution, no. of bits for internal multiplication

  The fine resolution is specified via p0418.
- Used to transmit the cyclic actual position value to the controller.
- The transmitted value is a relative, free-running actual value.
- Any overflows must be evaluated by the master controller.

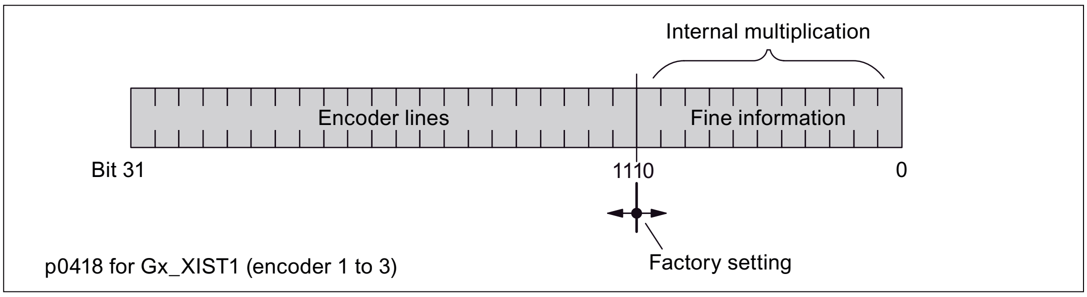


Figure 10-14 Subdivision and settings for Gx_XIST1

- Encoder lines of incremental encoder
  - For encoders with sin/cos 1Vpp:

    Encoder lines = no. of sinusoidal signal periods
- After power-up: Gx_XIST1 = 0
- An overflow in Gx_XIST1 must be viewed by the master controller.
- There is no modulo interpretation of Gx_XIST1 in the drive.

Encoder 1 actual position value 2 (G1_XACT2)

Different values are entered in Gx_XACT2 depending on the function.

- Priorities for Gx_XIST2

The following priorities should be considered for values in Gx_XIST2:

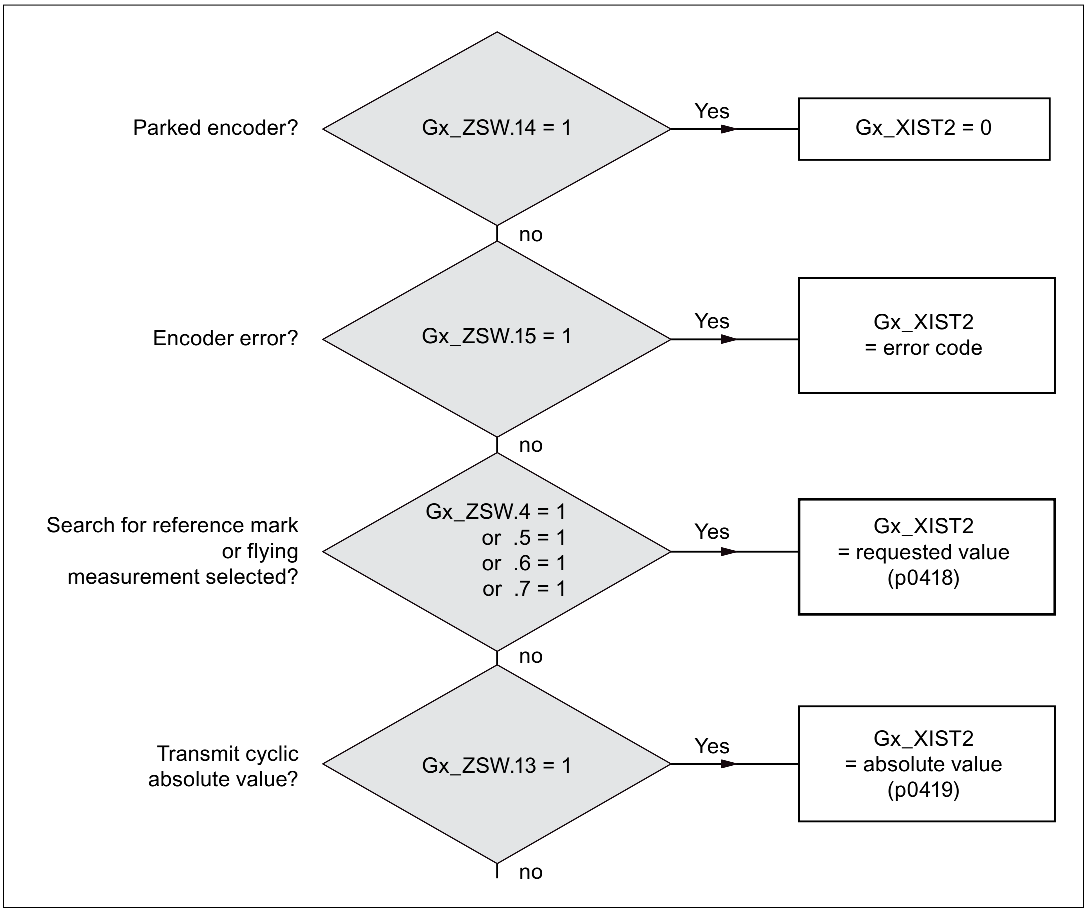


Figure 10-15 Priorities for functions and Gx_XIST2

- Resolution: Encoder pulses • 2n

  n : fine resolution, no. of bits for internal multiplication

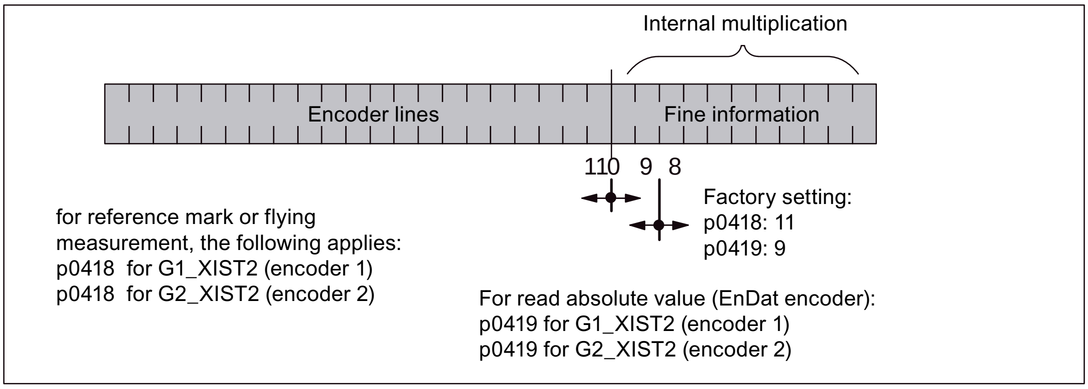


Figure 10-16 Subdivision and settings for Gx_XIST2

- Encoder lines of incremental encoder
  - For encoders with sin/cos 1Vpp:

    Encoder lines = no. of sinusoidal signal periods

Error code in Gn_XIST2

Table 10-20 Error code in Gn_XIST2

n_XIST2	Meaning	Possible causes / description
1	Encoder error	One or more existing encoder faults. Detailed information in accordance with drive messages.
2	Zero marker monitoring	–
3	Abort parking sensor	• Parking drive object already selected.
4	Abort find reference marker	• A fault exists (Gn_ZSW.15 = 1) • Encoder has no zero marker (reference marker) • Reference marker 2, 3 or 4 is requested • Switchover to "Measurement on-the-fly" during search for reference marker • Command "Read value x" set during search for reference marker • Inconsistent position measured value with distance-coded reference markers.
5	Abort, retrieve reference value	• More than four values requested • No value requested • Requested value not available
6	Abort flying measurement	• No probe configured p0488, p0489 • Switch over to "reference mark search" during flying measurement • Command "Read value x" set during flying measurement
7	Abort get measured value	• More than one value requested • No value requested. • Requested value not available • Parking encoder active • Parking drive object active
8	Abort absolute value transmission on	• Absolute encoder not available • Alarm bit absolute value protocol set
3841	Function not supported	–

Encoder 2 status word (G2_STW)

- See G1_STW (table 4-20)

Encoder 2 actual position value 1 (G2_XACT1)

- See G1_XIST1

Encoder 2 actual position value 2 (G2_XACT2)

- See G1_XIST2

Encoder 3 status word (G3_STW)

- See G1_STW (table 4-20)

Encoder 3 actual position value 1 (G3_XACT1)

- See G1_XIST1

Encoder 3 actual position value 2 (G3_XACT2)

- See G1_XIST2

Function diagrams (see SINAMICS S List Manual)

- 4720 Encoder interface, receive signals, encoders n
- 4730 Encoder interface, send signals, encoders n
- 4735 Find reference marker with equivalent zero mark, encoders n
- 4740 Measuring probe evaluation, measured value memory, encoders n

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameter drive, CU_S parameter is marked

- p0418[0...15] Fine resolution Gx_XACT1
- p0419[0...15] Fine resolution Gx_XACT2
- p0480[0...2] CI: Signal source for encoder control word Gn_STW
- p0488[0...2] Measuring probe 1 input terminal
- p0489[0...2] Measuring probe 2 input terminal
- p0490 Invert measuring probe (CU_S)

Visualization parameters drive

- r0481[0...2] CO: Encoder status word Gn_ZSW
- r0482[0...2] CO: Encoder position actual value Gn_XIST1
- r0483[0...2] CO: Encoder position actual value Gn_XIST2
- r0487[0...2] CO: Diagnostic encoder control word Gn_STW

10.1.3.6 Central control and status words

Description

The central process data exists for different telegrams. For example, telegram 391 is used for transferring measuring times and digital inputs/outputs.

The following central process data is available:

Receive signals:

- CU_STW Control Unit control word
- A_DIGITAL digital outputs
- MT_STW probe control word

Transmit signals:

- CU_ZSW Control Unit status word
- E_DIGITAL digital inputs
- MT_CTW Probe status word
- MTn_ZS_F Probe n measuring time, falling edge (n = 1, 2)
- MTn_ZS_S Probe n measuring time, rising edge (n = 1, 2)

CU_STW (control word for Control Unit, CU)

See function diagram [2448]

Table 10-21 Description of CU_STW (control word for Control Unit, CU)

Bit	Meaning	Remarks		BICO
0	Synchronization flag	–	This signal is used to synchronize the joint system time between the controller and drive unit.	BI: p0681[0]
1	RTC PING	–	This signal is used to set the UTC time using the PING event.	BI: p3104
2...6	Reserved	–	–	–
7	Acknowledging faults	0/1	Acknowledging faults	BI: p2103
8...11	Reserved	–	–	–
12	Controller sign-of-life bit 0	–	Controller sign-of-life	CI: p2045
13	Controller sign-of-life bit 1	–		
14	Controller sign-of-life bit 2	–		
15	Controller sign-of-life bit 3	–		

A_DIGITAL (digital outputs)

This process data can be used to control the Control Unit outputs.
See function diagram [2449]

Table 10-22 Description of A_DIGITAL (digital outputs)

Bit	Meaning	Remarks		BICO
0	Digital input/output 8 (DI/DO 8)	–	DI/DO 8 on the Control Unit must be parameterized as an output (p0728.8 = 1).	BI: p0738

Bit	Meaning	Remarks		BICO
1	Digital input/output 9 (DI/DO 9)	–	DI/DO 9 on the Control Unit must be parameterized as an output (p0728.9 = 1).	BI: p0739
2	Digital input/output 10 (DI/DO 10)	–	DI/DO 10 on the Control Unit must be parameterized as an output (p0728.10 = 1).	BI: p0740
3	Digital input/output 11 (DI/DO 11)	–	DI/DO 11 on the Control Unit must be parameterized as an output (p0728.11 = 1).	BI: p0741
4	Digital input/output 12 (DI/DO 12)	–	DI/DO 12 on the Control Unit must be parameterized as an output (p0728.12 = 1).	BI: p0742
5	Digital input/output 13 (DI/DO 13)	–	DI/DO 13 on the Control Unit must be parameterized as an output (p0728.13 = 1).	BI: p0743
6	Digital input/output 14 (DI/DO 14)	–	DI/DO 14 on the Control Unit must be parameterized as an output (p0728.14 = 1).	BI: p0744
7	Digital input/output 15 (DI/DO 15)	–	DI/DO 15 on the Control Unit must be parameterized as an output (p0728.15 = 1).	BI: p0745
8... 15	Reserved	–	–	–
Note: The bidirectional digital inputs/outputs (DI/DO) can be connected as either an input or an output (see also transmit signal E_DIGITAL).				

MT_STW

Control word for the "central probe" function. Display via r0685.

Table 10-23 Description of MT_STW (control word for Control Unit)

Bit	Meaning	Remarks		BICO
0	Falling edge probe 1	–	Activation of measuring time determination with the next falling edge For telegram 392, in addition, probes 3 and 6	CI: p0682
1	Falling edge probe 2	–		
2	Falling edge probe 3	–		
3	Falling edge probe 4	–		
4	Falling edge probe 5	–		
5	Falling edge probe 6	–		
6...7	Reserved	–	–	
8	Rising edge probe 1	–	Activation of measuring time determination with the next rising edge For telegram 392, in addition, probes 3 and 6	
9	Rising edge probe 2	–		
10	Rising edge probe 3	–		
11	Rising edge probe 4	–		
12	Rising edge probe 5	–		
13	Rising edge probe 6	–		
14... 15	Reserved	–	–	

CU_ZSW (status word for Control Unit, CU)

See function diagram [2458]

Table 10-24 Description of CU_ZSW (status word for Control Unit)

Bit	Meaning	Remarks		BICO
0...2	Reserved	–	–	–
3	Fault active	1	Fault active	BO: r2139.3
		0	No fault present	
4...6	Reserved	–	–	–
7	Alarm present	1	Alarm present	BO: 2139.7
		0	No alarm present	
8	SYNC	–	–	BO: r0899.8
9...11	Reserved	–	–	–
12	Drive unit sign-of-life bit 0	–	Slave sign of life	Implicitly interconnec-ted
13	Drive unit sign-of-life bit 1	–		
14	Drive unit sign-of-life bit 2	–		
15	Drive unit sign-of-life bit 3	–		

E_DIGITAL (digital inputs)

See function diagram [2459].

Table 10-25 Description of E_DIGITAL (digital inputs)

Bit	Meaning	Remarks		BICO
0	Digital input/output 8 (DI/DO = 8)	–	DI/DO 8 on the Control Unit must be parameterized as an input (p0728.8 = 0).	BO: p0722.8
1	Digital input/output 9 (DI/DO = 9)	–	DI/DO 9 on the Control Unit must be parameterized as an input (p0728.9 = 0).	BO: p0722.9
2	Digital input/output 10 (DI/DO = 10)	–	DI/DO 10 on the Control Unit must be parameterized as an input (p0728.10 = 0).	BO: p0722.10
3	Digital input/output 11 (DI/DO = 11)	–	DI/DO 11 on the Control Unit must be parameterized as an input (p0728.11 = 0).	BO: p0722.11
4	Digital input/output 12 (DI/DO = 12)	–	DI/DO 12 on the Control Unit must be parameterized as an input (p0728.12 = 0).	BO: p0722.12
5	Digital input/output 13 (DI/DO = 13)	–	DI/DO 13 on the Control Unit must be parameterized as an input (p0728.13 = 0).	BO: p0722.13
6	Digital input/output 14 (DI/DO = 14)	–	DI/DO 14 on the Control Unit must be parameterized as an input (p0728.14 = 0).	BO: p0722.14
7	Digital input/output 15 (DI/DO = 15)	–	DI/DO 15 on the Control Unit must be parameterized as an input (p0728.15 = 0).	BO: p0722.15
8	Digital input 0 (DI 0)	–	Digital input DI 0 on the Control Unit	BO: r0722.0
9	Digital input 1 (DI 1)	–	Digital input DI 1 on the Control Unit	BO: r0722.1
10	Digital input 2 (DI 2)	–	Digital input DI 2 on the Control Unit	BO: r0722.2
11	Digital input 3 (DI 3)	–	Digital input DI 3 on the Control Unit	BO: r0722.3
12	Digital input 4 (DI 4)	–	Digital input DI 4 on the Control Unit	BO: r0722.4
13	Digital input 5 (DI 5)	–	Digital input DI 5 on the Control Unit	BO: r0722.5
14	Digital input 6 (DI 6)	–	Digital input DI 6 on the Control Unit	BO: r0722.6
15	Digital input 7 (DI 7)	–	Digital input DI 7 on the Control Unit	BO: r0722.7

Bit	Meaning	Remarks	BICO
Note: The bidirectional digital inputs/outputs (DI/DO) can be connected as either an input or an output (see also receive signal A_DIGITAL).			

MT_ZSW

Status word for the "central probe" function.

Table 10-26 Description of MT_ZSW (status word for the "central probe" function)

Bit	Meaning	Remarks		BICO
0	Digital input probe 1	–	Display of digital inputs For telegram 392, in addition, probes 3 and 6	CO: r0688
1	Digital input probe 2	–		
2	Digital input probe 3	–		
3	Digital input probe 4	–		
4	Digital input probe 5	–		
5	Digital input probe 6	–		
6...7	Reserved	–	–	
8	Sub-sampling probe 1	–	Not yet carried out. For telegram 392, in addition, probes 3 and 6	
9	Sub-sampling probe 2	–		
8	Sub-sampling probe 3	–		
9	Sub-sampling probe 4	–		
8	Sub-sampling probe 5	–		
9	Sub-sampling probe 6	–		
10... 15	Reserved	–	–	

MTn_ZS_F and MTn_ZS_S

Display of the measuring time determined

The measuring time is specified as a 16-bit value with a resolution of 0.25 µs.

Features of the central probe

- The time stamps from probes in more than one drive can be transferred simultaneously in a single telegram.
- The time in the controller and drive unit is synchronized via the CU_STW and the CU_ZSW.
  Note: The controller must support time synchronization!
- A higher-level controller can then use the time stamp to determine the actual position value of more than one drive.
- The system outputs a message if the measuring time determination function in the probe is already in use (see also p0488, p0489, and p0580).

Example: central probe

Assumptions for the example:

- Determination of the time stamp MT1_ZS_S by evaluating the rising edge of probe 1
- Determination of the time stamp MT2_ZS_S and MT2_ZS_F by evaluating the rising and falling edge of probe 2
- Probe 1 on DI/DO 9 of the Control Unit (p0680[0] = 1)
- Probe 2 on DI/DO 10 of the Control Unit (p0680[1] = 2)
- Manufacturer-specific telegram p0922 = 391 is set.

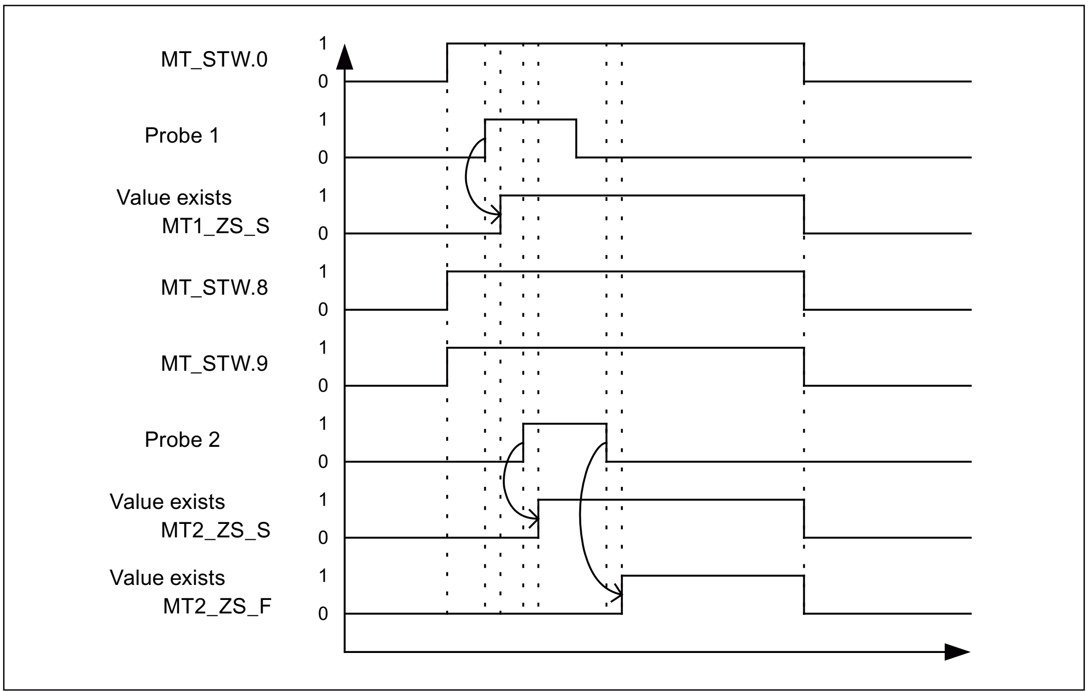


Figure 10-17 Function chart for central probe example

10.1.3.7 Motion Control with PROFIdrive

Description

The "Motion control with PROFIBUS" or "Motion Control with PROFINET" function can be used to implement an isochronous drive link between a master and one or more slaves via the PROFIBUS field bus or an isochronous drive link via PROFINET.

Note

The isochronous drive link is defined in the following documentation:
Reference: /P5/ PROFIdrive Profile Drive Technology

Properties

- No additional parameters need to be entered in addition to the bus configuration in order to activate this function, the master and slave must only be preset for this function (PROFIBUS).
- The master-side default setting is made via the hardware configuration, e.g. B. HW Config with SIMATIC S7. The slave-side default setting is made via the parameterization telegram when the bus is ramping up.
- Fixed sampling times are used for all data communication.
- The Global Control (GC) clock information on PROFIBUS is transmitted before the beginning of each cycle.
- The length of the clock cycle depends on the bus configuration. When the clock cycle is selected, the bus configuration tool (e.g. HW Config) supports:
  - High number of drives per slave/drive unit -> long cycle
  - High number of slaves/drive units -> long cycle
- A sign-of-life counter is used to monitor user data transfer and clock pulse failures.

Overview of closed-loop control

- Sensing of the actual position value on the slave can be performed using:
  - Indirect measuring system (motor encoder)
  - Additional direct measuring system
- The encoder interface must be configured in the process data.
- The control loop is closed via the PROFIBUS.
- The position controller is located on the master.
- The current and speed control systems and actual value sensing (encoder interface) are located on the slave.
- The position controller clock cycle is transmitted across the field bus to the slaves.
- The slaves synchronize their speed and/or current controller cycle with the position controller cycle on the master.
- The speed setpoint is specified by the master.

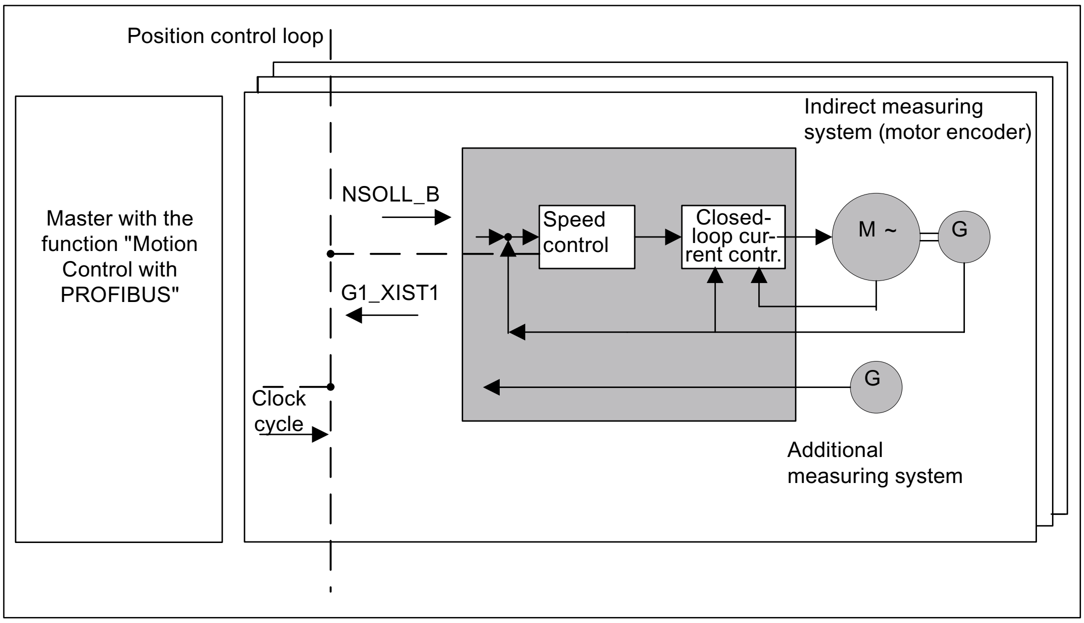


Figure 10-18 Overview of "Motion control with PROFIBUS" (example: master and 3 slaves)

Structure of the data cycle

The data cycle comprises the following elements:

1. Global Control telegram (PROFIBUS only)
2. Cyclic part
   - Setpoints and actual values
3. Acyclic part
   - Parameters and diagnostic data
4. Reserve (PROFIBUS only)
   - Transmission of token (TTH).
   - For searching for a new node in the drive line-up (GAP)
   - Waiting time until next cycle

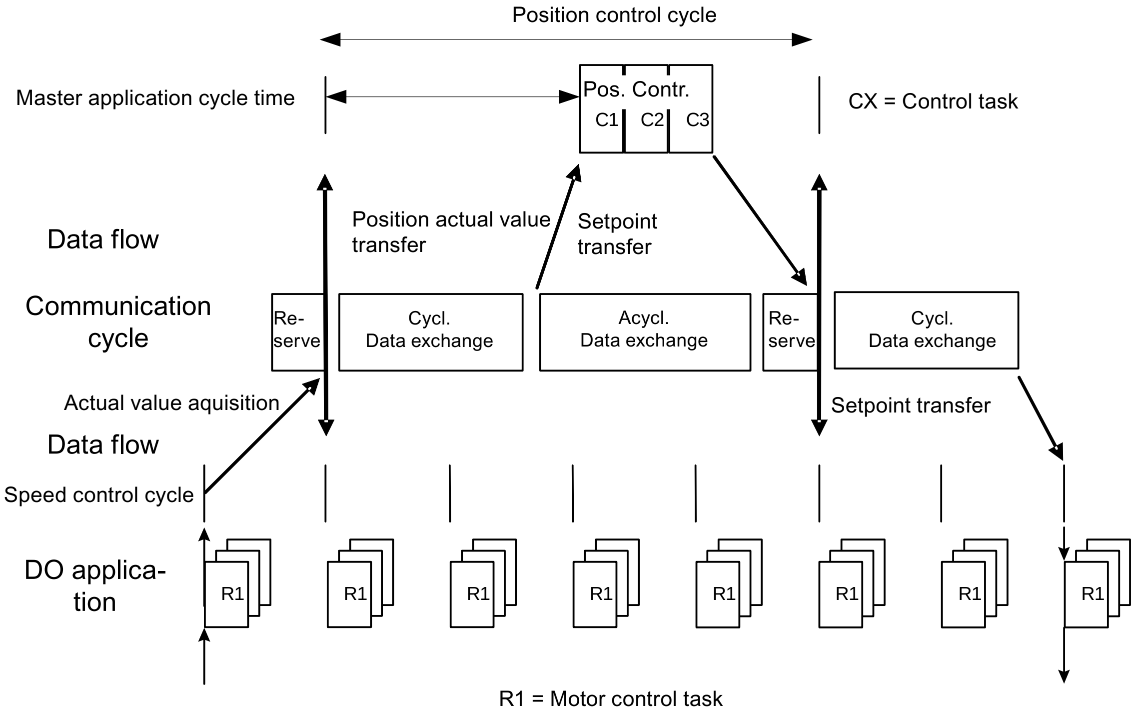


Figure 10-19 Isochronous drive link/Motion Control with PROFIdrive

10.1.4 Acyclic communication

10.1.4.1 General information about acyclic communication

Description

With acyclic communication, as opposed to cyclic communication, data transfer takes place only when an explicit request is made (e.g. in order to read and write parameters).

The read data set/write data set services are available for acyclic communication.

The following options are available for reading and writing parameters:

- S7 protocol

  This protocol uses the STARTER commissioning tool, for example, in online mode via PROFIBUS.
- PROFIdrive parameter channel with the following data sets:
  - PROFIBUS: Data set 47 (0x002F)

    The DPV1 services are available for master class 1 and class 2.
  - PROFINET: Data set 47 and 0xB02F al global access, data set 0xB02E as local access

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Note

Please refer to the following documentation for a detailed description of acyclic communication:
Reference: /P5/ PROFIdrive Profile Drive Technology

Addressing:

PROFIBUS DP, the addressing can either take the form of the logical address or the diagnostics address.

PROFINET IO, addressing is only undertaken using a diagnostics address which is assigned to a module as of socket 1. Parameters cannot be accessed via socket 0.

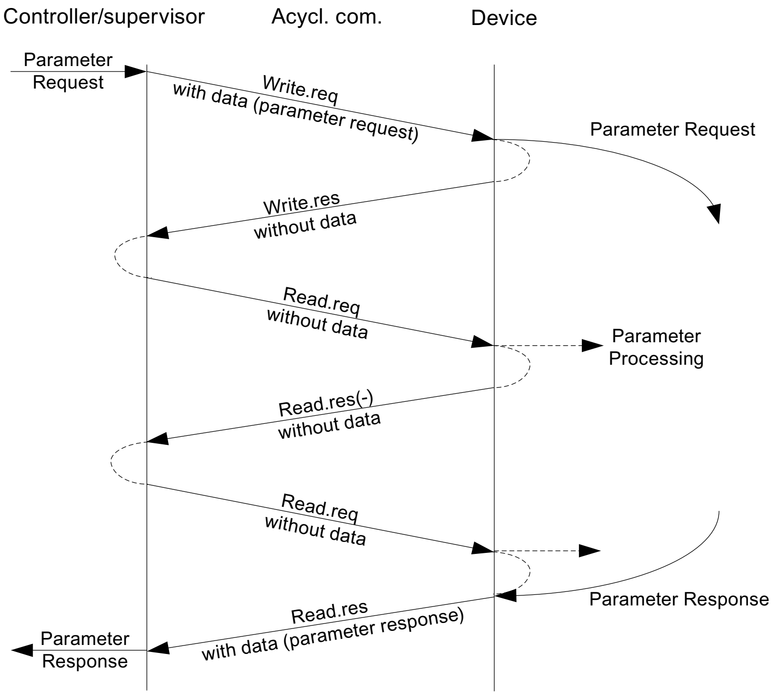

Figure 10-20 Reading and writing data

Characteristics of the parameter channel

- One 16-bit address each for parameter number and subindex.
- Concurrent access by several PROFIBUS masters (master class 2) or PROFINET IO-Supervisor (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.

10.1.4.2 Structure of orders and responses

Structure of parameter request and parameter response

	Parameter request			Offset
Values for write access only	Request header	Request reference	Request ID	0
		Axis	No. of parameters	2
	1. parameter address	Attribute	No. of elements	4
		Parameter number		6
		Subindex		8
	...			
	nth parameter address	Attribute	No. of elements	
		Parameter number		
		Subindex		
	1. parameter value(s)	Format	No. of values	
		Values		
		...		
	...			
	nth parameter value(s)	Format	No. of values	
		Values		
		...		

	Parameter response			Offset
Values for read access only Error values for negative response only	Response header	Request reference mirrored	Response ID	0
		Axis mirrored	No. of parameters	2
	1. parameter value(s)	Format	No. of values	4
		Values or error values		6
		...		
	...			
	nth parameter value(s)	Format	No. of values	
		Values or error values		
		...		

Description of fields in DPV1 parameter request and response

Field	Data type	Values	Comment
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 0x02	Read request Write request

Field	Data type	Values	Comment
	Specifies the type of request. 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, p0977).		
Response ID	Unsigned8	0x01 0x02 0x81 0x82	Read request (+) Write request (+) Read request (-) Write request (-)
	Mirrors the request identifier and specifies whether request execution was positive or negative. Negative means: Cannot execute part or all of request. The error values are transferred instead of the values for each subresponse.		
Drive object number	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 Limited by DPV1 telegram length
	Defines the number of adjoining areas for the parameter address and/or parameter value for multi-parameter requests. The number of parameters = 1 for single requests.		
Attribute	Unsigned8	0x10 0x20 0x30	Value Description Text (not implemented)
	Type of parameter element accessed.		
No. of elements	Unsigned8	0x00 0x01 ... 0x75	Special function No. 1 ... 117 Limited by DPV1 telegram length
	Number of array elements accessed.		
Parameter number	Unsigned16	0x0001 ... 0xFFFF	No. 1 ... 65535
	Addresses the parameter accessed.		
Subindex	Unsigned16	0x0000 ... 0xFFFF	No. 0 ... 65535
	Addresses the first array element of the parameter to be accessed.		
Format	Unsigned8	0x02 0x03 0x04 0x05 0x06 0x07 0x08 Other values 0x40 0x41 0x42 0x43 0x44	Data type integer8 Data type integer16 Data type integer32 Data type unsigned8 Data type unsigned16 Data type unsigned32 Data type floating point See PROFIdrive profile V3.1 Zero (without values as a positive subresponse to a write request) Byte Word Double word Error

Field	Data type	Values	Comment
	The format and number specify the adjoining space containing values in the telegram. 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 Limited by DPV1 telegram length
	Specifies the number of subsequent values.		
Error values	Unsigned16	0x0000 ... 0x00FF	Meaning of error value --> see table 4-29
	The error values in the event of a negative response. 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.		
Values	Unsigned16	0x0000 ... 0x00FF	
	The values of the parameter for read or write access. 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.		

Error values in DPV1 parameter responses

Table 10-27 Error values in DPV1 parameter responses

Error value	Meaning	Comment	Additional 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 value limits.	Subindex
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

Error value	Meaning	Comment	Additional info
0x15	Response too long	The length of the present response exceeds the maximum transfer length.	–
0x16	Illegal parameter address	Impermissible 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	You have attempted to access a drive object that does not exist.	–
0x65	Presently deactivated.	You have tried to access a parameter that, although available, is currently inactive (e.g. n control set and access to parameter from V/f control).	–
0x6B	Parameter %s [%s]: no write access for the enabled controller	–	–
0x6C	Parameter %s [%s]: unit unknown	–	–
0x6D	Parameter %s [%s]: Write access only in the commissioning state, encoder (p0010 = 4).	–	–
0x6E	Parameter %s [%s]: Write access only in the commissioning state, motor (p0010 = 3).	–	–
0x6F	Parameter %s [%s]: Write access only in the commissioning state, power unit (p0010 = 2).	–	–
0x70	Parameter %s [%s]: Write access only in the quick commissioning mode (p0010 = 1).	–	–
0x71	Parameter %s [%s]: Write access only in the ready mode (p0010 = 0).	–	–
0x72	Parameter %s [%s]: Write access only in the commissioning state, parameter reset (p0010 = 30).	–	–
0x73	Parameter %s [%s]: Write access only in the commissioning state, Safety (p0010 = 95).	–	–
0x74	Parameter %s [%s]: Write access only in the commissioning state, tech. application/units (p0010 = 5).	–	–
0x75	Parameter %s [%s]: Write access only in the commissioning state (p0010 not equal to 0).	–	–
0x76	Parameter %s [%s]: Write access only in the commissioning state, download (p0010 = 29).	–	–
0x77	Parameter %s [%s] may not be written in download.	–	–

Error value	Meaning	Comment	Additional info
0x78	Parameter %s [%s]: Write access only in the commissioning state, drive configuration (device: p0009 = 3).	–	–
0x79	Parameter %s [%s]: Write access only in the commissioning state, define drive type (device: p0009 = 2).	–	–
0x7A	Parameter %s [%s]: Write access only in the commissioning state, data set basis configuration (device: p0009 = 4).	–	–
0x7B	Parameter %s [%s]: Write access only in the commissioning state, device configuration (device: p0009 = 1).	–	–
0x7C	Parameter %s [%s]: Write access only in the commissioning state, device download (device: p0009 = 29).	–	–
0x7D	Parameter %s [%s]: Write access only in the commissioning state, device parameter reset (device: p0009 = 30).	–	–
0x7E	Parameter %s [%s]: Write access only in the commissioning state, device ready (device: p0009 = 0).	–	–
0x7F	Parameter %s [%s]: Write access only in the commissioning state, device (device: p0009 not 0).	–	–
0x81	Parameter %s [%s] may not be written in download.	–	–
0x82	Transfer of the control authority (master) is inhibited by BI: p0806.	–	–
0x83	Parameter %s [%s]: requested BICO interconnection not possible	BICO output does not supply float values. The BICO input, however, requires a float value.	–
0x84	Parameter %s [%s]: parameter change inhibited (refer to p0300, p0400, p0922)	–	–
0x85	Parameter %s [%s]: access method not defined.	–	–
0xC8	Below the valid values.	Modification request for a value that, although within "absolute" limits, is below the currently valid lower limit.	–
0xC9	Above the valid values.	Modification request for a value that, although within "absolute" limits, is below the currently valid lower limit (e.g. governed by the current converter rating).	–
0xCC	Write access not permitted.	Write access is not permitted because an access key is not available.	–

10.1.4.3 Determining the drive object numbers

Further information about the drive system (e.g. drive object numbers) can be determined as follows using parameters p0101, r0102, and p0107/r0107:

1. The value of parameter r0102 ("Number of drive objects") for drive object/axis 1 is read via a read request.

   Drive object 1 is the Control Unit (CU), which is a minimum requirement for each drive system.

2. Depending on the result of the initial read request, further read requests for drive object 1 are used to read the indices for parameter p0101 ("Drive object numbers"), as specified by parameter r0102.

   Example:
   If the number of drive objects is "5", the values for indices 0 to 4 for parameter p0101 are read. Of course, the relevant indexes can also be read at once.

   Note

   The first two points provide you with the following information:

   - How many drive objects exist in the drive system?
   - The numbers of the existing drive objects

   ---

3. Following this, parameter r0107/p0107 ("Drive object type") is read for each drive object/axis (indicated by the drive object number).

   Depending on the drive object, parameter 107 can be either an adjustable or visualization parameter.

   The value in parameter r0107/p0107 indicates the drive object type. The coding for the drive object type is specified in the parameter list.

4. From here, refer to the parameter list for each drive object.

10.1.4.4 Example 1: read parameters

Prerequisites

1. The PROFIdrive controller has been commissioned and is fully operational.
2. PROFIdrive communication between the controller and the device is operational.
3. The controller can read and write data sets in conformance with PROFIdrive DPV1.

Task description

Following the occurrence of at least one fault (ZSW1.3 = "1") on drive 2 (also drive object number 2), the active fault codes must be read from the fault buffer r0945[0] ... r0945[7].

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

Basic procedure

1. Create a request to read the parameters.

2. Invoke the request.
3. Evaluate the response.

Activity

1. Create the request.

Parameter request			Offset
Request header	Request reference = 25 hex	Request ID = 01 hex	0 + 1
	Axis = 02 hex	No. of parameters = 01 hex	2 + 3
parameter address	Attribute = 10 hex	No. of elements = 08 hex	4 + 5
	Parameter no. = 945 dec		6
	Subindex = 0 dec		8

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:

  01 hex —> This identifier is required for a read request.
- Axis:

  02 hex —> Drive 2, fault buffer with drive- and device-specific faults
- No. of parameters:

  01 hex —> One parameter is read.
- Attribute:

  10 hex —> The parameter values are read.
- No. of elements:

  08 hex —> The current fault incident with 8 faults is to be read.
- Parameter number:

  945 dec —> p0945 (fault code) is read.
- Subindex:

  0 dec —> Read access starts at index 0.

2. Invoke the parameter request.

If STW1.3 = "1" —> Invoke parameter request

3. Evaluate the parameter response.

Parameter response			Offset
Response header	Request reference mirrored = 25 hex	Response ID = 01 hex	0 + 1
	Axis mirrored = 02 hex	No. of parameters = 01 hex	2 + 3

Parameter response			Offset
Parameter value	Format = 06 hex	No. of values = 08 hex	4 + 5
	1. value = 1355 dec		6
	2. value = 0 dec		8
	...		...
	8. value = 0 dec		20

Information about the parameter response:

- Request reference mirrored:
  This response belongs to the request with request reference 25.
- Response ID:
  01 hex —> Read request positive, values stored as of 1st value
- Axis mirrored, no. of parameters:
  The values correspond to the values from the request.
- Format:
  06 hex —> Parameter values are in Unsigned16 format.
- No. of values:
  08 hex —> 8 parameter values are available.
- 1. value ... 8th value
  A fault is only entered in value 1 of the fault buffer for drive 2.

10.1.4.5 Example 2: write parameters (multi-parameter request)

Prerequisites

1. The PROFIdrive controller has been commissioned and is fully operational.
2. PROFIdrive communication between the controller and the device is operational.
3. The controller can read and write data sets in conformance with PROFIdrive DPV1.
   Special requirements for this example:
4. Control type: Vector, servo with activated "Extended setpoint channel" Function Module

Task description

Jog 1 and 2 are to be set up for drive 2 (also drive object number 2) via the input terminals of the Control Unit. A parameter request is to be used to write the corresponding parameters as follows:

- BI: p1055 = r0722.4 — Jog bit 0
- BI: p1056 = r0722.5 — Jog bit 1
- p1058 = 300 1/min — Jog 1 speed setpoint
- p1059 = 600 1/min — Jog 2 speed setpoint

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

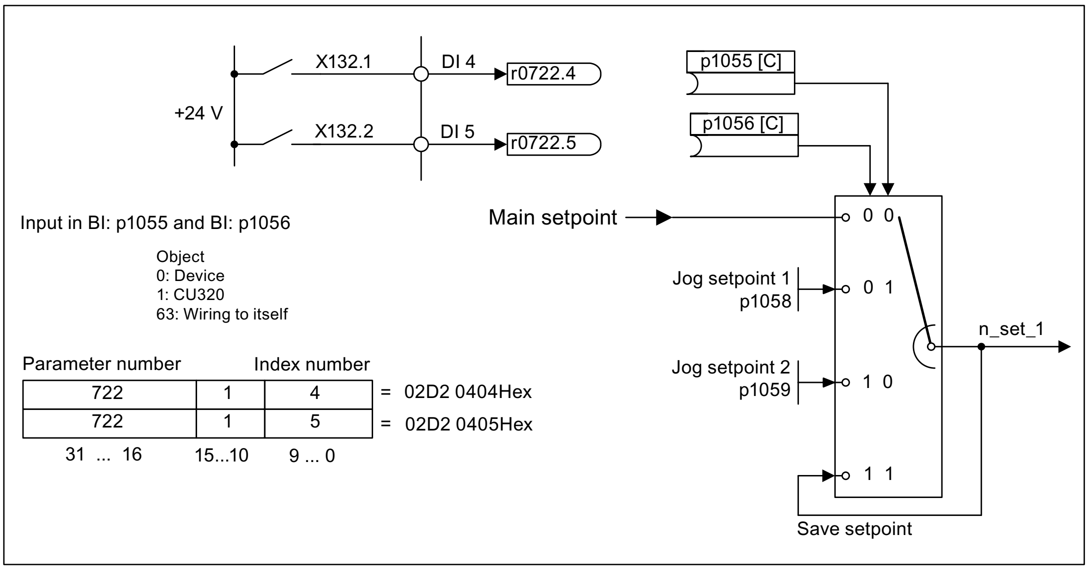

Figure 10-21 Task description for multi-parameter request (example)

Basic procedure

1. Create a request to write the parameters.
2. Invoke the request.
3. Evaluate the response.

Version

1. Create the request.

Parameter request			Offset
Request header	Request reference = 40 hex	Request ID = 02 hex	0 + 1
	Axis = 02 hex	No. of parameters = 04 hex	2 + 3
1. parameter address	Attribute = 10 hex	No. of elements = 01 hex	4 + 5
	Parameter no. = 1055 dec		6
	Subindex = 0 dec		8
2. parameter address	Attribute = 10 hex	No. of elements = 01 hex	10 + 11
	Parameter no. = 1056 dec		12
	Subindex = 0 dec		14
3. parameter address	Attribute = 10 hex	No. of elements = 01 hex	16 + 17
	Parameter no. = 1058 dec		18
	Subindex = 0 dec		20
4. parameter address	Attribute = 10 hex	No. of elements = 01 hex	22 + 23
	Parameter no. = 1059 dec		24

Parameter request			Offset
	Subindex = 0 dec		26
4. parameter address	Attribute = 10 hex	No. of elements = 01 hex	22 + 23
	Parameter no. = 1059 dec		24
	Subindex = 0 dec		26
4. parameter address	Attribute = 10 hex	No. of elements = 01 hex	22 + 23
	Parameter no. = 1059 dec		24
	Subindex = 0 dec		26
1. parameter value(s)	Format = 07 hex	No. of values = 01 hex	28 + 29
	Value = 02D2 hex		30
	Value = 0404 hex		32
2. parameter value(s)	Format = 07 hex	No. of values = 01 hex	34 + 35
	Value = 02D2 hex		36
	Value = 0405 hex		38
3. parameter value(s)	Format = 08 hex	No. of values = 01 hex	40 + 41
	Value = 4396 hex		42
	Value = 0000 hex		44
4. parameter value(s)	Format = 08 hex	No. of values = 01 hex	46 + 47
	Value = 4416 hex		48
	Value = 0000 hex		50

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:

  02 hex —> This identifier is required for a write request.

- Axis:

  02 hex —> The parameters are written to drive 2.

- No. of parameters

  04 hex —> The multi-parameter request comprises 4 individual parameter requests.

1. parameter address ... 4th parameter address

- Attribute:

  10 hex —> The parameter values are to be written.

- No. of elements

  01 hex —> 1 array element is written.

- Parameter number

  Specifies the number of the parameter to be written (p1055, p1056, p1058, p1059).

- Subindex:

  0 dec —> ID for the first array element.

1. parameter value ... 4th parameter value

- Format:

  07 hex —> Data type Unsigned32

  08 hex —> Data type FloatingPoint
- No. of values:

  01 hex —> A value is written to each parameter in the specified format.
- Value:

  BICO input parameter: enter signal source.

  Adjustable parameter: enter value

2. Invoke the parameter request.
3. Evaluate the parameter response.

Parameter response			Offset
Response header	Request reference mirrored = 40 hex	Response ID = 02 hex	0
	Axis mirrored = 02 hex	No. of parameters = 04 hex	2

Information about the parameter response:

- Request reference mirrored:

  This response belongs to the request with request reference 40.
- Response ID:

  02 hex —> Write request positive
- Axis mirrored:

  02 hex —> The value matches the value from the request.
- No. of parameters:

  04 hex —> The value matches the value from the request.

10.2 Communication via PROFIBUS DP

10.2.1 General information about PROFIBUS

10.2.1.1 General information about PROFIBUS for SINAMICS

General information

PROFIBUS is an open international field bus standard for a wide range of production and process automation applications.

The following standards ensure open, multi-vendor systems:

- International standard EN 50170
- International standard IEC 61158

PROFIBUS is optimized for high-speed, time-critical data communication at field level.

Note

PROFIBUS for drive technology is standardized and described in the following document:
Reference: /P5/ PROFIdrive Profile Drive Technology

CAUTION

Before synchronizing to the isochronous PROFIBUS, all of the pulses of the drive objects must be inhibited - also for those drives that are not controlled via PROFIBUS.

The cyclic PZD channel is deactivated when the CBE20 is plugged in!

⚠ CAUTION

No CAN cables must be connected to interface X126. If CAN cables are connected, the CU320 and other CAN bus nodes may be destroyed.

Master and slave

- Master and slave properties

Table 10-28 Master and slave properties

Features	Master	Slave
As bus node	Active	Passive
Send messages	Permitted without external request	Only possible on request by master
Receive messages	Possible with no restrictions	Only receive and acknowledge permitted

- Master

  Masters are categorized into the following classes:

  – Master class 1 (DPMC1):

    Central automation stations that exchange data with the slaves in cyclic and acyclic mode. Communication between the masters is also possible.

    Examples: SIMATIC S7, SIMOTION

  – Master class 2 (DPMC2):

    Devices for configuration, commissioning, operator control and monitoring during bus operation. Devices that only exchange data with the slaves in acyclic mode.

    Examples: Programming devices, human machine interfaces

- Slaves

  With respect to PROFIBUS, the SINAMICS drive unit is a slave.

Bus access method

PROFIBUS uses the token passing method, i.e. the active stations (masters) are arranged in a logical ring in which the authorization to send is received within a defined time frame.

Within this time frame, the master with authorization to send can communicate with other masters or handle communication with the assigned slaves in a master/slave procedure.

PROFIBUS telegram for cyclic data transmission and acyclic services

Each drive unit that supports cyclic process data exchange uses a telegram to send and receive all the process data. A separate telegram is sent in order to perform all the acyclic services (read/write parameters) under a single PROFIBUS address. The acyclic data is transmitted with a lower priority after cyclic data transmission.

The overall length of the telegram increases with the number of drive objects that are involved in exchanging process data.

Sequence of drive objects in the telegram

On the drive side, the sequence of drive objects in the telegram is displayed via a list in p0978[0...15] where it can also be changed.

You can use the STARTER commissioning tool to display the sequence of drive objects for a commissioned drive system in online mode by choosing —> "Drive unit" —> "Configuration".

When you create the configuration on the master side (e.g. HW Config), the process-data-capable drive objects for the application are added to the telegram in this sequence.

The following drive objects can exchange process data:

Drive object

- Active Infeed (A_INF)
- Basic Infeed (B_INF)
- Smart Infeed (S_INF)
- SERVO

- VECTOR
- Terminal Module 15 (TM15DI/DO)
- Terminal Module 31 (TM31)
- Terminal Module 41 (TM41)
- Terminal Board 30 (TB30)
- Control Unit (CU_S)

Note

The sequence of drive objects in the configuration must be the same as that in the drive system.

The structure of the telegram depends on the drive objects taken into account during configuration. Configurations that do not take into account all of the drive objects in the drive system are permitted.

Example:

The following configurations, for example, are possible:

- Configuration with SERVO, SERVO, SERVO
- Configuration with A_INF, SERVO, SERVO, SERVO, TB30
- and others

10.2.1.2 Example: telegram structure for cyclic data transmission

Task

The drive system comprises the following drive objects:

- Control Unit (CU_S)
- Active Infeed (A_INF)
- SERVO 1 (comprises a Single Motor Module and other components)
- SERVO 2 (comprises a Double Motor Module terminal X1 and other components)
- SERVO 3 (comprises a Double Motor Module terminal X2 and other components)
- Terminal Board 30 (TB30)

The process data is to be exchanged between the drive objects and the higher-level automation system.

- Telegrams to be used:
  - Telegram 370 for Active Infeed
  - Standard telegram 6 for servo
  - User defined for Terminal Board 30

Component and telegram structure

The predefined component structure results in the telegram structure shown in the following diagram.

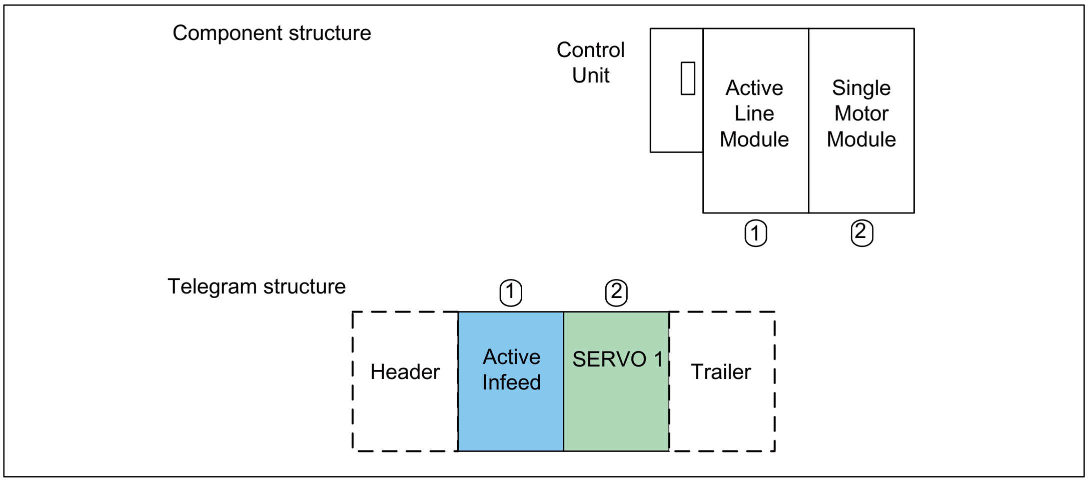

Figure 10-22 Component and telegram structure

You can check and change the sequence of the telegrams via p0978[0...15].

Configuration settings (e.g. HW Config for SIMATIC S7)

The components are mapped to objects for configuration.

Due to the telegram structure shown, the objects in the "DP slave properties" overview must be configured as follows:

- Active Infeed (A_INF): Telegram 370
- SERVO 1: Standard telegram 6
- SERVO 2: Standard telegram 6
- SERVO 3: Standard telegram 6
- Terminal Board 30 (TB30): User defined

DP slave properties – overview

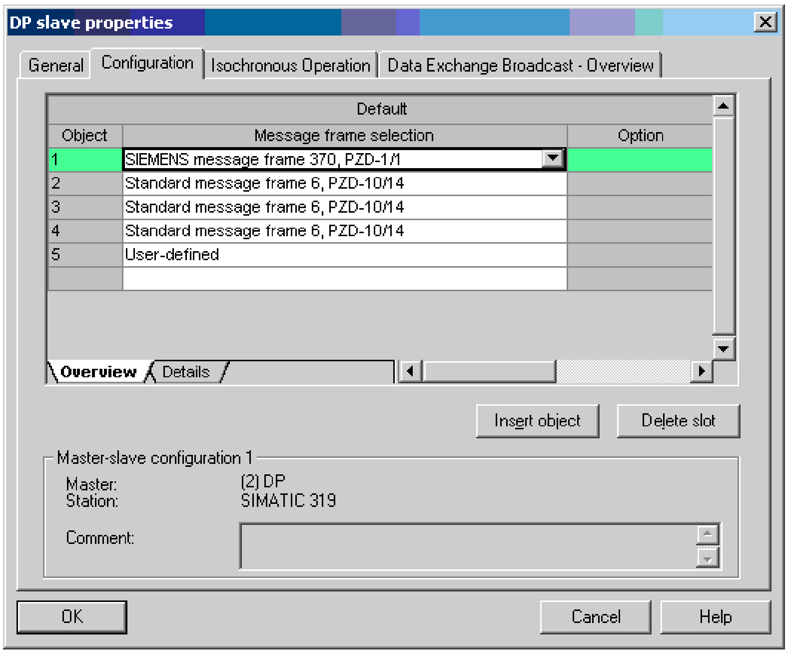

Figure 10-23 Slave properties – overview

When you click "Details", the properties of the configured telegram structure are displayed (e.g. I/O addresses, axis separator).

DP slave properties – details

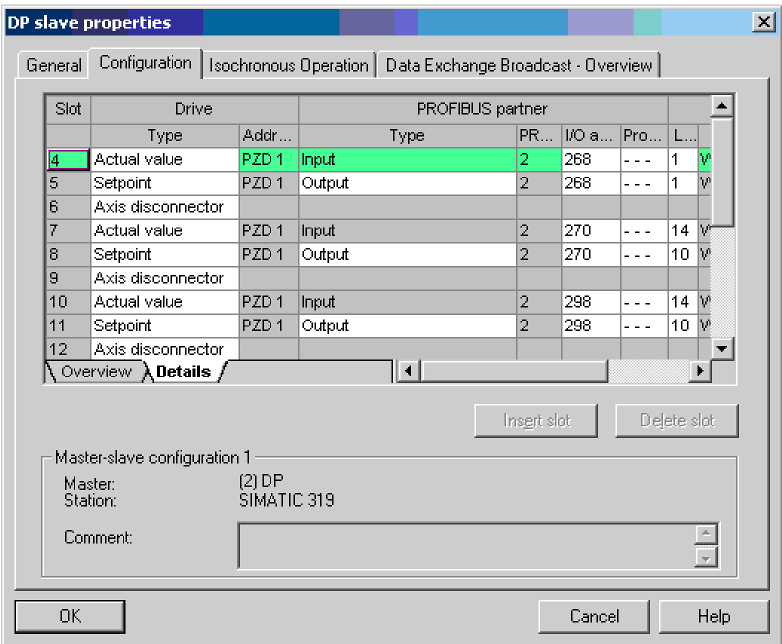

Figure 10-24 Slave properties – details

The axis separator separates the objects in the telegram as follows:

- Slot 4 and 5: Object 1 —> Active Infeed (A_INF)
- Slot 7 and 8: Object 2 —> SERVO 1
- Slot 10 and 11: Object 3 —> SERVO 2

etc.

10.2.2 Commissioning PROFIBUS

10.2.2.1 General information about commissioning

Interfaces and diagnostic LED

A PROFIBUS interface with LEDs and address switches is available as standard on the Control Unit.

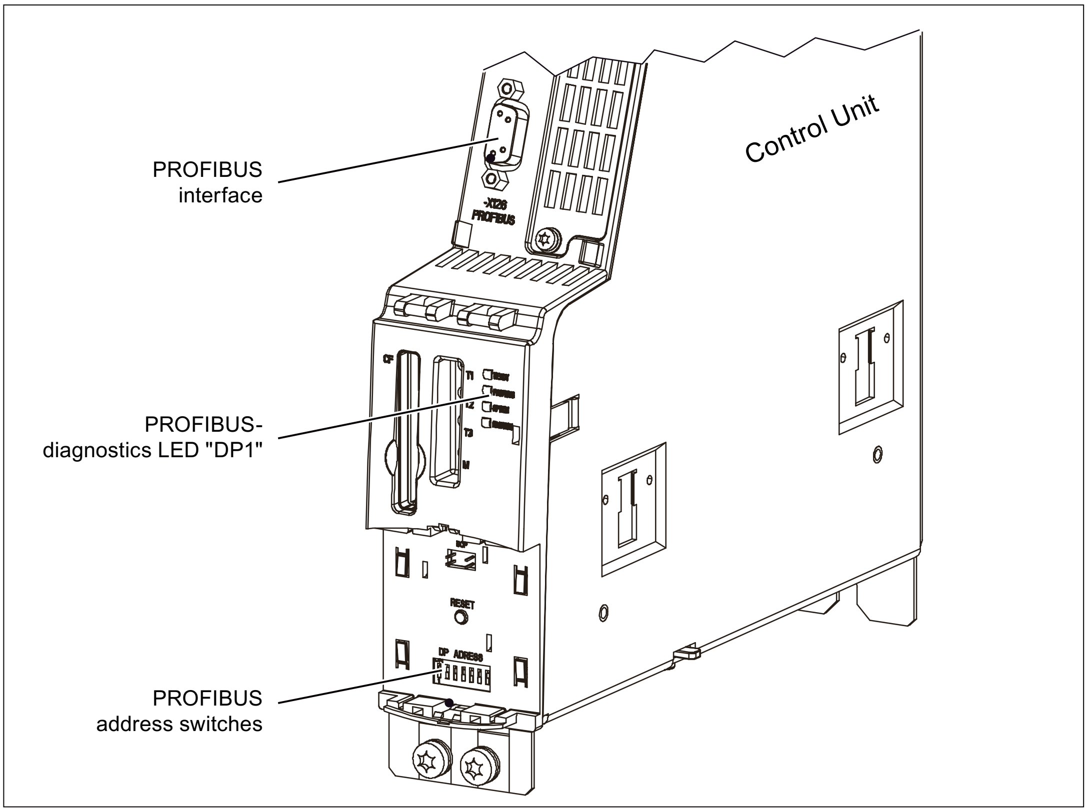

Figure 10-25 Interfaces and diagnostic LED

- PROFIBUS interface

  The PROFIBUS interface is described in the following documentation:

References: /GH1/ SINAMICS S120 Equipment Manual for Control Units and Additional System Components

- PROFIBUS diagnostic LED

Note

A teleservice adapter can be connected to the PROFIBUS interface (X126) for remote diagnosis purposes.

Setting the PROFIBUS address

Two methods are available for setting the PROFIBUS address:

1. Via the PROFIBUS address switches on the Control Unit
   – In this case, p0918 is read-only and simply displays the set address.
   – A change is not effective until POWER ON.
2. Via p0918
   – You can only use this method when all the PROFIBUS address switches from S1 to S7 are set to ON or OFF.
   – Address changes made via parameters must be saved in a non-volatile memory using the "Copy from RAM to ROM" function.
   – A change is not effective until POWER ON.

Example:

Setting the PROFIBUS address using the PROFIBUS address switches on the Control Unit.

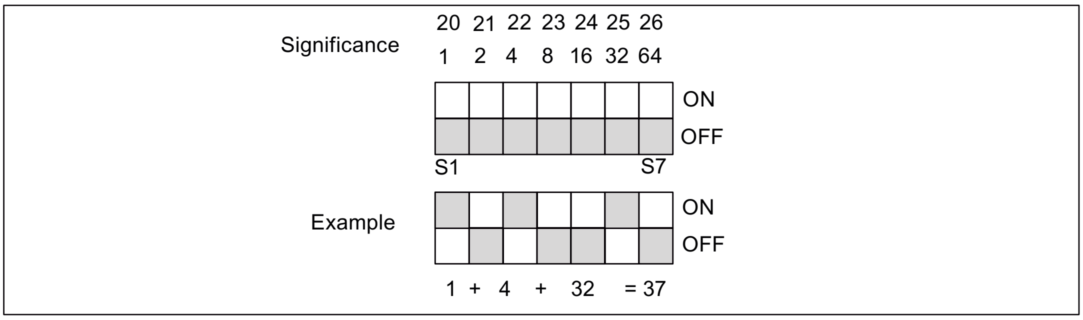

Figure 10-26 Example: PROFIBUS address via PROFIBUS address switch on Control Unit

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Note

The factory settings are "ON" or "OFF" for all switches. With these two settings, the PROFIBUS address is set by parameterization.

Parameter p0918 is unique to the Control Unit (see Control Unit). The factory setting is 126.

Address 126 is used for commissioning. Permitted PROFIBUS addresses are 1 ... 126.

If more than one CU is connected to one PROFIBUS line, the address settings must differ from the factory settings. Note that each address can only be assigned once on a PROFIBUS line. This can be achieved using the address switch or by setting parameter p0918 accordingly. The setting can be made by connecting the 24 V supply step by step and resetting p0918, for example.

The address setting on the switch is displayed in r2057.

Each change made to the bus address is not effective until POWER ON.

Device master file

A device master file provides a full and clear description of the features of a PROFIBUS slave.

The GSD files can be found at the following locations:

- On the Internet: http://www4.ad.siemens.de/WW/view/de/113204
- On the CD for the STARTER commissioning tool

  Order no. 6SL3072-0AA00-0AGx
- On the CompactFlash card in directory

  \\SIEMENS\SINAMICS\DATA\CFG\

Commissioning for VIK–NAMUR

To be able to operate a SINAMICS drive as a VIK-NAMUR drive, standard telegram 20 must be set and the VIK-NAMUR identification number activated via p2042 =1. In this case, only the NAMUR GSD can be used.

Device identification

An identification parameter for individual slaves facilitates diagnosis and provides an overview of the nodes on the PROFIBUS.

The information for each slave is stored in the following CU-specific parameter: r0964[0...6] device identification

Bus terminating resistor and shielding

Reliable data transmission via PROFIBUS depends, amongst other things, on the setting for the bus terminating resistors and the shielding for the PROFIBUS cables.

- Bus terminating resistor

The bus terminating resistors in the PROFIBUS plugs must be set as follows:

  – First and last nodes in the line switch on terminating resistor
  – Other nodes in the line: switch out terminating resistor

- Shielding for the PROFIBUS cables

  The cable shield in the plug must be connected at both ends with the greatest possible surface area.

  References: /GH1/ SINAMICS S120 Equipment Manual for Control Units and Additional System Components

10.2.2.2 Commissioning procedure

Preconditions and assumptions for commissioning

PROFIBUS slave

- The PROFIBUS address to be set for the application is known.
- The telegram type for each drive object is known by the application.

PROFIBUS master

- The communication properties of the SINAMICS S120 slave must be available in the master (GSD file or drive ES slave OM).

Commissioning steps (example with SIMATIC S7)

1. Set the PROFIBUS address on the slave.
2. Set the telegram type on the slave.
3. Carry out the following in HW Config:
   – Connect the drive to PROFIBUS and assign an address.
   – Set the telegram type.

     The same telegram type as on the slave should be set for every drive object exchanging process data via PROFIBUS.

     The master can send more process data than the slave uses. A telegram with a larger PZD number than is assigned for the drive object STARTER can be configured on the master. The PZDs not supplied by the drive object are filled with zeros.

     The setting "without PZD" can be defined on a node or object (e.g. infeed controlled via terminals).
4. The I/O addresses must be assigned in accordance with the user program.

10.2.2.3 Diagnosis options

The standard slave diagnostics can be read online in the HW Config.

10.2.2.4 SIMATIC HMI addressing

You can use a SIMATIC HMI as a PROFIBUS master (master class 2) to access SINAMICS directly. With respect to SIMATIC HMI, SINAMICS behaves like a SIMATIC S7. For accessing drive parameters, the following simple rule applies:

- Parameter number = data block number
- Parameter sub-index = bit 0 - 9 of data block offset
- Drive object number = bit 10 - 15 of data block offset

Pro Tool and WinCC flexible

The SIMATIC HMI can be configured flexibly with "Pro Tool" or "WinCC flexible".

The following specific settings for drives must be observed when configuration is carried out with Pro Tool or WinCC flexible.

Controllers: Protocol always "SIMATIC S7 – 300/400"

Table 10-29 Other parameters

Field	Value
Network parameter profile	DP
Network parameter baud rate	Any
Communication partner address	PROFIBUS address of the drive unit
Communication partner slot/subrack	don’t care, 0

Table 10-30 Tags: "General" tab

Field	Value
Name	Any
Control	Any
Type	Depending on the addressed parameter value, e.g.: INT: for integer 16 DINT: for integer 32 WORD: for unsigned 16 REAL: for float
Area	DB
DB (data block number)	Parameter number 1 ... 65535
DBB, DBW, DBD (data block offset)	Drive object no. and subindex Bit 15 – 10: Drive object no. 0 ... 63 Bit 9 – 0: Sub-index 0 ... 1023 In other words: DBW = 1024 * drive object no. + sub-index
Length	Not activated
Acquisition cycle	Any

Field	Value
No. of elements	1
Decimal places	Any

Note

- You can operate a SIMATIC HMI together with a drive unit independently of an existing control.
  A basic "point-to-point" connection can only be established between two nodes (devices).
- The "variable" HMI functions can be used for drive units. Other functions cannot be used (e.g. "messages" or "recipes").
- Individual parameter values can be accessed. Entire arrays, descriptions, or texts cannot be accessed.

10.2.2.5 Monitoring: telegram failure

Description

After a telegram failure and a monitoring time has elapsed (t_An), bit r2043.0 is set to "1" and alarm A01920 is output. Binector output r2043.0 can be used for an emergency stop, for example.

After a delay time has elapsed (p2044), fault F01910 is output. Fault F01910 triggers fault response OFF2 (pulse inhibit) for the supply and fault response OFF3 (emergency stop) for SERVO/VECTOR. If no OFF response is to be triggered, the fault response can be reparameterized accordingly.

Fault F01910 can be acknowledged immediately. The drive can then be operated even without PROFIBUS.

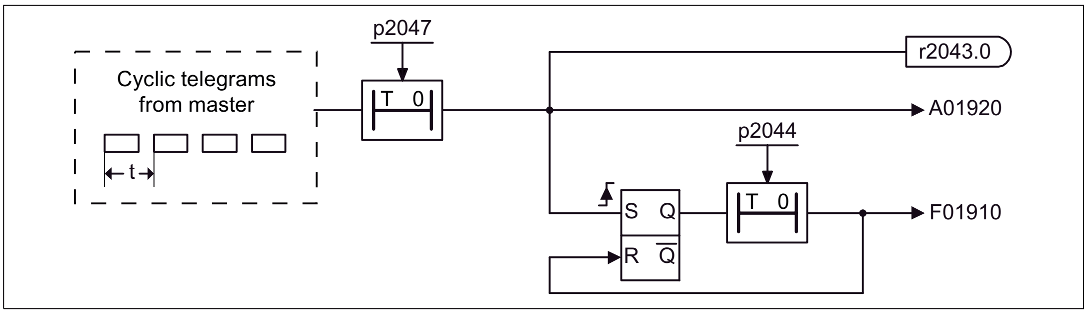

Figure 10-27 Monitoring: telegram failure

Example: emergency stop with telegram failure

Assumption:

A drive unit with an Active Line Module and a Single Motor Module.

VECTOR mode is activated.

After the ramp-down time has elapsed (p1135), the drive is at a standstill.

Settings:

- A_INF p2044 = 2
- VECTOR p2044 = 0

Sequence:

After a telegram failure (t > t_An), binector output r2043.0 of drive object CU switches to "1". At the same time, alarm A01920 is output for the A_INF drive objects and alarm A01920 and fault F01910 are output for VECTOR. When F01910 is output, an OFF3 is triggered for the drive. After a delay time (p2044) of two seconds has elapsed, fault F01910 is output on the infeed and triggers OFF2.

10.2.3 Motion Control with PROFIBUS

Motion Control /Isochronous drive link with PROFIBUS

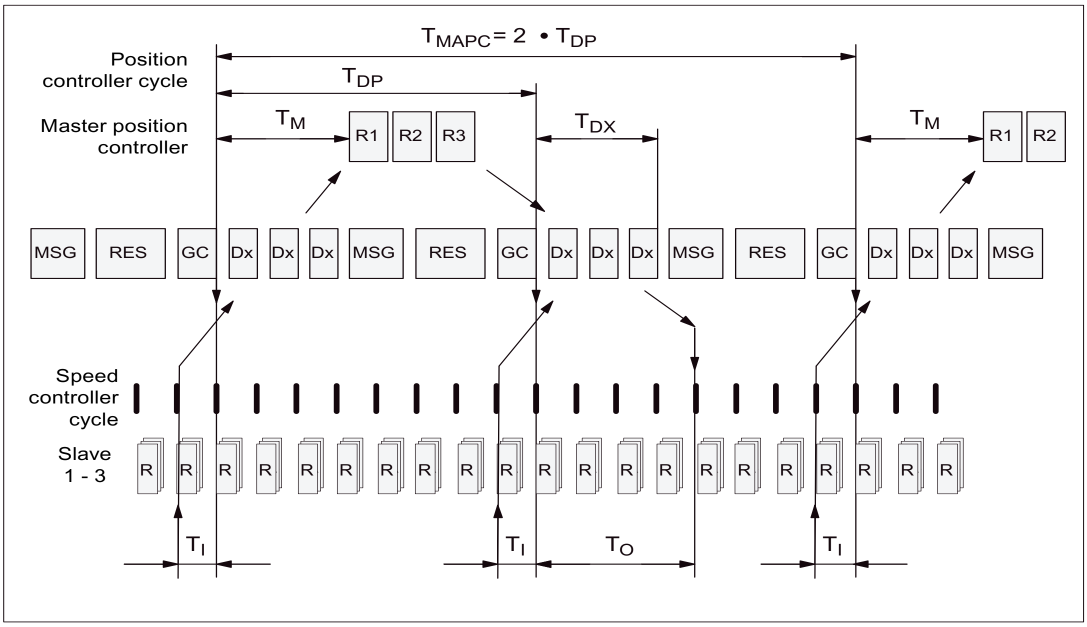

Figure 10-28 Motion Control/Isochronous drive link with PROFIBUS, optimized cycle with $T_{MAPC} = 2 \cdot T_{DP}$

Sequence of data transfer to closed-loop control system

1. Position actual value G1_XIST1 is read into the telegram image at time T_I before the start of each cycle and transferred to the master in the next cycle.
2. Closed-loop control on the master starts at time T_M after each position controller cycle and uses the current actual values read previously from the slaves.
3. In the next cycle, the master transmits the calculated setpoints to the telegram image of the slaves. The speed setpoint command NSOLL_B is issued to the closed-loop control system at time T_O after the beginning of the cycle.

Designations and descriptions for Motion Control

Table 10-31 Time settings and meanings

Name	Value[1)]	Limit value	Description
T_{BASE_DP}	5DC hex ≐ 1500 dec	-	Time basis for T_{DP} calculation: T_{BASE_DP} = 1500 • T_{Bit} = 125 µs T_{Bit} = 1/12 µs at 12 Mbaud T_{BASE_DP} corresponds to the largest current controller cycle (p0115[0]) of a drive object (servo/vector).
T_{DP}	8	$T_{DP} \geq T_{DP\_MIN}$	Cycle time T_{DP} = integer multiple • T_{BASE_DP} calculation: T_{DP} = 8 • T_{BASE_DP} = 1 ms
		T_{DP_MIN} = 8	Min. DP cycle time calculation: T_{DP_MIN} = 8 • T_{BASE_DP} = 1 ms
T_{MAPC}	1	n • T_{DP} n = 1 - 14	Master application cycle time This is the time frame in which the master application generates new setpoints (e.g. in the position controller cycle). Calculation: T_{MAPC} = 1 • T_{DP} = 1 ms
T_{SAPC}			Slave application cycle time
T_{BASE_IO}	5DC hex ≐ 1500 dec	-	Time basis for T_I, T_O calculation: T_{BASE_IO} = 1500 • T_{Bit} = 125 µs T_{Bit} = 1/12 µs at 12 Mbaud T_{BASE_IO} corresponds to the largest current controller cycle (p0115[0]) of a drive object (servo/vector) in the drive unit.
T_I	2	$T_{I\_MIN} \leq T_I < T_{DP}$	Time of actual-value sensing This is the time at which the actual position value is captured before the start of each cycle. T_I = integer multiple of T_{BASE_IO} calculation: T_I = 2 • 125 µs = 250 µs When T_I = 0: T_I = T_{DP}
		T_{I_MIN} = 1	Min. T_I calculation: T_{I_MIN} = 1 • T_{BASE_IO} = 125 µs T_{I_MIN} corresponds to the largest current controller cycle (p0115[0]) of a drive object (servo/vector) in the drive unit.

Name	Value[1)]	Limit value	Description
T_O	4	$T_{DX} + T_{O\_MIN}$ $\leq T_O \leq T_{DP}$	Time of setpoint transfer This is the time at which the transferred setpoints (speed setpoint) are accepted by the closed-loop control system after the start of the cycle. T_O = integer multiple of T_{BASE_IO} Servo calculation: $T_O = 4 \bullet T_{BASE\_IO} = 500$ µs When $T_O = 0$: $T_O \doteq T_{DP}$ Vector calculation: $T_O = 4 \bullet 1000$ µs = 4000 µs When $T_O = 0$: $T_O \doteq T_{DP}$ T_O corresponds to the largest speed controller cycle (p0115[1]) of a drive object (vector) in the drive unit.
		$T_{O\_MIN} = 1$	Servo: Minimum time distance between T_O and T_{DX} $T_{O\_MIN} = 1 \bullet T_{BASE\_IO} = 125$ µs Vector: Minimum time distance between T_O and T_{DX} $T_{O\_MIN} = 1 \bullet T_{n\_reg} = 1000$ µs T_{n_reg} corresponds to the largest speed controller cycle (p0115[1]) of a drive object (vector) in the drive unit.
T_{DX}	E10 hex ≐ 3600 dec	$T_{DX} < T_{DP}$	Data exchange time This is the time required within one cycle for transferring process data to all available slaves. T_{DX} = integer multiple of T_{Bit} T_{Bit} = 1/12 µs at 12 MBaud calculation: $T_{DX} = 3600 \bullet T_{BIT} = 300$ µs
T_{PLL_W}	0	-	PLL window (half the width of the GC synchronization window) The following applies to the setting: • Small window --> minimization of synchronization fluctuations on the drive • Large window --> higher tolerance of GC fluctuations Calculation (assumption: T_{PLL_W} = A hex ≐ 10 dez) $T_{PLL\_W} = 10 \bullet TBIT = 0.833$ µs T_{Bit} = 1/12 µs at 12 Mbps
T_{PLL_D}	0	-	PLL dead time The PLL dead time can be used to compensate for different data transfer times to the slaves (e.g. due to repeaters). The slaves with faster transfer times are delayed by a corresponding PLL dead time. Calculation: $T_{PLL\_D} = 0 \bullet T_{BIT} = 0$ µs T_{Bit} = 1/12 µs at 12 MBaud
GC			Global Control Telegram (Broadcast Telegram)
T_{TH}			Token hold time This time is calculated by the engineering system.
Dx			Data_Exchange This service is used to implement user data exchange between master and slave 1 - n.

Name	Value[1)]	Limit value	Description
MSG			Acyclic service After cyclic transmission, the master checks whether the token hold time has already expired. If not, another acyclic DPV1 service is transmitted.
RES			Reserve: "Active pause" until the isochronous cycle has expired
R			Processing time for speed or position controller
T_M			Master time This is the time from the start of the position controller cycle to the start of master closed-loop control.
GAP			Attempt to open connection with new node. This attempt takes place every xth cycle.
T_J			T_J returns the duration of the cycle jitter. The cycle jitter is the delay of the GC telegram.
1) The values correspond to device master file si0280e5.gs_			

Setting criteria for times

- Cycle (T_{DP})
  - T_{DP} must be set to the same value for all bus nodes.
  - $T_{DP} > T_{DX}$ and $T_{DP} \geqq T_O$

    T_{DP} is thus large enough to enable communication with all bus nodes.

NOTICE
After T_{DP} has been changed on the PROFIBUS master, the drive system must be switched on (POWER ON) or the parameter p0972=1 (Reset drive unit) must be set.

- T_I and T_O
  - Setting the times in T_I and T_O to be as short as possible reduces the dead time in the position control loop.
  - $T_O > T_{DX} + T_{Omin}$
- A tool is available for setting and optimization purposes (e.g. HW Config in SIMATIC S7). The following must be noted:
  - Configuring reserves allows the following:

    Class 2 masters can be connected

    Non-cyclic communication

Minimum times for reserves

Table 10-32 Minimum times for reserves

Data	Time required [µs]
Basic load	300
Per slave	20

Data	Time required [µs]
Per byte of user data	1,5
One additional class 2 master	500

User data integrity

User data integrity is verified in both transfer directions (master <—> slave) by a sign-of-life (4-bit counter).

The sign-of-life counters are incremented from 1 to 15 and then start again at 1.

- Master sign-of-life
  - STW2.12 ... STW2.15 are used for the master sign-of-life.
  - The master sign-of-life counter is incremented in each master application cycle (TMAPC).
  - The number of sign-of-life errors tolerated can be set via p0925.
  - p0925 = 65535 deactivates sign-of-life monitoring on the slave.
  - Monitoring

    The master sign-of-life is monitored on the slave and any sign-of-life errors are evaluated accordingly.

    The maximum number of tolerated master sign-of-life errors with no history can be set via p0925.

    If the number of tolerated sign-of-life errors set in p0925 is exceeded, the response is as follows:

    – A corresponding message is output.

    – The value zero is output as the slave sign-of-life.

    – Synchronization with the master sign-of-life is started.
- Slave sign-of-life
  - ZSW2.12 ... ZSW2.15 are used for the slave sign-of-life.
  - The slave sign-of-life counter is incremented in each DP cycle (T_{DP}).

10.2.4 Slave-to-slave communications

10.2.4.1 General information

Description

For PROFIBUS-DP, the master addresses all of the slaves one after the other in a DP cycle. In this case, the master transfers its output data (setpoints) to the particular slave and receives as response the input data (actual values). Fast, distributed data transfer between drives (slaves) is possible using the "slave-to-slave communications" function without involving the master.

The following terms are used for the functions described here:

- Slave-to-slave communications
- Data Exchange Broadcast (DXB.req)
- Slave-to-slave communications (is used in the following)

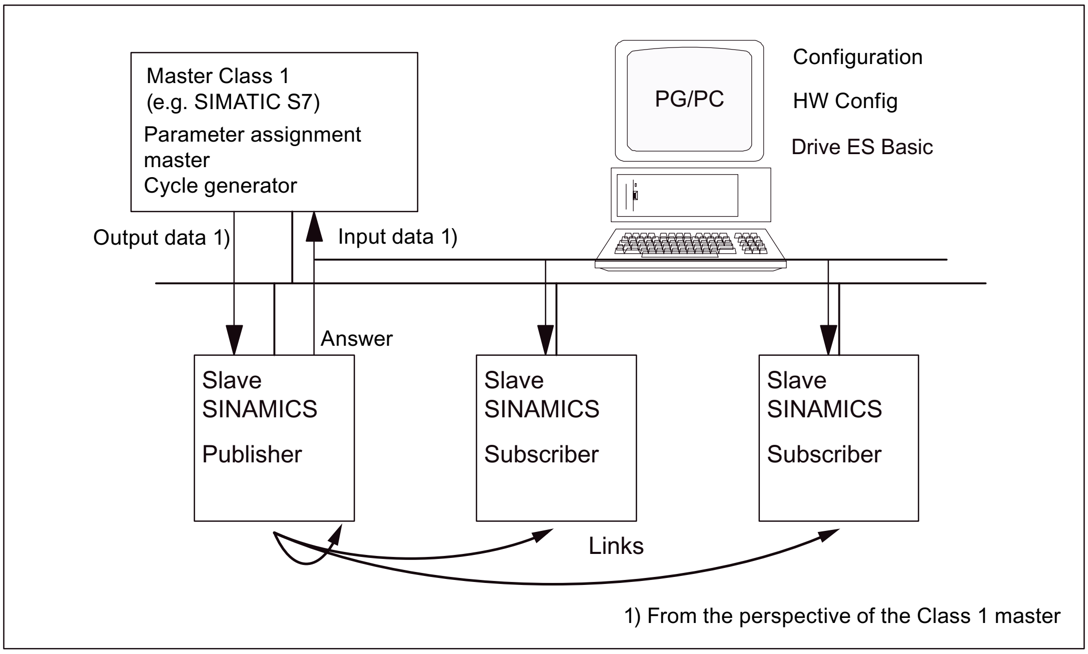

Figure 10-29 Slave-to-slave communications with the publisher-subscriber model

Publisher

With the "slave-to-slave communication" function, at least one slave must act as the publisher.

The publisher is addressed by the master when the output data is transferred with a different layer 2 function code (DXB.req). The publisher then sends its input data to the master with a broadcast telegram to all bus nodes.

Subscriber

The subscribers evaluate the broadcast telegrams, sent from the publishers, and use the data which has been received as setpoints. The setpoints are used, in addition to the setpoints received from the master, corresponding to the configured telegram structure (p0922).

Links and taps

The links configured in the subscriber (connection to publisher) contain the following information:

- From which publishers may input data be received?
- Which input data is there?
- A which location should the input data be used as setpoints?

Several taps are possible within a link. Several input data or input data areas, which are not associated with one another, can be used as setpoint via a tap.

Links are possible to the device itself. This means, e.g. for a Double Motor Module, data can be transferred from drive A to B. This internal link corresponds, as far as the timing is concerned, to a link via PROFIBUS.

Prerequisites and limitations

The following limitations should be observed for the "slave-to-slave" communications function:

- Drive ES Basic V5.3 SP3
- Firmware version ≥ 2.4
- Number of process data, max. per drive
- Number of links to Publishers
- Number of taps per link

Applications

For example, the following applications can be implemented using the "slave-to-slave communications" function:

- Axis couplings (this is practical for isochronous mode)
  - Angular-locked synchronism where the position reference value or position actual value is entered
  - Torque setpoint coupling (master/slave operation)

    Master drive speed controlled <–> slave drive torque controlled
- Specifying binector connections from another slave

10.2.4.2 Setpoint assignment in the subscriber

Setpoints

The following statements can be made about the setpoint:

- Number of setpoint

  When bus communications is being established, the master signals the slave the number of setpoints (process data) to be transferred using the configuring telegram (ChkCfg).
- Contents of the setpoints

  The structure and contents of the data for the "SINAMICS slave" using the local process data configuring (p0922).
- Operation as "standard" slave

  The drive (slave) only receives its setpoints and output data from the master.
- Operation as subscriber

  When a slave is operated as a subscriber, some of the setpoints are defined by one or more publishers rather than by the master.

  The slave is informed of the assignment via the parameterization and configuration telegram when bus communication is being established.

Example, setpoint assignment

The slave in the illustration receives its process data as follows:

- STW1 and STW2 from the master
- NSOLL_B and MOMRED as tap from a publisher

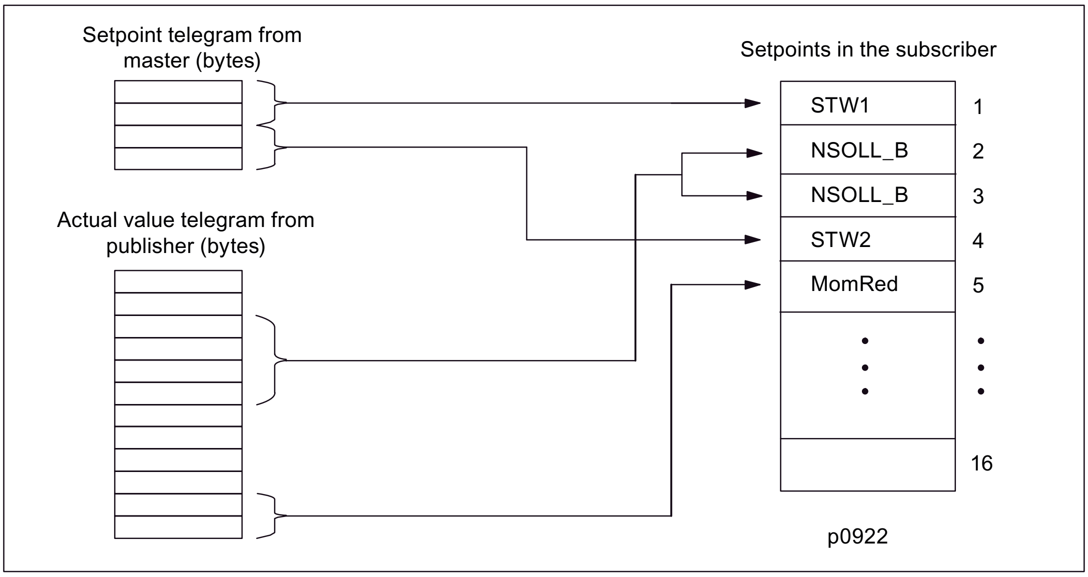

Figure 10-30 Example, setpoint assignment

10.2.4.3 Activating/parameterizing slave-to-slave communications

The "slave-to-slave communications" function must be activated both in the publishers as well as in the subscribers, whereby only the subscriber is to be configured. The Publisher is automatically activated by the bus system when booting.

Activation in the Publisher

The master is informed abut which slaves are to be addressed as publishers with a different layer 2 function code (DXB request) via the configuration of the subscriber links.

The publisher then sends its input data not only to the master but also as a broadcast telegram to all bus nodes.

These settings are made automatically by the S7 software.

Activation in the Subscriber

The slave, which is to be used as Subscriber, requires a filter table. The slave must know which setpoints are received from the master and which are received from a publisher.

STEP7 automatically generates the filter table.

The filter table contains the following information:

- Address of the publisher
- Length of the process data
- Position (offset) of the input data
- Amount of data
- Target of the data

Parameterizing telegram (SetPrm)

The filter table is transferred, as dedicated block from the master to the slave with the parameterizing telegram when bus communications are established.

Configuring telegram (ChkCfg)

Using the configuration telegram, a slave knows how may setpoints are to be received from the master and how many actual values are to be sent to the master.

For slave-to-slave communications, a special space ID is required for each tap. The PROFIBUS configuration tool (e.g. HW Config) generates this ID and then transferred with the ChkCfg in the drives that operate as Subscribers.

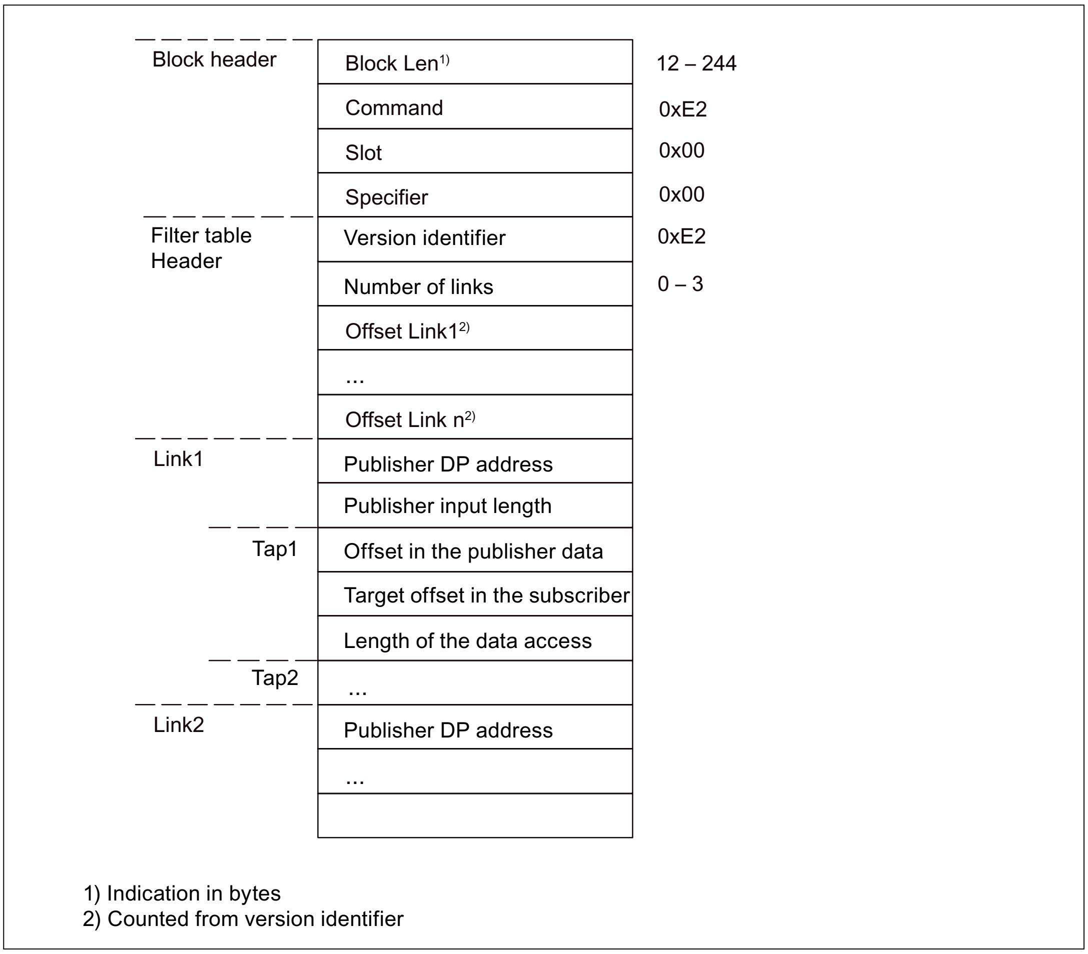

Figure 10-31 Filter block in the parameterizing telegram (SetPrm)

10.2.4.4 Commissioning of the PROFIBUS slave-to-slave communication

The commissioning of slave-to-slave communication between two SINAMICS drives using the additional Drive ES Basic package is described below.

Settings in HW Config

The project below is used to describe the settings in HW Config.

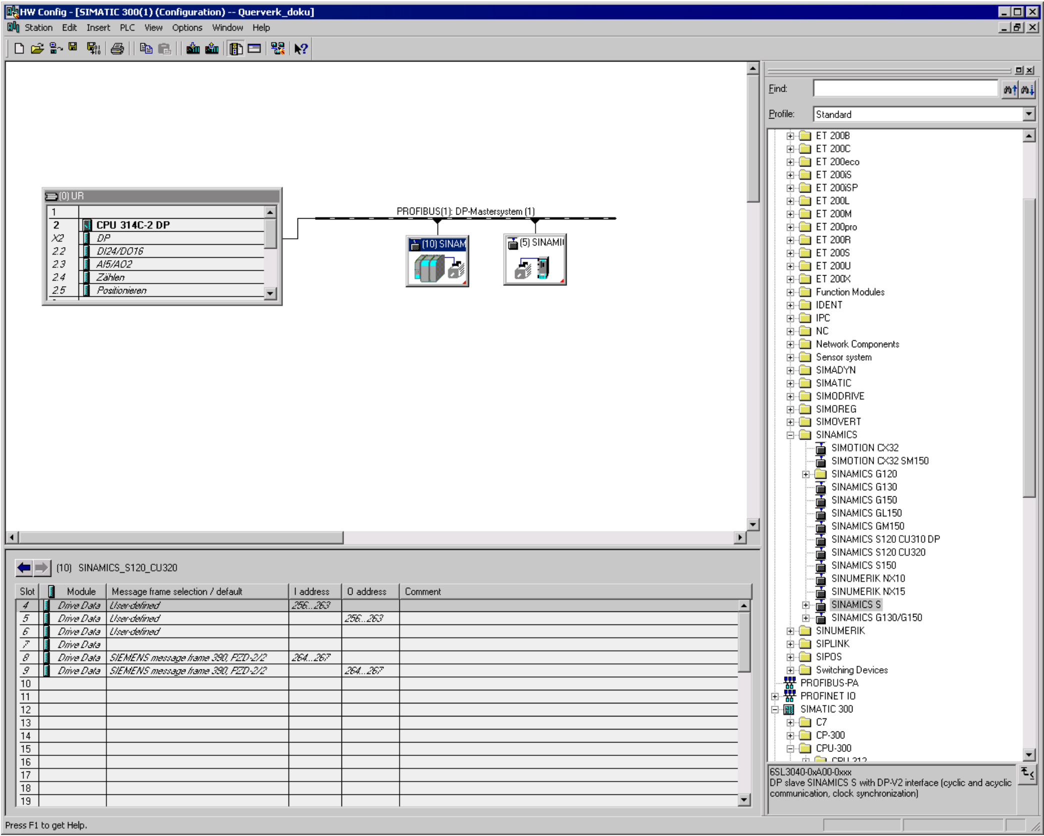

Figure 10-32 Example project of a PROFIBUS network in HW Config

Procedure

1. Select a slave (e.g. CU320) and use its properties to configure the telegram for the connected drive object.
2. In the "Configuration" tab of the drive unit, select e.g. the standard telegram 2 for the associated servo or vector drive in the telegram selection.

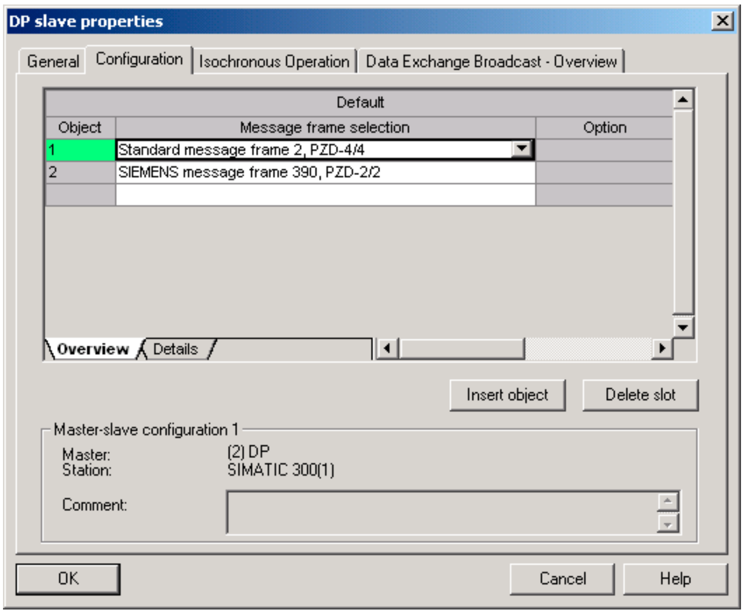

Figure 10-33 Telegram selection for drive object

3. Then go to the detail view.
   Slots 4/5 contain the actual value/setpoint for the drive object.
   The slots 7/8 are the telegram portions for the actual value/setpoint of the CU.

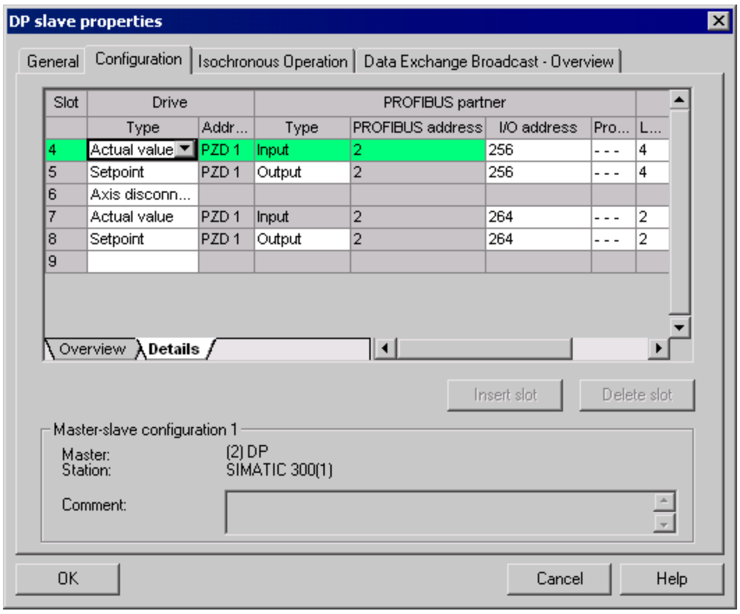

Figure 10-34 Detail view of slave configuration

4. The "Insert slot" button can be used to create a new setpoint slot for the CU320 drive object.

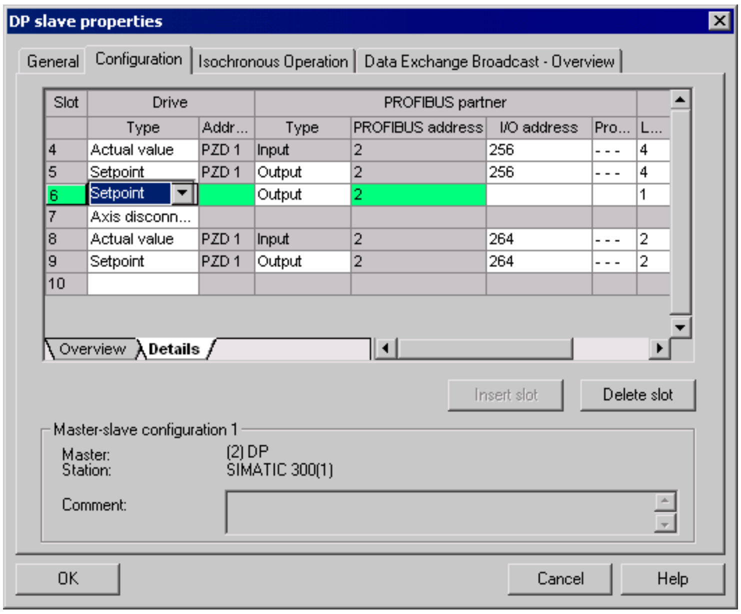

Figure 10-35 Insert new slot

5. Assign the setpoint slot the type "slave-to-slave communication".
6. Select the Publisher DP address in the "PROFIBUS address" column.
   This displays all DP slaves from which actual value data can be requested. It also provides the possibility of sharing data via slave-to-slave communication within the same drive group.
7. The "I/O address" column displays the start address for every DO.
   Select the start address of the data of the DO to be read. This is 268 in the example.
   If the complete data of the Publisher are not read, set this via the "Length" column. You may also offset the start address for the request so that data can be read out in the middle of the DO telegram.

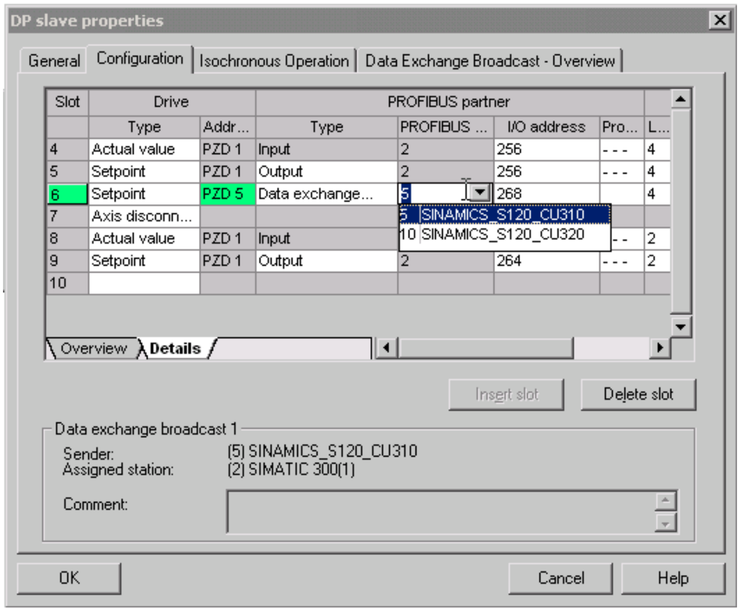

Figure 10-36 Configuring the slave-to-slave communication nodes

8. The "Data Exchange Broadcast - Overview" tab shows you the configured slave-to-slave communication relationships which correspond to the current status of the configuration in HW Config.

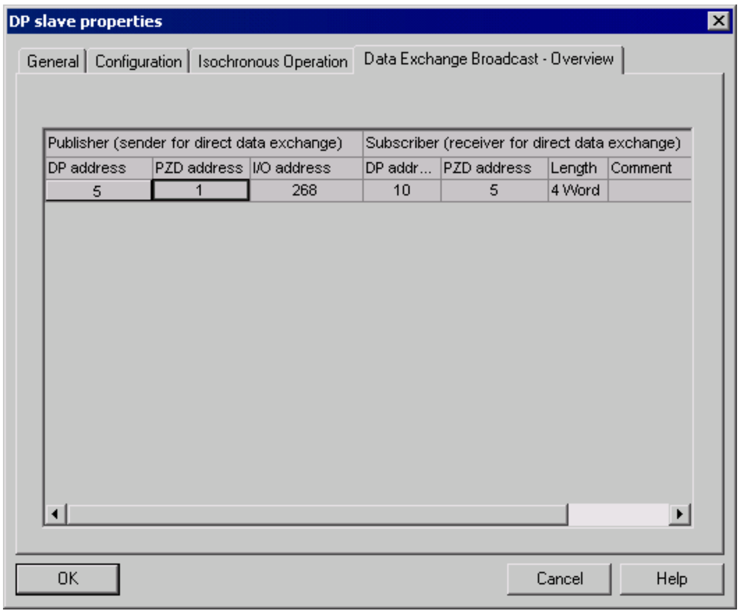

Figure 10-37 Data Exchange Broadcast - Overview

9. When the slave-to-slave communication links have been created, the standard telegram for the drive object is replaced with the "User-defined" telegram in the configuration overview.

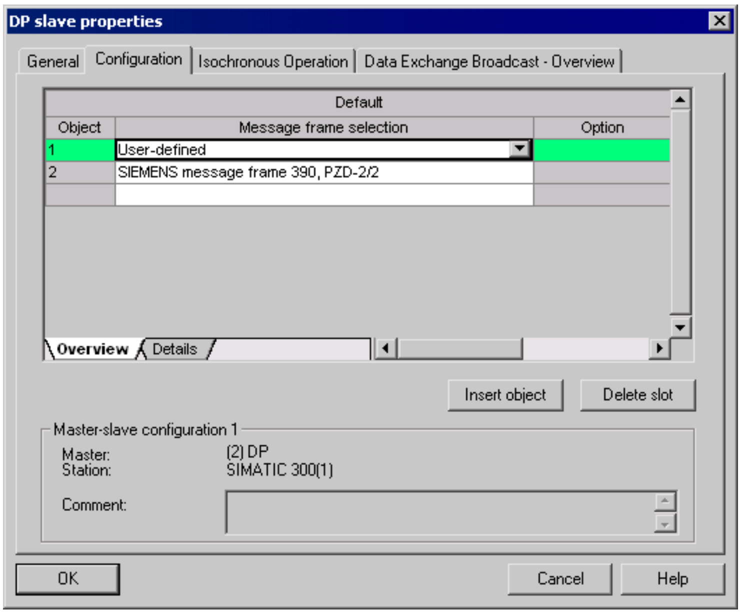

Figure 10-38 Telegram assignment for slave-to-slave communication

10. The details after the creation of the slave-to-slave communication link for the drive object of the CU320 are as follows:

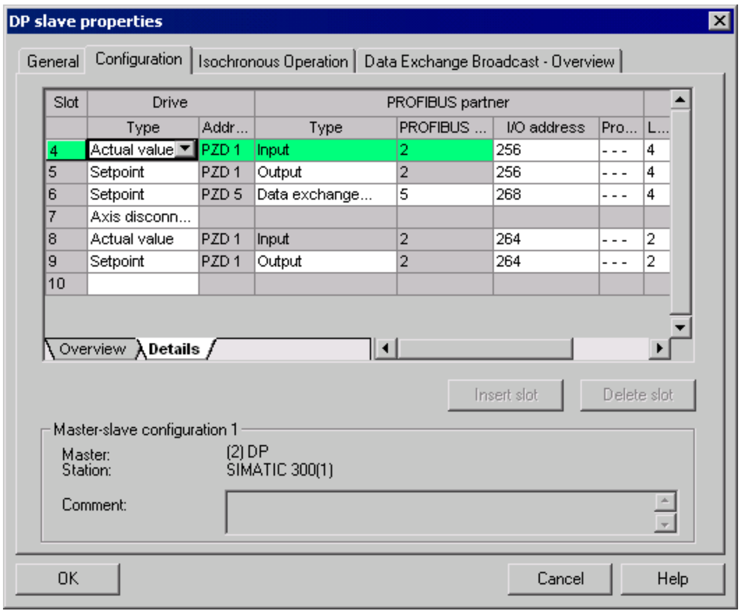

Figure 10-39 Details after the creation of the slave-to-slave communication link

11. You are required to adjust the standard telegrams accordingly for every DO (e.g. drive object) of the selected CU that shall actively participate in slave-to-slave communication.

Commissioning in STARTER

Slave-to-slave communication is configured in HW Config and is simply an extension of an existing telegram. Telegrams can be extended in STARTER (e.g. p0922 = 999).

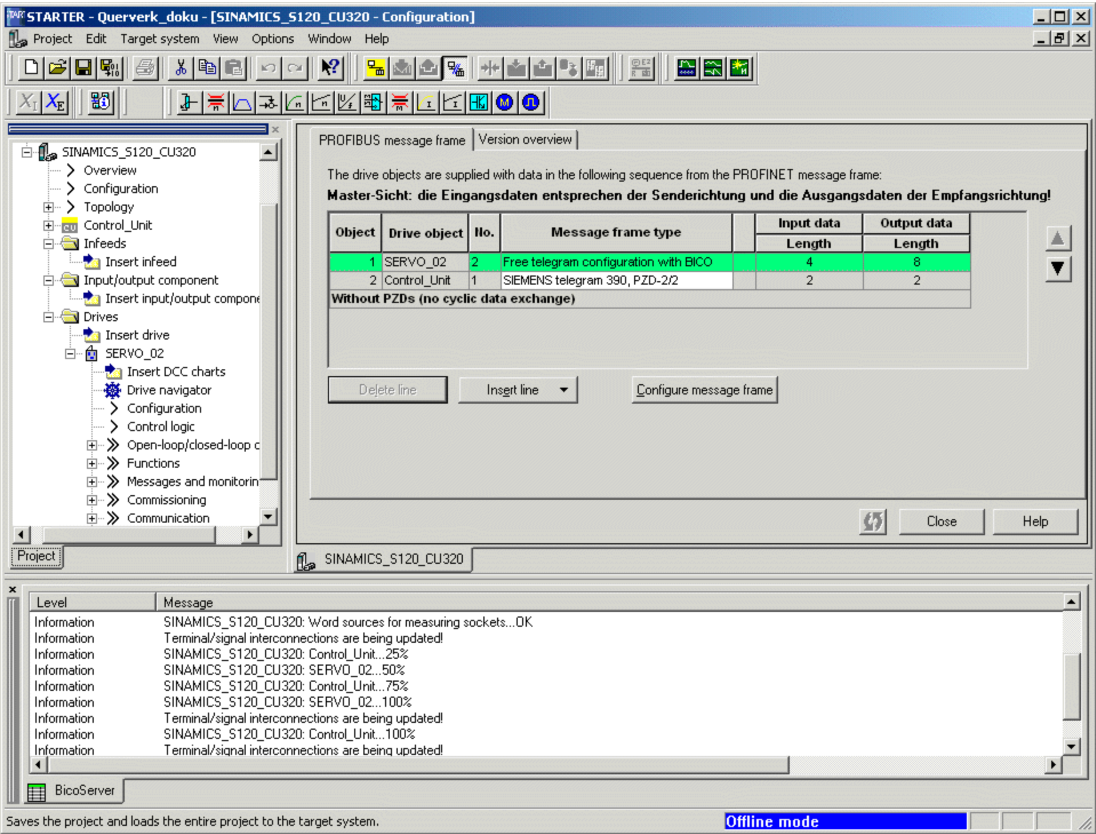

Figure 10-40 Configuring the slave-to-slave communication links in STARTER

In order to terminate the configuration of slave-to-slave communication for the DOs, the telegram data of the DOs in STARTER must be matched to those in the HW Config and must be extended. The configuration is made centrally via the configuration of the respective CU.

Procedure

1. In the overview for the PROFIBUS telegram, you can access the telegrams of the drive objects, here SERVO_02. Select the telegram type "Free telegram configuration" for the configuration.
2. Enter the telegram lengths for the input data and output data according to the settings in HW Config. For slave-to-slave communication links, the input data comprise the standard telegram and the slave-to-slave communication data.
3. Then set the telegram in the telegram selection to the standard telegram for drive objects (in the example: standard telegram 2), which results in a split display of the telegram types (standard telegram + telegram extension). The telegram extension represents the telegram portion of slave-to-slave communication.

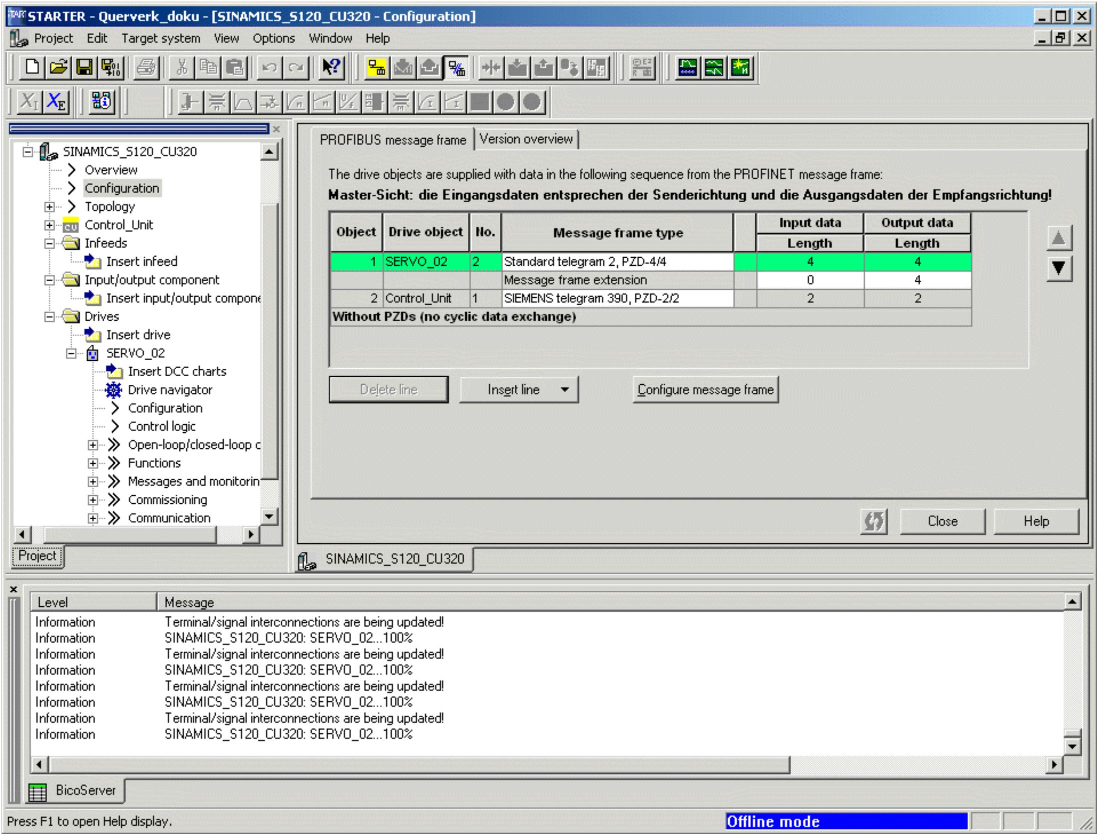

Figure 10-41 Display of the telegram extension

By selecting the item "Communication -> PROFIBUS" for the drive object "SERVO2" in the object tree you get the structure of the PROFIBUS telegram in receive and transmit direction. The telegram extension from PZD5 is the portion for slave-to-slave communication.

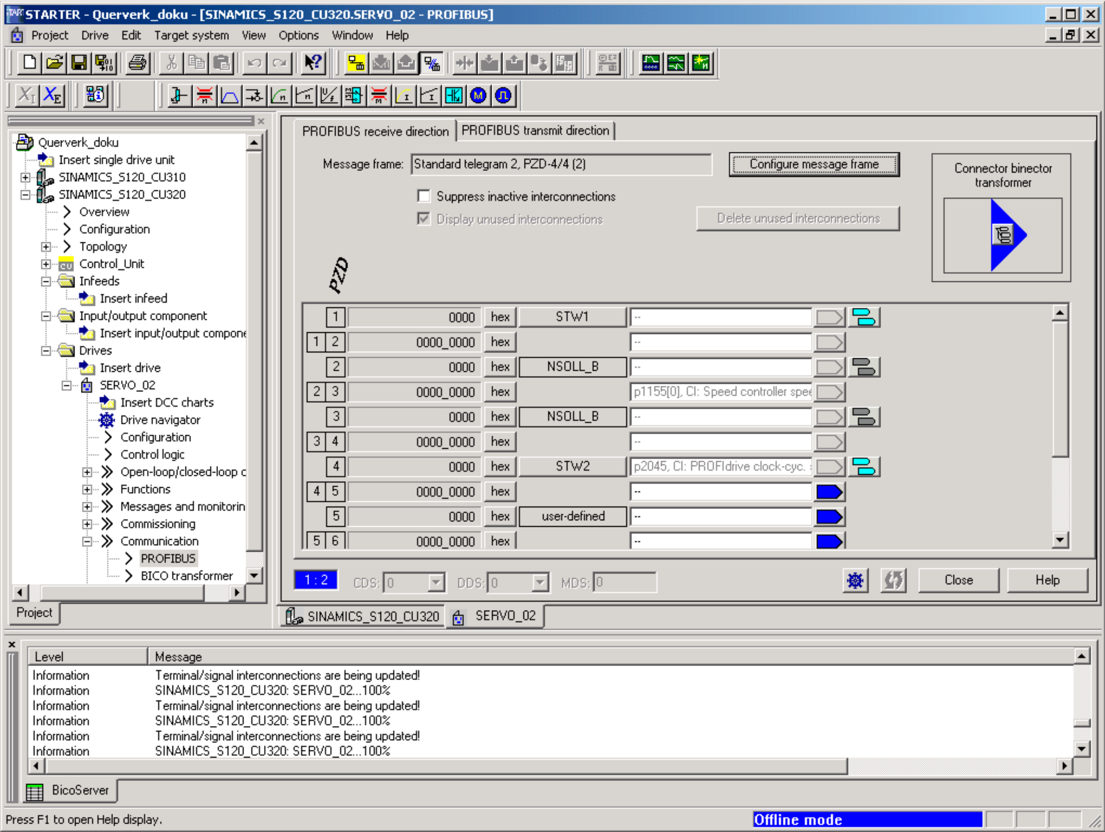

Figure 10-42 Configuring the PROFIBUS slave-to-slave communication in STARTER

4. To integrate the drive objects into slave-to-slave communication, you need to assign corresponding signals to the corresponding connectors in the PZDs. A list for the connector shows all signals that are available for interconnection.

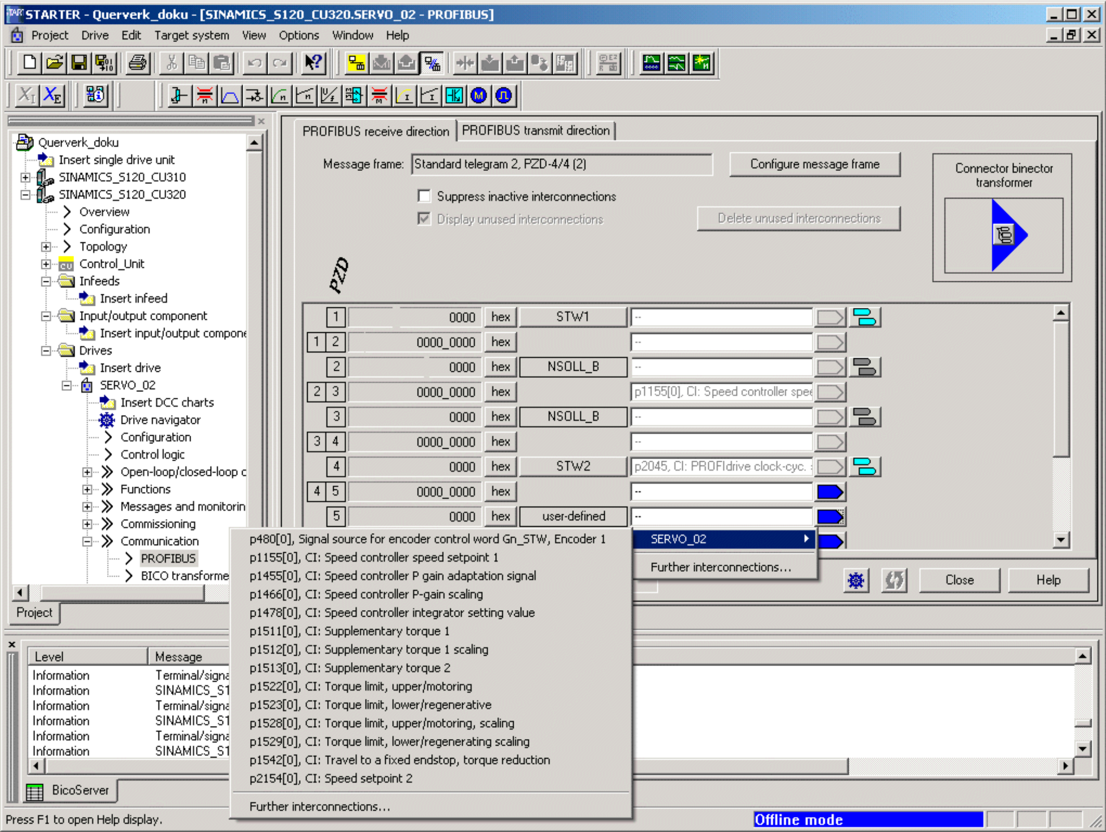

Figure 10-43 Combining the PZDs for slave-to-slave communication with external signals

10.2.4.5 GSD (GeräteStammDaten) file

GSD File

A special GSD file exists for the SINAMICS family to permit integration of the PROFIBUS slave-to-slave communication into SINAMICS.

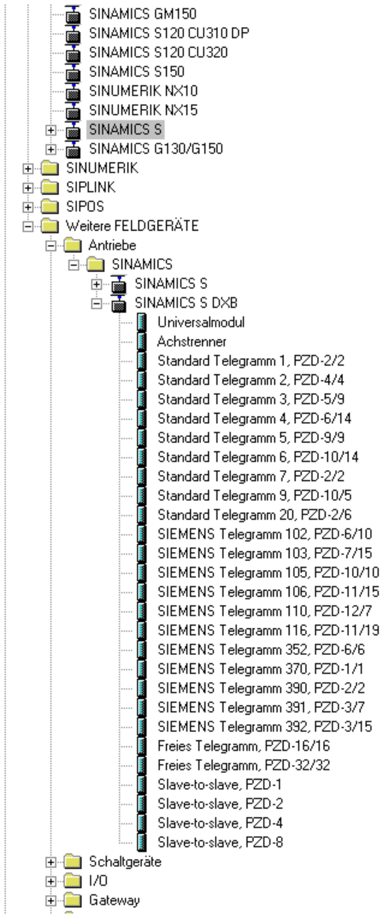

Figure 10-44 Hardware catalog of the GSD file with slave-to-slave communication functionality

The SINAMICS S DXB GSD file contains standard telegrams, free telegrams and slave-to-slave telegrams for configuring slave-to-slave communication. The user must take these telegram parts and an axis delimiter after each DO to compose a telegram for the drive unit.

The processing of a GSD file in HW Config is covered by the SIMATIC documentation.

10.2.4.6 Diagnosing the PROFIBUS slave-to-slave communication in STARTER

Diagnostics

Since the PROFIBUS slave-to-slave communication is implemented on the basis of a broadcast telegram, only the subscriber can detect connection or data faults, e.g. via the Publisher data length (see "Configuration telegram").

The Publisher can only detect and report an interruption of the cyclic connection to the DP master (A1920, F1910). The broadcast telegram to the subscriber will not provide any feedback. A fault of a subscriber must be fed back via slave-to-slave communication. In case of a "master drive" 1:n, however, the limited quantity framework (see "Links and requests") should be observed. It is not possible to have n subscribers report their status via slave-to-slave communication directly to the "master drive" (Publisher)!

For diagnostic purposes, there are the diagnostic parameters r2075 ("PROFIBUS diagnostics, receive telegram offset PZD") and r2076 ("PROFIBUS diagnostics, transmit telegram offset PZD"). The parameter r2074 ("PROFIBUS diagnostics, receive bus address PZD") displays the DP address of the setpoint source of the respective PZD.

r2074 and r2075 enable the source of a slave-to-slave communication relationship to be verified in the Subscriber.

Note

The Subscribers do not monitor the existence of an isochronous Publisher sign of life.

Alarms and error messages with PROFIBUS slave-to-slave communication

An alarm A1945 signals that a publisher of a device (CU320) is missing or has failed. Any interruption to the Publisher is also reported by an error F1946 at the affected DO. A failure of the Publisher will therefore only affect the respective DOs.

A1945	PROFIBUS: Connection of device to Publisher x interrupted
Reaction:	NONE
Acknowledgment:	NONE
Cause:	The cyclic data transfer between this PROFIBUS device and a slave-to-slave communication publisher was not established or was interrupted. Examples: Bus connection interrupted Publisher failed New startup of DP master
Remedy:	Check Publisher and bus connections to Publisher, to DP master and between DP master and Publisher.

F1946 (A)	PROFIBUS: Connection of drive object to Publisher x interrupted
Reaction:	OFF1 (NONE; OFF2; OFF3)
Acknowledgment:	IMMEDIATELY
Cause:	The cyclic data transfer between this drive object and a slave-to-slave communication Publisher was not established or was interrupted. Examples: Bus connection interrupted Publisher failed New startup of DP master
Remedy:	Check Publisher and bus connections to Publisher, to DP master and between DP master and Publisher.

10.3 Communications via PROFINET IO

10.3.1 General information about PROFINET IO

10.3.1.1 General information about PROFINET IO for SINAMICS

General information

PROFINET IO is an open Industrial Ethernet standard for a wide range of production and process automation applications. PROFINET IO is based on Industrial Ethernet and observes TCP/IP and IT standards.

The following standards ensure open, multi-vendor systems:

- International standard IEC 61158

PROFINET IO is optimized for high-speed, time-critical data communication at field level.

PROFINET

Within the framework of Totally Integrated Automation (TIA), PROFINET represents a consequent enhancement of:

- PROFIBUS DP, the established field bus,
  and
- Industrial Ethernet, the communication bus for the cell level.

Experience gained from both systems was and is being integrated into PROFINET. As an Ethernet-based automation standard defined by PROFIBUS International (PROFIBUS user organization), PROFINET is a manufacturer-independent communication and engineering model.

When a CBE20 is inserted, SINAMICS S120 becomes an IO device in the sense of PROFINET. With SINAMICS S120 and CBE20, communications can either be established via PROFINET IO with IRT or via PROFINET IO with RT. Mixed operation is not supported.

Note

PROFINET for drive technology is standardized and described in the following document:

References:
/P5/ PROFIdrive Profile Drive Technology
PROFINET System Description,
Order no. 6ES7398-8FA10-8AA0, 6ES7151-1AA10-8AA0

CAUTION
The cyclic PZD channel for PROFIBUS DP is deactivated when the **CBE20** is plugged in

10.3.1.2 Real-time (RT) and isochronous real-time (IRT) communication

Real-time communication

If supervisors are involved in communication, this can result in excessively long runtimes for the production automation system. When communicating time-critical IO user data, PROFINET therefore uses its own real time channel, rather than TCP/IP.

Definition: Real Time (RT) and determinism

Real time means that a system processes external events over a defined period.

Determinism means that a system responds in a predictable manner (deterministically).

In industrial networks, both of these requirements are important. PROFINET meets these requirements. PROFINET is implemented as a deterministic real time network as follows:

- Transmission of time-critical data takes place at guaranteed time intervals. To achieve this, PROFINET provides an optimized communication channel for real time communication: Real Time (RT).
- An exact prediction of the time at which the data transfer takes place is possible.
- Problem-free communication using other standard protocols is guaranteed within the same network.

Definition: Isochronous real time communication (IRT)

Isochronous Real Time Ethernet: Real time properties of PROFINET IO where IRT telegrams are transmitted deterministically via planned communication paths in a defined sequence to achieve the best possible synchronism and performance. This is also known as time-scheduled communications whereby knowledge about the network structure is utilized. IRT requires special network components that support planned data transfer.

When the transfer procedure is implemented in the ERTEC ASICs (Enhanced Real-Time Ethernet Controller), this results in cycle times of at least. 500 μs and a jitter accuracy of less than 1 μs.

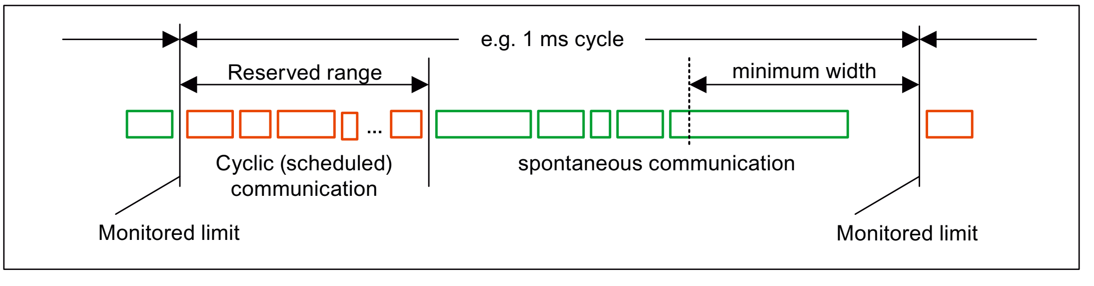

Figure 10-45 Broadband distribution/reservation, PROFINET IO IRT

Note

When operating S7-300 stations with SINAMICS drives, presently only communications via PROFINET IO with RT are possible. For SIMOTION with SINAMICS drives, communications via PROFINET IO with IRT are possible.

10.3.1.3 Addresses

Definition: MAC address

Each PROFINET device is assigned a worldwide unique device identifier in the factory. This 6-byte long device identifier is the MAC address. The MAC address is divided up as follows:

- 3 bytes manufacturer's ID and
- 3 bytes device identifier (consecutive number).

The MAC address is usually indicated on the front of the device.

e.g.: 08-00-06-6B-80-C0

IP address

To allow a PROFINET device to be addressed as a node on Industrial Ethernet, this device also requires an IP address that is unique within the network. The IP address is made up of 4 decimal numbers with a range of values from 0 through 255. The decimal numbers are separated by a period. The IP address is made up of

- The address of the (sub-) network and
- The address of the node (generally called the host or network node)

IP address assignment

The TCP/IP protocol is a prerequisite for establishing a connection and parameterization. This is the reason that an IP address is required.

The IP addresses of IO devices can be assigned by the IO controller and always have the same sub-network mask as the IO controller. The can be consecutively assigned from the IP address of the IO controller. The IP address can be changed manually, if necessary - and is saved in a volatile fashion.

If the IP address is to be stored in a non-volatile memory, the address must be assigned using the Primary Setup Tool (PST) or with the STARTER.

This can also be carried out in HW Config in STEP 7, where the function is called "Edit Ethernet node".

Note

If the network is part of an existing Ethernet company network, obtain the information from your network administrator (IP address, sub-network mask and a router that is possibly being used.)

Device name

When it is shipped, an IO device does not have a device name. An IO device can only be addressed by an IO controller, for example, for the transfer of project engineering data (including the IP address) during startup or for user data exchange in cyclic operation, after it has been assigned a device name with the IO supervisor.

NOTICE
The device name must be saved in a non-volatile fashion either using the Primary Setup Tool (PST) or using HW Config from STEP 7.

Replacing Control Unit CU320 (IO Device)

If the IP address and device name are stored in a non-volatile memory, this data is also forwarded with the memory card (CF card) of the Control Unit.

If an IO device must be completely replaced due to a device or module defect, the Control Unit automatically assigns parameters and configures the new device or module. Following this, cyclic exchange of user data is restarted. The CF card allows module exchange without an IO supervisor when a fault occurs in a PROFINET device.

Definition: Sub-network mask

The bits set in the sub-network define the part of the IP address that contains the address of the (sub-) network. The following generally applies:

- The network address is obtained by an AND operation on the IP address and sub-network mask
- The node address is obtained by an AND NOT operation on the IP address and sub-network mask.

Example of the sub-network mask

Sub-network mask: 255.255.0.0 (decimal) = 11111111.11111111.00000000.00000000 (binary) IP address: 140.80.0.2 significance: The first 2 bytes of the IP address decide the sub-network - in other words 140.80. The last two bytes address the node - in other words 0.2.

Default router

If data needs to be forwarded by means of TCP/IP to a partner located outside the sub-network, this is carried out via the default router. In the properties dialog in STEP 7 (Properties of Ethernet interface > Parameters > Network transfer), the default router is described as the router. STEP 7 assigns the local IP address to the default router.

10.3.1.4 Data transfer

Features

The Communication Board CBE20 supports:

- IRT – isochronous real-time Ethernet
- RT – real-time Ethernet
- Standard Ethernet services (TCP/IP, LLDP, UDP and DCP)

PROFIdrive telegram for cyclic data transmission and non-cyclic services

Telegrams to send and receive process data are available for each drive object of a drive unit with cyclic process data exchange. In addition to cyclic data transfer, acyclic services can also be used for parameterizing and configuring the drive. These acyclic services can be used by the supervisor or the controller.

The total length of the Ethernet frame increases with the number of drive objects in a drive unit.

Sequence of drive objects in the data transfer

The sequence of drive objects is displayed via a list in p0978[0...15] where it can also be changed.

Note

The sequence of drive objects in HW Config must be the same as that in the drive (p0978).

NOTICE
A ring-type topology is not permissible.

10.3.2 Hardware setup

10.3.2.1 Configuring SINAMICS drives with PROFINET

Communication Board Ethernet CBE20

The CBE20 option board is inserted in the option slot of the CU320. The CBE20 is equipped with four ports that can be used to connect the PROFINET sub-network.

New device ID for PROFINET (from FW2.5 SP1)

From FW 2.5 SP1, a new device ID is maintained in the firmware, which uniquely and distinctively identifies the drive object (e.g. S120 or G150) where the CBE20 is plugged in.

Note

This new device ID can only be evaluated and processed with SIMATIC S7-CPUs that have loaded FW version 2.5 or higher. With a different FW version in the S7, no communication between the S7 and the drive with a new device ID is possible!

References

For a description of the CBE20 and how you can use it in the drive, please refer to the manual GH1 "Control Units".

The connection of a SINAMICS S120 with CBE20 to a PROFINET IO network is described in detail in the System Manual "SIMOTION SCOUT Communication".

Clock generation

The SINAMICS S120 with CBE20 can only act as a sync slave within a PROFINET IO network.

CBE20 module is plugged in CU320:

- The cyclic DP interface is disabled.
- Transmission type IRT, device is sync slave and isochronous, clock is applied to bus: CBE20 synchronizes, providing the clock for the CU320.
- RT or IRT (option "not isochronous") has been configured. The SINAMICS does not use a local clock (clock configured in SINAMICS).

No CBE20 module plugged but configured:

- SINAMICS uses local clock (clock configured in SINAMICS), no data exchange via PROFINET, alarm A1487 "Topology fault" is issued.
  Access via PROFINET is not available.

Telegrams

The following PROFIdrive telegrams can be selected for PROFINET IO communication:

- isochronous standard telegrams 1-6, 20
- Telegram 102-106, 352, 370
- Telegram 999

DCP flashing

This function is used to check the correct assignment to a module and its interfaces. This function is supported by a SINAMICS S120 from FW 2.4 with plugged CBE20.

1. In HW Config or STEP7 Manager, select the menu item "Target system" > "Ethernet" > "Edit Ethernet node".
2. The "Edit Ethernet node" dialog box opens.
3. Click on the "Browse" button.
4. The "Browse Network" dialog box opens and displays the connected nodes.
5. After the SINAMICS S120 with CBE20 has been selected as a node, activate the "DCP flashing" function by means of the "Flash" button.

The DCP flashing will be effective on the RDY LED (READY LED 2Hz, green/orange or red/orange) on the CPU320.

The LED will continue to flash as long as the dialog is open. When the dialog is closed, the LED will go out automatically. The function is available as of STEP7 V5.3 SP1 via Ethernet.

Step 7 routing with CBE20

The CBE20 does not support STEP 7 routing between PROFIBUS and PROFINET IO.

Connecting the supervisor

You can go online with the STARTER in a number of ways, which are illustrated below:

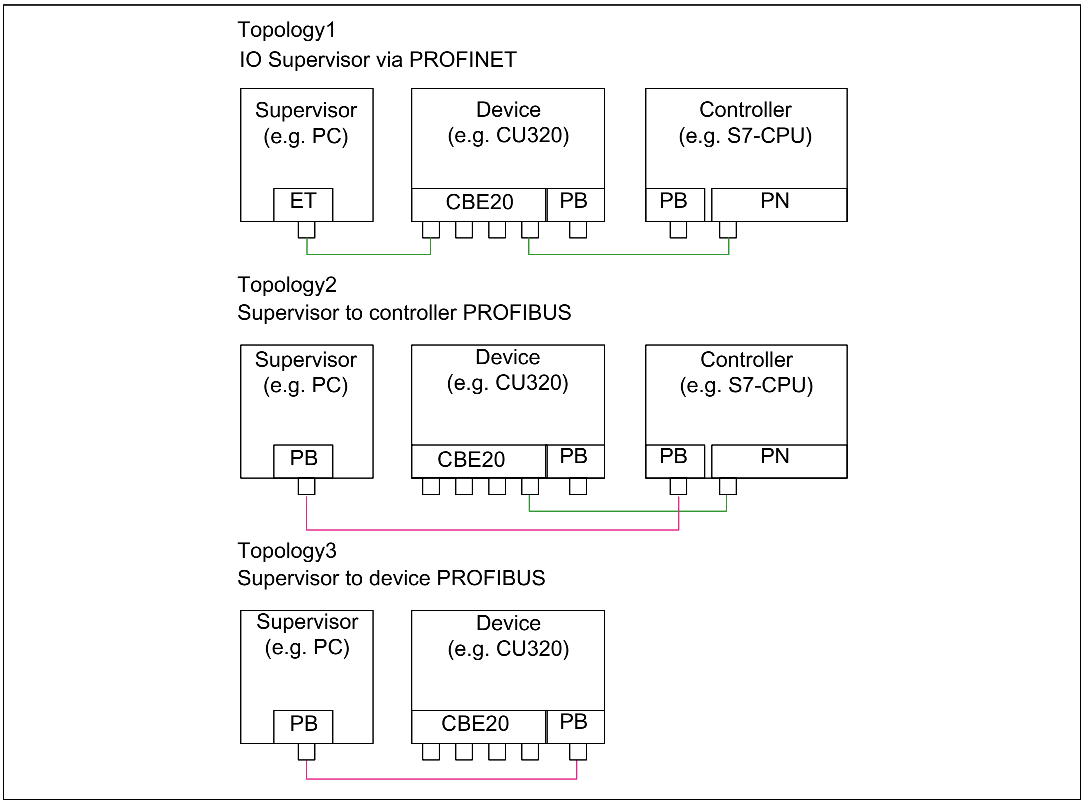

Figure 10-46 Connecting the supervisor

NOTICE
SINAMICS does not support routing from PROFIBUS to PROFINET and vice versa.

10.3.3 RT classes

10.3.3.1 RT classes for PROFINET IO

Description

PROFINET IO is a scalable realtime communications system based on Ethernet technology. The scalable approach is expressed with three realtime classes.

RT

The RT communication is based on standard Ethernet. The data is transferred via prioritized Ethernet message frames.

IRTflex

This realtime class is not supported in FW 2.5 SP1.

IRTtop

In addition to the bandwidth reservation, the message frame traffic can be further optimized by configuring the topology. This enhances the performance during data exchange and the deterministic behavior. The IRT time interval can thus be further optimized or minimized compared with IRTflex.

In addition to the isochronous data transfer, with IRT even the application (position control cycle, IPO cycle) can be synchronized in the devices. This is an essential requirement for closed-loop axis control and synchronization via the bus.

Table 10-33 Comparison between RT and IRTtop

RT class	RT	IRTtop
Transfer mode	Switching based on the MAC address; prioritization of the RT message frame possible using Ethernet-Prio (VLAN tag)	Path-based switching using a topology-based planning; no transmission of TCP/IP frames in the IRTtop interval.
MinDeviceInterval	Typically 2-8 msec	Fully deterministic, also for 250 μsec
Isochronous application	-	Yes
Start time of the isochronous application	-	Times for receiving the data scheduled exactly. A synchronous application can be started directly afterwards (similar to DP)
Determinism	Variance of the transmission duration by started TCP/IP message frames	Exactly planned transfer; times for transmission and receiving are guaranteed for any topologies.
Reload the network configuration after a change	-	Whenever the topology or the communication relationships change
Cross-traffic (controller-controller)	-	Yes

RT class	RT	IRTtop
Maximum switching depth (number of switches in one line)	10 at 1 ms	20
Synchronization accuracy	-	Forwarding of the sync message frame in software. Accuracy <1 µs
Possible transmission cycle clocks (observe any device-specific restrictions)	500 (as of FW2.5 SP1), 1,000, 2,000, 4,000 µs	500 (as of FW2.5 SP1), 1,000 – 4,000 µs in increments of 125 µs. The increment depends on the controller.

Set RT class

The IO controller determines which RT class its IO system supports, by setting the real time class at its controller interface. If IRTtop is set, it is not possible to operate any IRTflex devices on the IO controller and conversely. RT devices can always be operated, even if IRT classes are set.

You can set the RT class in the HW Config for the associated PROFINET device.

1. Double-click on the PROFINET board entry in the module in HW Config.

   The "Properties" dialog box is opened.

2. Select the realtime class for RT class in the Synchronization tab.
3. Confirm with "OK".

10.3.3.2 PROFINET IO with RT

PROFINET IO with RT is the optimal solution for the integration of I/O systems without particular requirements in terms of performance and isochronous mode. This is a solution that also uses standard Ethernet in the devices and commercially available industrial switches as infrastructure components. A special hardware support is not required.

Not isochronous

Because standard Ethernet does not support any synchronization mechanisms, isochronous operation is not possible with PROFINET IO with RT!

The realtime capability is comparable with the present PROFIBUS DP solutions with 12 MBaud, whereby a sufficiently large bandwidth portion is available for the parallel transmission of IT services on the same line.

PROFINET IO message frames have priority over IT message frames in accordance with IEEE802.1q. This ensures the required determinism in the automation technology.

Data exchange

Communication is possibly only within a network (subnet).

Refresh time

The refresh time is in the range of 1 ms, 2 ms and 4 ms. The real refresh time depends on the bus load, the devices used and the quality structure of the I/O data. The refresh time is a multiple of the send clock.

10.3.3.3 PROFINET IO with IRT - Overview

Overview

PROFINET IO with IRT distinguishes itself through the separate time domains for IRT, RT and TCP/IP communication. This is ensured by high-precision hardware-supported cycle monitoring.

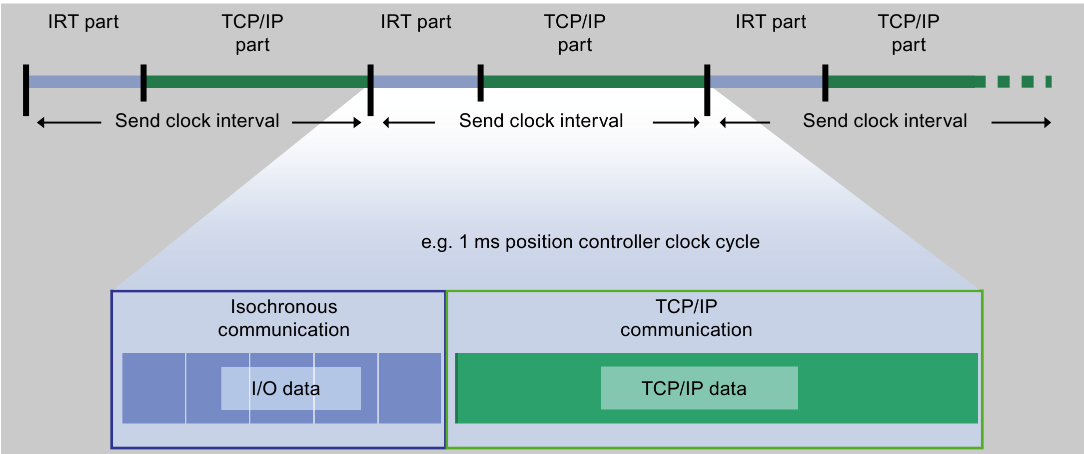

Figure 10-47 IRT Communication - Overview

PROFINET IO with IRT is available in two versions:

- IRTflex (**flex**ible) with fixed bandwidth reservation (not available in FW2.5 SP1)
- IRTtop (**top** performance) with planned IRT communication

Time synchronization and isochronous mode on PROFINET IO with IRTtop

In addition, a high-performance and isochronous connection to the application with low load on the application CPU is also ensured. Isochronous data transfer with cycle times well below one millisecond and with a deviation in the cycle start (jitter) of less than a microsecond provide sufficient performance reserves for demanding motion control applications.

In contrast to standard Ethernet and PROFINET IO with RT, the message frames for PROFINET IO with IRT are transmitted as scheduled.

Sync domain

The sync domain can be configured in the HW Config. SINAMICS S120 is an IO device and must be assigned to a sync master as a sync slave.

10.3.3.4 PROFINET IO with IRTtop

The performance capability is significantly increased with PROFINET IRTtop for motion control applications. A hardware support enables a significant increase in performance compared with the present field bus solutions. By planning the message frame traffic in time for IRTtop, a considerable data traffic optimization is achieved compared with IRTflex.

IRTtop is particularly suited for:

- The control and synchronization of axes via PROFINET
- A fast, isochronous I/O integration with short terminal-terminal times

For PROFINET IO with IRTtop, the synchronization of all devices on a shared Sync master is necessary. The sum of all synchronized devices form a sync domain.

Send clock/refresh time

Within this time all cyclic and acyclic data (IRTtop data) is transferred. The send clock of 500 µs (as of FW2.5 SP1)/1 ms - 4 ms is the maximum range in which the send clock can be set. The actual send clock that can be set depends on various factors:

- Bus load
- Type of devices used
- Computing power available in the controller
- Supported send clocks in the participating PROFINET devices of a sync domain

A typical send clock is, for example, 1 ms. However, it can be set in steps of 125 µs within the limits of 500 µs (as of FW2.5 SP1)/1 ms to 4 ms.

Time-scheduled data transmission

Scheduling is the specification of the communication paths and the exact transmission times for the data to be transferred. The bandwidth can be optimally utilized through communication scheduling and therefore the best possible performance achieved. The highest determinism quality is achieved through the scheduling of the transmission times which is especially advantageous for an isochronous application connection.

The communication scheduling is performed by the engineering system. An IRT planning algorithm is available for this. The schedule results must be transferred to each IO controller through a download. The IO controller then loads the schedule results into the IO devices during ramp-up. The communication with IRTtop is performed on the basis of these schedule data.

The scheduled data transfer requires a hardware support for PROFINET IO with IRTtop in the form of a communication ASIC (Application Specific Integrated Circuit). In order for the scheduled communication not to be endangered by spontaneously transmitted IT message frames, a certain part of the cyclic communication is reserved exclusively for the transmission of IRTtop. This is called bandwidth reservation. The rest of the communication cycle can be used for RT and IT communication.

Data exchange

Communication is generally also possible via network limits via routers. However, PROFINET IO with IRTtop only runs within a sync domain.

10.3.4 Motion Control with PROFINET

Motion Control/Isochronous drive link with PROFINET

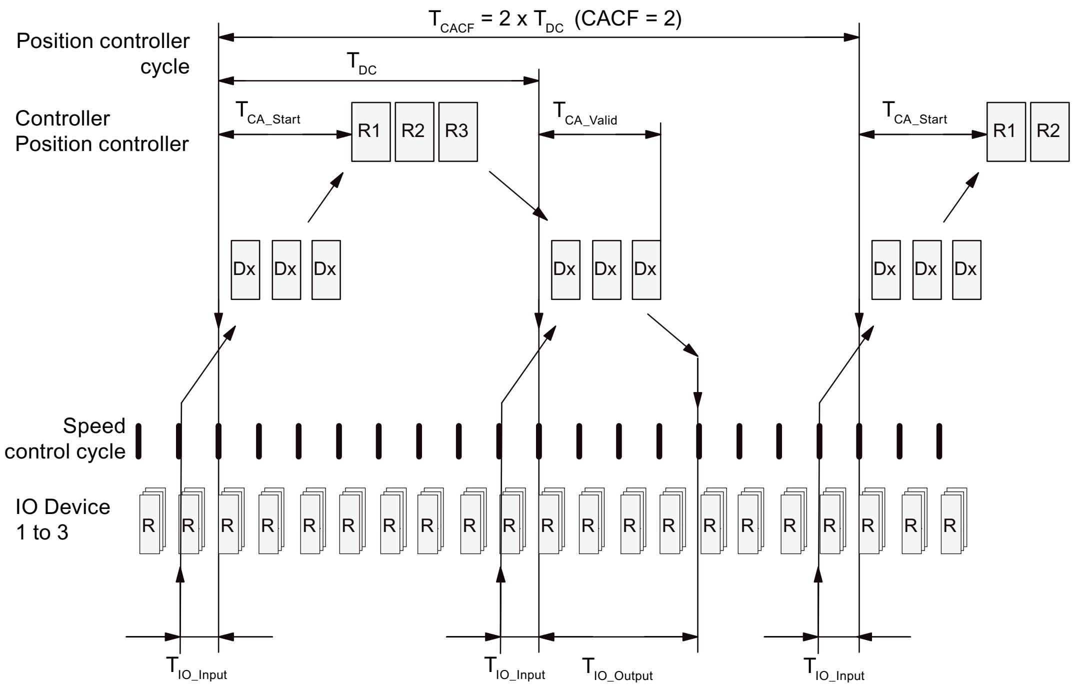

Figure 10-48 Motion Control/Isochronous drive link with PROFINET, optimized cycle with CACF = 2

Sequence of data transfer to closed-loop control system

1. Position actual value G1_XIST1 is read into the telegram image at time T_{IO_Input} before the start of each cycle and transferred to the master in the next cycle.
2. Closed-loop control on the master starts at time T_{CA_Start} after each position controller cycle and uses the current actual values read previously from the slaves.
3. In the next cycle, the master transmits the calculated setpoints to the telegram image of the slaves. The speed setpoint command NSOLL_B is issued to the closed-loop control system at time T_{IO_Output} after the beginning of the cycle.

Designations and descriptions for Motion Control

Table 10-34 Time settings and meanings

Name	Value1)	Limit value	Description
T_{DC_BASE}	T_DC_BASE = 4	-	Time basis for cycle time T_{DC} calculation: T_{DC_BASE} =T_DC_BASE • 31.25 μs = 4 • 31.25 μs = 125 μs
T_{DC}	T_DC_MIN = 4 T_DC_MAX = 32	T_DC_MIN ≤ T_DC ≤ T_DC_MAX	Cycle time T_{DC} = T_DC • T_{DC_BASE} ,T_DC: Integer factor T_{DC_MIN} = T_DC_MIN • T_{DC_BASE} = 4•125 μs = 500 μs T_{DC_MAX} = T_DC_MAX • T_{DC_BASE} = 32•125 μs = 4 ms
T_{CACF}	-	CACF = 1-14	IO controller application cycle time This is the time frame in which the IO controller application generates new setpoints (e.g. in the position controller cycle). Calculation example: T_{CACF} = CACF• T_DC= 2•500 μs = 1 ms
T_{CA_Valid}	-	$T_{CA\_Valid} < T_{DC}$	Time, measured from the beginning of the cycle, at which the actual values of all IO devices for the controller application process (position control) are available.
T_{CA_Start}	-	$T_{CA\_Start} > T_{CA\_Valid}$	Time, measured from the beginning of the cycle, at which the controller application process (position control) starts.
T_{IO_BASE}	T_IO_BASE = 125000		Time base for T_{IO_Input}, T_{IO_Output} T_{IO_BASE} =T_IO_BASE • 1 ns= 125000 • 1ns = 125 μs
T_{IO_Input}	T_IO_InputMIN = 3	T_IO_InputMIN < T_IO_Input ≤ T_DC	Time of actual value acquisition This is the time at which the actual values are acquired before a new cycle starts. T_{IO_Input} = T_IO_Input • T_{IO_BASE} T_IO_Input: integer factor
		$T_{IO\_InputMIN}$	Minimum value for T_{IO_Input} Calculation: $T_{IO\_InputMIN}$ = T_IO_InputMIN • T_{IO_BASE} = 375 μs
T_{IO_Output}	T_IO_OutputMIN = 2	T_IO_OutputMIN ≤ T_IO_Output ≤ T_DC	Time of setpoint transfer This is the time, calculated from the beginning of the cycle, at which the transferred setpoints (speed setpoint) are accepted by the closed-loop control system. T_{IO_Output} = T_IO_Output • T_{IO_BASE} T_IO_Output: integer factor
		$T_{IO\_OutputMIN}$	Minimum value for T_{IO_Output} Calculation: $T_{IO\_OutputMIN}$ = T_IO_OutputMIN • T_{IO_BASE} = 250 μs
Dx			Data_Exchange This service is used to implement user data exchange between IO controller and IO device 1 - n.
R or Rx			Processing time for speed or position controller
1) The values correspond to the device master file gsdml-v2.1-siemens-sinamics-s-cu3x0-20070615.xml			

Setting criteria for times

- Cycle (T_{DC})
  - T_{DC} must be set to the same value for all bus nodes. T_{DC} is a multiple of SendClock.
  - $T_{DC} > T_{CA\_Valid}$ and $T_{DC} \geqq T_{IO\_Output}$

    T_{DC} is thus large enough to enable communication with all bus nodes.

NOTICE
After T_{DC} has been changed on the PROFINET IO controller, the drive system must be switched on (POWER ON) or the parameter p0972=1 (Reset drive unit) must be set.

- T_{IO_Input} and T_{IO_Output}
  - Setting the times in T_{IO_Input} and T_{IO_Output} to be as short as possible reduces the dead time in the position control loop.
  - $T_{IO\_Output} > T_{CA\_Valid} + T_{IO\_Output\_MIN}$
- Settings and optimization can be done via a tool (e.g. HW Config in SIMATIC S7).

User data integrity

User data integrity is verified in both transfer directions (IO controller <—> IO device) by a sign of life (4-bit counter).

The sign-of-life counters are incremented from 1 to 15 and then start again at 1.

- IO controller sign of life
  - STW2.12 ... STW2.15 are used for the IO controller sign of life.
  - The IO controller sign-of-life counter is incremented on each IO controller application cycle (T_{CACF}).
  - The number of sign-of-life errors tolerated can be set via p0925.
  - p0925 = 65535 deactivates sign-of-life monitoring on the IO device.
  - Monitoring

    The IO controller sign-of-life is monitored on the IO device and any sign-of-life errors are evaluated accordingly.

    The maximum number of tolerated IO controller sign-of-life errors with no history can be set via p0925.

    If the number of tolerated sign-of-life errors set in p0925 is exceeded, the response is as follows:

    1. A corresponding message is output.
    2. The value zero is output as the IO device sign of life.
    3. A new synchronization with the IO controller sign of life is started.
- IO device sign of life
  - STW2.12 ... STW2.15 are used as IO device sign of life.
  - The IO device sign-of-life counter is incremented in each DC cycle (T_{DC}).

Applications 11

11.1 Parallel operation of communication interfaces for CU320

General information

Only one of the two available hardware communication interfaces could be used for the processing of the cyclic process data (setpoints/actual values) in the CU320. This was either the

- onboard interface (PROFIBUS DP) or the
- additional option interface/COMM board (PROFINET, CAN,...).

The onboard interface was disabled when the COMM board was plugged in.

The parameterizable function (p8839) permits the parallel use of the onboard interface (PROFIBUS DP) and the COMM board (e.g. PROFINET) in the SINAMICS system.

The following applications can then be implemented:

- PROFIBUS DP for drive control and PROFINET for the acquisition of actual values/measured values of the drive.
- PROFIBUS DP for control and PROFINET for engineering only
- Mixed mode with two masters (one for logic % coordination and one for technology).
- Use of redundant communication interfaces

Assignment of communication interfaces to cyclic interfaces

Two cyclic interfaces exist for setpoints and actual values, which differ by their parameter ranges used (BICO, etc.) and the usable functionalities. These two interfaces are designated IF1 (cyclic interface 1) and IF2 (cyclic interface 2).

The HW communixation interfaces (onboard, COMM board) are firmly assigned to one of these cyclic interfaces (IF1, IF2), depending on their type (PROFIBUS DP, PROFINET, CAN, ...). The respective other interface is disabled (except CAN).

For the parallel operation of the communication interfaces, this formerly fixed assignment to the cyclic interfaces can be determined as desired by user parameterization.

Properties of the cyclic interfaces IF1 and IF2

The following table shows the different features of the two cyclic interfaces:

Table 11-1 Properties of the cyclic interfaces IF1 and IF2

Feature	IF1	IF2
Setpoint (BICO signal source)	r2050, r2060	r8850, r8860
Actual value (BICO signal sink)	p2051, p2061	p8851, p8861
PROFIdrive conformance	Yes	No
PROFIdrive telegram selection (p922)	Yes	No
Isochronous mode possible	Yes	No
Slave-to-slave communication (PROFIBUS only)	Yes	Yes
List of drive objects (p978)	Yes	Yes
Max. PZD (16bit) setpoint / actual value SERVO	16 / 19	16 / 16
Max. PZD (16bit) setpoint / actual value vector	32 / 32	16 / 16
Max. PZD (16bit) setpoint / actual value infeeds	5 / 8	5 / 8
Max. PZD (16bit) setpoint / actual value TM41	16 / 19	
Max. PZD (16bit) setpoint / actual value TM15	30 / 30	
Max. PZD (16bit) setpoint / actual value TM17	36 / 36	
Max. PZD (16bit) setpoint / actual value TM / TB (other)	5 / 5	
Max. PZD (16bit) setpoint / actual value CU (device)	5 / 15	

Table 11-2 Implicit assignment of hardware to cyclic interfaces

Plugged hardware interface	IF1	IF2
No option, onboard interface only (PROFIBUS)	Onboard	--
PROFINET option (CBE20)	COMM board	--
CAN option (CBC10)	Onboard	COMM board
PROFIBUS option	Onboard	--

For parallel operation of the hardware interfaces and the explicit assignment to the cyclic interfaces IF1 and IF2, the new parameter p8839[0,1] "PZD Interface hardware assignment" exists for the device IO in the expert list.

The default setting of p8839[0,1]=99 enables the implicit assignment (see table above).

An alarm is generated in case of unvalid or inconsistent parameterization of the assignment.

Note

Parallel operation of PROFIBUS and PROFINET

Isochronous applications can only run via the cyclic interface IF1. With an additional PROFINET module plugged in, there are two parameterization options:

- p8839(0) = 1 and p8839(1) = 2: PROFIBUS isochronous, PROFINET cyclic

- p8839(0) = 2 and p8839(1) = 1: PROFINET isochronous, PROFIBUS cyclic

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Additional parameters for IF2

To permit a better use of the IF2 also for a PROFIBUS / PROFINET connection, the following extensions of the parameter list are available:

Infeeds:
r8850, p8851, r8853

Additional diagnostic parameters (meaning of 88xx identical with 20xx):
r8874, r8875, r8876

Additional binector-connector converter (meaning of 88xx identical with 20xx):
p8880, p8881, p8882, p8883, p8884, r8889

Additional connector-binector converter (meaning of 88xx identical with 20xx):
r8894, r8895, p8898, p8899

Note

It is not possible in the HW Config configuration tool to represent a PROFIBUS / PROFINET slave with two interfaces. In parallel operation, the SINAMICS will therefore appear twice in the project or in two projects although there is only one physical device.

Parameters

p8839	PZD Interface hardware assignment
Description:	Assigns the cyclic interface a hardware interface. Index 0: Assignment for interface 1 (IF1) Index 1: Assignment for interface 2 (IF2)
Values:	0: not active
	1: ONBOARD hardware
	2: COMM BOARD
	99: Automatic (assignment according to plugged HW, compatible setting)

The following rules apply to the setting of p8839:

- The setting of p8839 applies to all DOs of a CU (device parameter).
- For the setting p8839(0) = 99 and p8839(1) = 99 (automatic assignment, default), the assignment will be made on the basis of the plugged hardware. To render this automatic assignment active, it must be selected for both indexes; otherwise an alarm is generated, and the setting p8839(x) = 99 is treated in the same manner as 'not active'.
- An alarm is issued if the same hardware (onboard or COMM board) is selected in p8839(0) and p8839(1). In this case, the setting of p8839(0) is effective. The setting of p8839(1) is treated as 'not active'.
- With the CAN module plugged (CBC10), an entry of p8839(0) = 2 is invalid (no assignment of CAN module to IF1). An alarm is issued.

- With the setting p8839(x) = 2 and the COMM board missing / defective, the respective interface is not automatically fed by the onboard interface. Instead, an alarm is issued.

Alarm

A_8550	PZD interface hardware assignment incorrect
Description:	The assignment of the hardware to the PZD interface has been incorrectly parameterized.
Values:	1: Only one of the two indexes is not equal to 99
	2: Both PZD interfaces have been assigned the same hardware
	3: Assigned COMM board missing
	4: CBC10 has been assigned to interface 1

11.2 Switching on a drive object x_Infeed by means of a vector drive object

Description

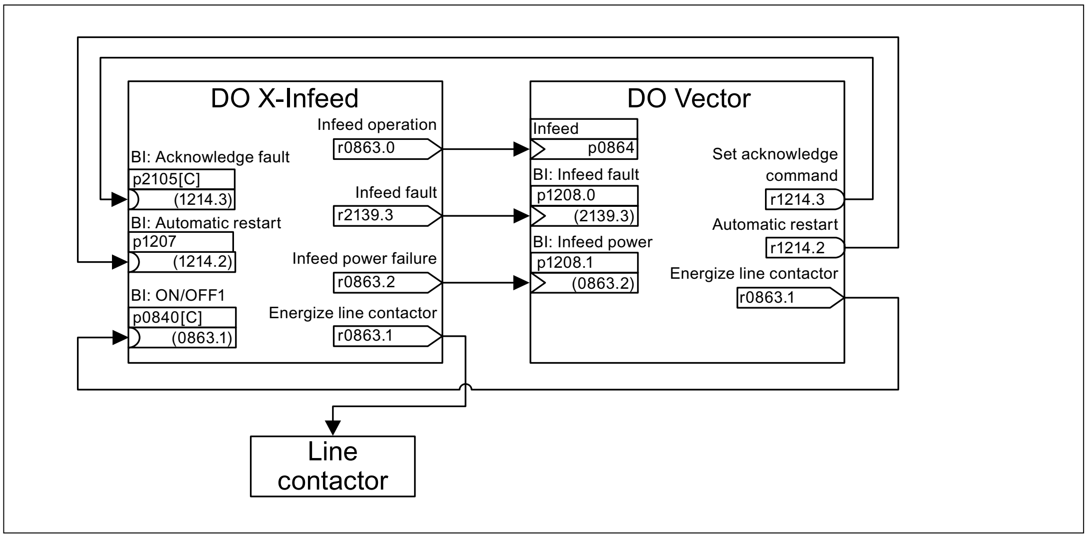


Figure 11-1 BICO interconnection

Using this BICO interconnection, a drive object (DO) x_Infeed can be switched-in by a vector drive object. This power-on version is mainly used for chassis units, if only one Line Module and one Motor Module are used. If the associated application requires an automatic restart function then the following procedure is recommended in order to implement it:

- The automatic restart function is activated on the DO vector (p1210).
- In addition to the automatic restart function, the flying restart function (p1200) must be activated on DO vector if it must be assumed that an automatic restart must be made for a motor that is still rotating.

Individual steps when restarting:

- After the line supply returns and the electronics has booted, the faults that have occurred at DO vector as a result of its automatic restart are acknowledged depending on the settings in p1210.
- The faults of the DO x_Infeed are acknowledged via the connection r1214.3 => p2105.
- The ON command (p0840) for the infeed is generated via the binector output "control line contactor" of the DO vector (p0863.1).
- The power-on attempt is interrupted if, during the new power-on sequence, a fault occurs on the DO x_Infeed. The fault is communicated to the DO vector via the BICO connection p1208.0 => r2139.3 shown above.
- The automatic restart of the DOs x_Infeed have absolutely no significance for the described power-on version.

11.3 Motor changeover

11.3.1 Description

The motor changeover is used in the following cases, for example:

- Changing-over between different motors and encoders
- Switching over different windings in a motor (e.g. star-delta switchover)
- Adapting the motor data

If several motors are operated alternately on a Motor Module, a matching number of drive data sets must be created.

Note

To switch to rotating motor, the "flying restart" function must be activated (p1200).

NOTICE
When changing over the drive data set between several motors that physically exist with integrated holding brakes, it is not permissible that the internal brake control is used.

11.3.2 Example: motor switchover for four motors

Prerequisites:

- The drive has been commissioned for the first time.
- 4 motor data sets (MDS), p0130 = 4

- 4 drive data sets (DDS), p0180 = 4
- 4 digital outputs to control the auxiliary contactors
- 4 digital inputs to monitor the auxiliary contactors
- 2 digital inputs for selecting the data set
- 4 auxiliary contactors with auxiliary contacts (1 NO contact)
- 4 motor contactors with positively-driven auxiliary contacts (3 NC contact, 1NO contact)
- 4 motors, 1 Control Unit, 1 infeed, and 1 Motor Module

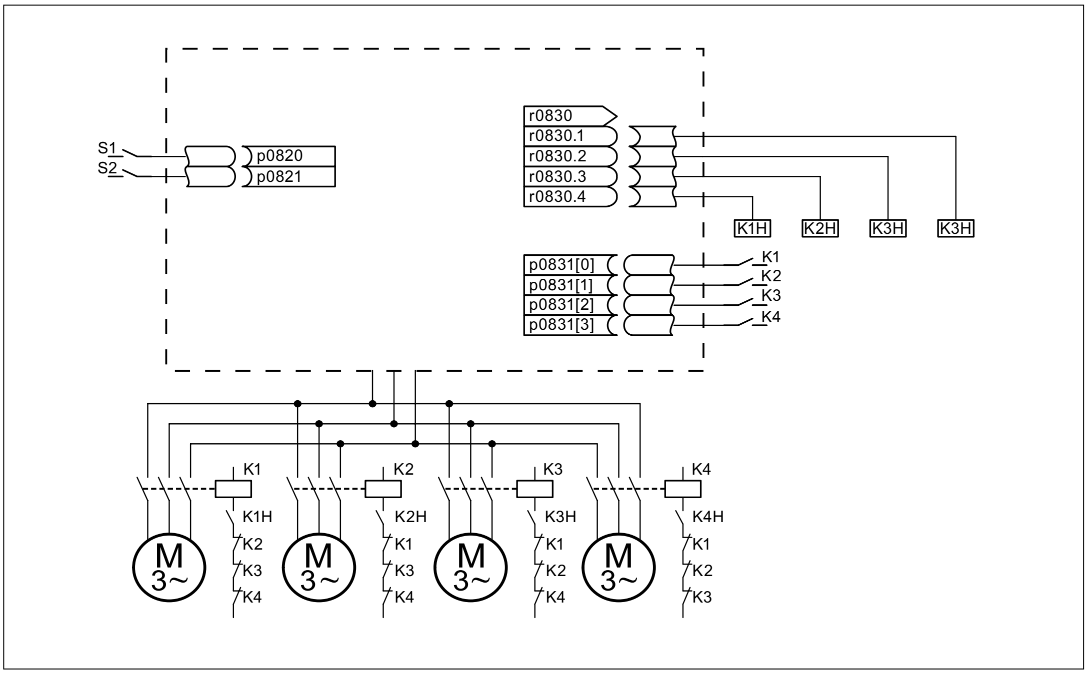


Figure 11-2 Example of motor changeover

Table 11-3 Settings for the example

Parameter	Settings	Remark
p0130	4	Configure 4 MDS
p0180	4	Configure 4 DDS
p0186[0..3]	0, 1, 2, 3	The MDS are assigned to the DDS.
p0820, p0821	Digital inputs DDS selection	The digital inputs for motor switchover via DDS selection are selected. Binary coding is used (p0820 = bit 0 etc.).
p0822 to p0824	0	
p0826[0..3]	1, 2, 3, 4	Different numbers indicate a different thermal model
p0827[0..3]	1, 2, 3, 4	The bits of p0830 are assigned to the MDS. If p0827[0] = 1, for example, bit p0830.1 is set when MDS0 is selected via DDS0.
p0830.1 to p0830.4	Digital outputs, auxiliary contactors	The digital outputs for the auxiliary contactors are assigned to the bits.
p0831[0..3]	Digital inputs, auxiliary contacts	The digital inputs for the feedback signal of the motor contactors are assigned.

Parameter	Settings	Remark
p0833.0..2	0, 0, 0	The drive controls the contactors and pulse suppression. Parking bit (Gn_ZSW14) is set.

Procedure for switching over the motor data set

1. Start condition:

   For synchronous motors, the actual speed must be lower than the speed at the start of field weakening. This prevents the regenerative voltage generated from being greater than the terminal voltage.
2. Pulse suppression:

   The pulses are cancelled after selecting a new drive data set using p0820 to p0824.
3. Open the motor contactor:

   Motor contactor 1 is opened r0830 = 0 and the status bit "Motor changeover active" (r0835.0) is set.
4. Change over the drive data set:

   The requested data set is activated (r0051 = requested data set).
5. Energize the motor contactor:

   After the feedback signal (motor contactor opened) for motor contactor 1, the appropriate bit of r0830 is set and motor contactor 2 is energized.
6. Enable the pulses:

   After the feedback signal (motor contactor closed) for motor contactor 2, the bit "motor changeover active" (r0835.0) is reset and the pulses are enabled. The motor has now been changed over.

11.3.3 Example of a star/delta switchover

Preconditions:

- The drive has been commissioned for the first time.
- 2 motor data sets (MDS), p0130 = 2
- 2 drive data sets (DDS), p0180 = 2
- 2 digital outputs for controlling the auxiliary contactor
- 2 digital inputs for monitoring the auxiliary contactor
- 1 free speed monitoring (p2155)
- 2 auxiliary contactors with auxiliary contacts (1 NO contact)
- 2 motor contactors with positively-driven auxiliary contacts (1 NC contacts, 1 NO contact)
- 1 motor, 1 Control Unit, 1 infeed, and 1 Motor Module

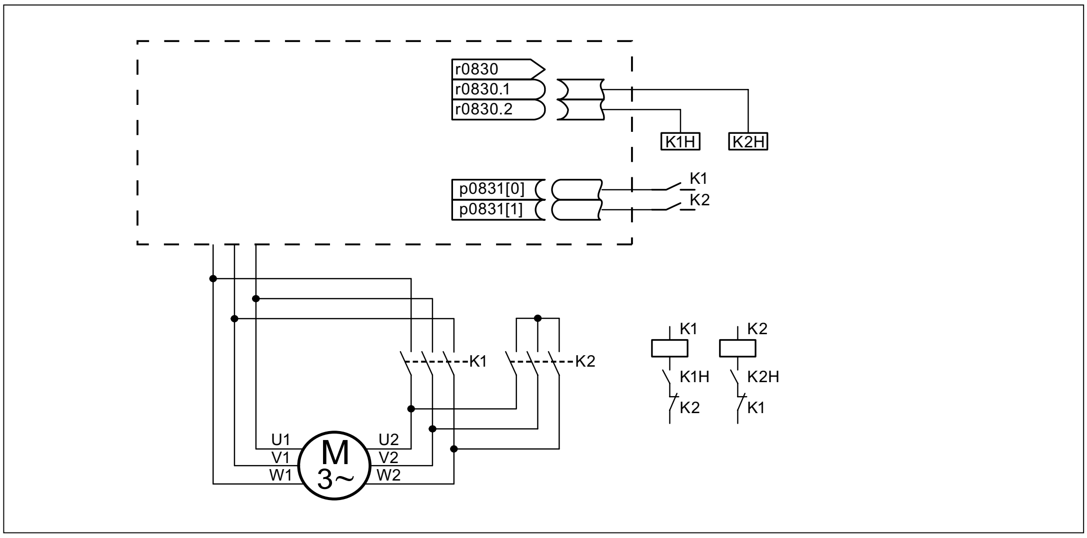


Figure 11-3 Example: star/delta switchover

Table 11-4 Settings for the example

Parameter	Settings	Comments
p0130	2	Configure 2 MDS.
p0180	2	Configure 2 DDS.
p0186[0..1]	0, 1	The MDS are assigned to the DDS.
p0820	p2197.2	Switchover to delta connection after speed in p2155 is exceeded.
p0821 to p0824 0	0	
p0826[0..1]	0; 0	Identical numbers signify the same thermal model.
p0827[0..1]	1, 2	Assign the bit from p0830 to the MDS. If p0827[0] = 1, for example, bit p0830.1 is set when MDS0 is selected via DDS0.
p0830.1 and p0830.2	Digital outputs auxiliary contactors	The digital outputs for the auxiliary contactors are assigned to the bits.
p0831[0..1]	Digital inputs auxiliary contacts	The digital inputs for the checkback from the motor contactors are assigned.
p0833.0..2	0, 0, 0	The drive is responsible for controlling the contactor circuit and the pulse inhibit. Parking bit (Gn_ZSW14) is set.
p2155	Switchover speed	Sets the speed at which the switchover is to be carried out in delta.

Procedure for star/delta switchover

1. Start condition:

   For synchronous motors, the actual speed must be lower than the star field weakening speed. This prevents the regenerative voltage from exceeding the terminal voltage.

2. Pulse inhibit:

   After selecting a new drive data set using p0820, the pulses are inhibited.

3. Open the motor contactor:

   Motor contactor 1 is opened r0830 = 0 and the status bit "Motor data set changeover active" (r0835.0) is set.

4. Change over the drive data set:

   The requested data set is activated (r0051 = requested data set).

5. Energize the motor contactor:

   After the feedback signal (motor contactor opened) for motor contactor 1, the appropriate bit of r0830 is set and motor contactor 2 is energized.

6. Enable the pulses:

   After the feedback signal (motor contactor closed) for motor contactor 2, the bit "motor changeover active" (r0835.0) is reset and the pulses are enabled. The switchover is complete.

11.3.4 Integration

The motor switchover function is integrated in the system as follows.

Function diagrams (see SINAMICS S List Manual)

- 8565 Drive Data Sets (DDS)
- 8570 Encoder Data Sets (EDS)
- 8575 Motor Data Sets (MDS)

Overview of key parameters (see SINAMICS S List Manual)

- r0051 Drive data set (DDS) effective
- p0130 Motor data sets (MDS) number
- p0140 Encoder data sets (EDS) number
- p0180 Drive data sets (DDS) number
- p0186 Motor data sets (MDS) number
- p0187 Encoder 1 encoder data
- p0820 BI: Drive data set selection DDS, bit 0
- ...
- p0824 BI: Drive data set selection DDS, bit 4
- p0826 Motor switchover motor number
- p0827 Motor switchover status bit number
- p0828 BI: Motor switchover feedback
- p0830 CO/BO: Motor switchover status
- p0831 BI: Motor switchover contactor feedback
- p0833 Data set changeover configuration

11.4 Application examples with the DMC20

11.4.1 Features

The DRIVE-CLiQ Hub Module Cabinet 20 (DMC20) has the following features:

- Own drive object
- 6 DRIVE-CLiQ ports
- Own faults and alarms

Typical applications would include:

- Implementation of a distributed topology via a DRIVE-CLiQ cable
- Hot plugging (a DRIVE-CLiQ connection is withdrawn in operation)

11.4.2 Description

The DRIVE-CLiQ Hub Module Cabinet 20 (DMC20) is used for the star-shaped distribution of a DRIVE-CLiQ line. With the DMC20, an axis grouping can be expanded with four DRIVE-CLiQ sockets for additional subgroups.

The component is especially suitable for applications which require DRIVE-CLiQ nodes to be removed in groups, without interrupting the DRIVE-CLiQ line and therefore the data exchange.

11.4.3 Example, distributed topology

Description

Several direct length measuring systems are used in a machine. These are to be combined in an electrical cabinet and connected to the Control Unit via a DRIVE-CLiQ cable.

When using a DMC20, up to five measuring systems can be combined. The measuring systems are not assigned directly to the drive objects. Instead, they must be assigned to the drive objects in the topology view in STARTER.

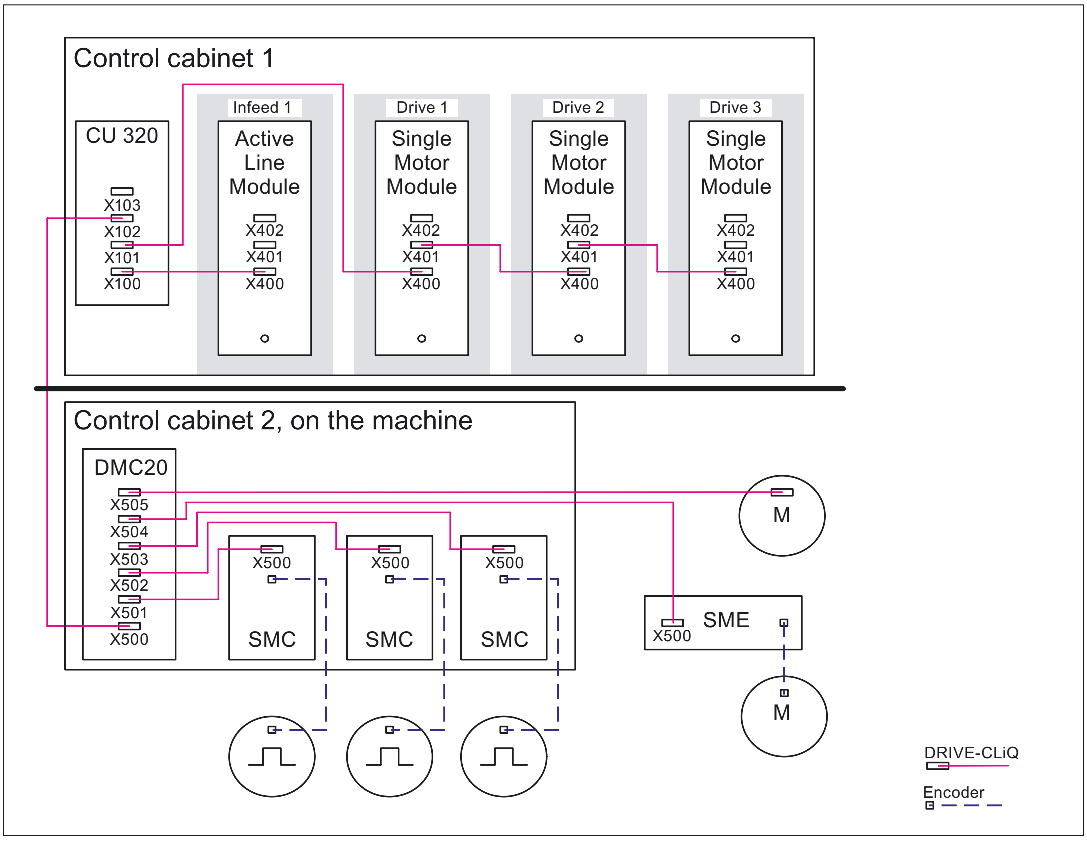


Figure 11-4 Example, distributed topology using DMC20

11.4.4 Example, hot plugging

Description

Using the hot-plugging function, components can be withdrawn from the operational drive line-up (the other components continue to operate) on the DRIVE-CLiQ line. This means that the corresponding drive object must first be deactivated/parked beforehand using parameter p0105 or STW2.7.

The following requirements must be met:

Hot plugging is only possible when a drive object is connected in a star configuration to a Control Unit or to the DRIVE-CLiQ Hub DMC20.

The system does not support removing DRIVE-CLiQ connections between the other DRIVE-CLiQ components e.g. Sensor/Terminal Module to the Motor Module, Motor Module to the Motor Module.

The complete drive object (Motor Module, motor encoder, Sensor Module) is disabled via p0105.
STW2.7 is used to set the function "Park axis" for all components that are assigned to the motor control (Motor Module, motor encoders). All components that belong to Encoder_2 or Encoder_3 remain active. The "Park axis" function is only enabled by setting the ZSW2.7 bit with pulse inhibit.

> **Note**
>
> Drives with enabled safety functions must not be deactivated, see chapter "Safety Integrated" for further details.

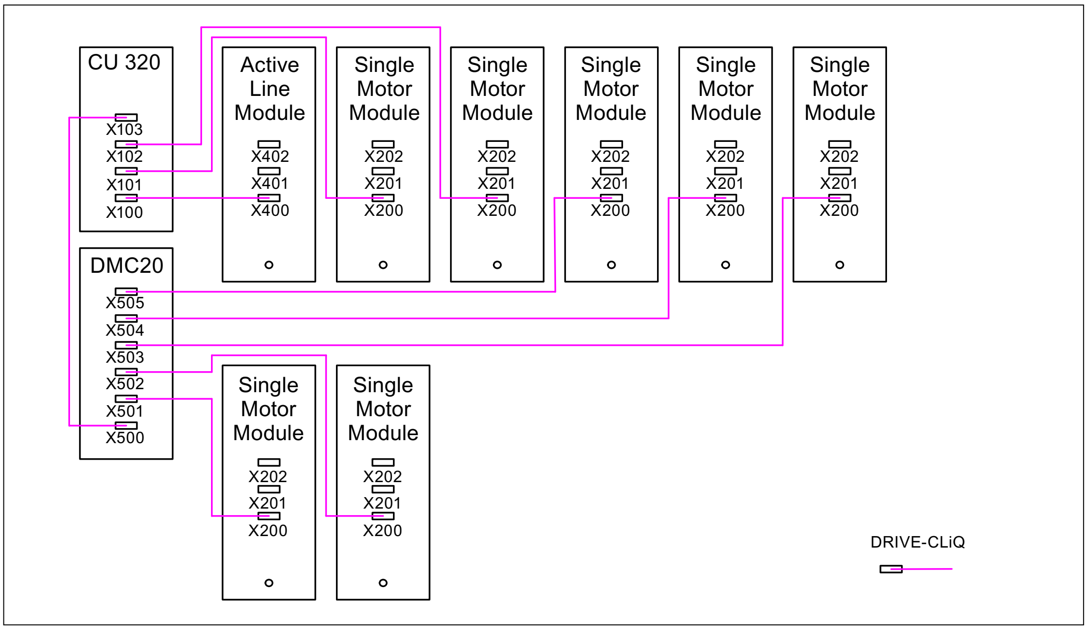


Figure 11-5 Example: topology vector V/f hot plugging

> **Note**
>
> In order to disconnect and isolate the power unit from the DC link, additional measures must be applied - such as DC link wiring through the DC link infeed adapter and DC link disconnecting devices. The safety information and instructions in the Equipment Manual must be carefully observed.

11.4.5 Instructions for offline commissioning with STARTER

With automatic online configuration in STARTER, the DMC20 is detected and adopted in the topology. Offline commissioning requires the following operation steps:

1. Configure a drive unit offline
2. Right-click on Topology -> enter new object -> DRIVE-CLiQ Hub
3. Configuring a topology

11.4.6 Overview of key parameters (see SINAMICS S List Manual)

- p0105 Activate/deactivate drive object
- r0106 Drive object active/inactive
- p0897 BI: Parking axis selection
- r0896.0 BO: Parking axis status word
- p0151 DRIVE-CLiQ Hub component number
- p0154 DRIVE-CLiQ Hub identification using LED
- p0157 DRIVE-CLiQ Hub EPROM data version
- r0158 DRIVE-CLiQ Hub firmware version

11.5 Control Units without infeed control

11.5.1 Description

Description

To ensure that the drive line-up functions satisfactorily, you must ensure – among other things – that the drives only draw power from the DC link when the infeed is in operation. In a DC link line-up that is controlled by just one Control Unit and in which a drive object has an infeed, the BICO interconnection p0864 = p0863.0 is established automatically during commissioning.

In the following cases, the BICO input p0864 must be supplied manually:

- Smart Line Modules without DRIVE-CLiQ (5 kW and 10 kW)
- DC link line-up with more than one Control Unit

11.5.2 Examples: interconnecting "Infeed ready"

Smart Line Modules without DRIVE-CLiQ (5 kW and 10 kW)

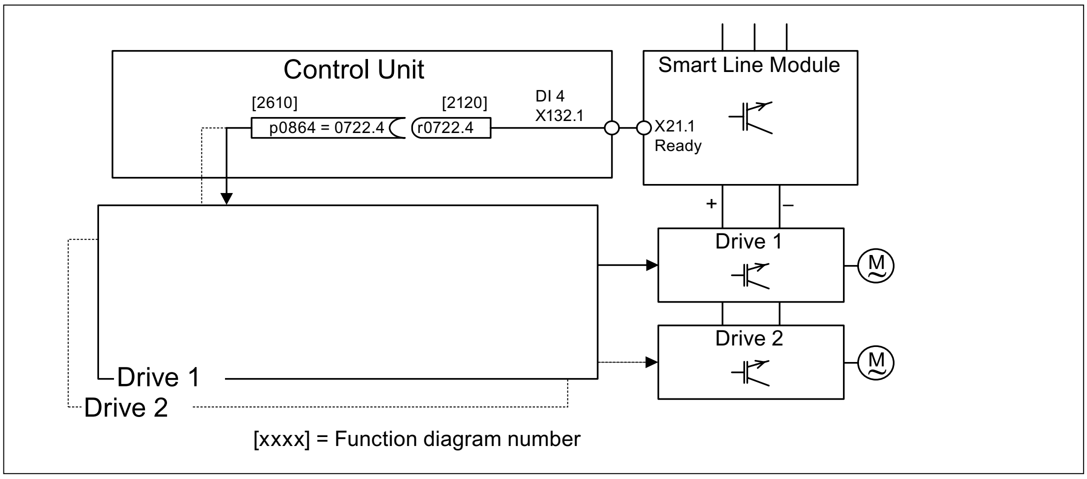


Figure 11-6 Example: interconnecting a Smart Line Module without DRIVE-CLiQ

DC link line-up with more than one Control Unit

In the following example, two Control Units control drives that are connected to the same DC link. The source for the " Infeed operation" signal can also be a digital input.

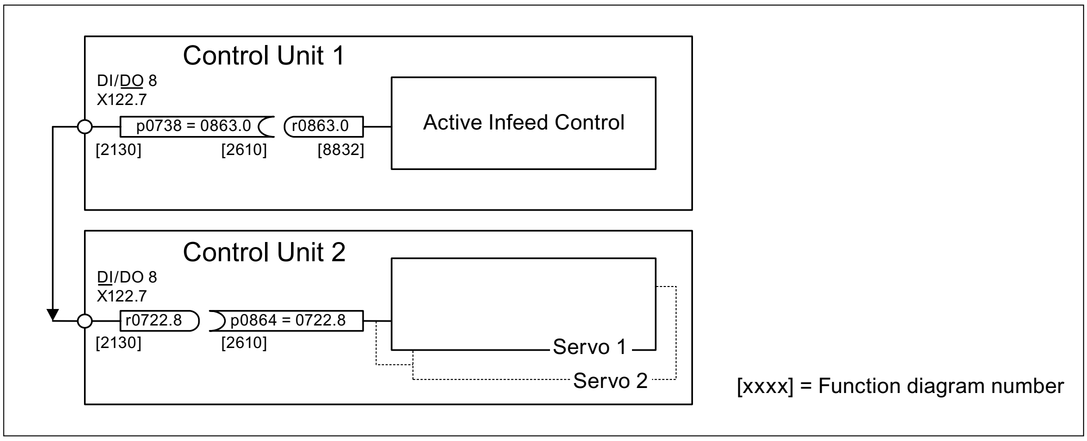


Figure 11-7 Example: interconnection with more than one Control Unit

11.6 Application: emergency stop with power failure and/or emergency stop (Servo)

11.6.1 Introduction

If the power fails, a drive line-up normally responds with OFF2 even when a Control Supply Module is used in conjunction with a Braking Module (i.e. the connected motors coast down). The Control Supply Module provides the electronics with power via the supply system or DC link. In this way, controlled movements can be made if a power failure occurs, for example, provided that the DC link voltage is available. The following section describes how all the drives carry out an emergency stop (OFF3) if the power fails.

11.6.2 Description

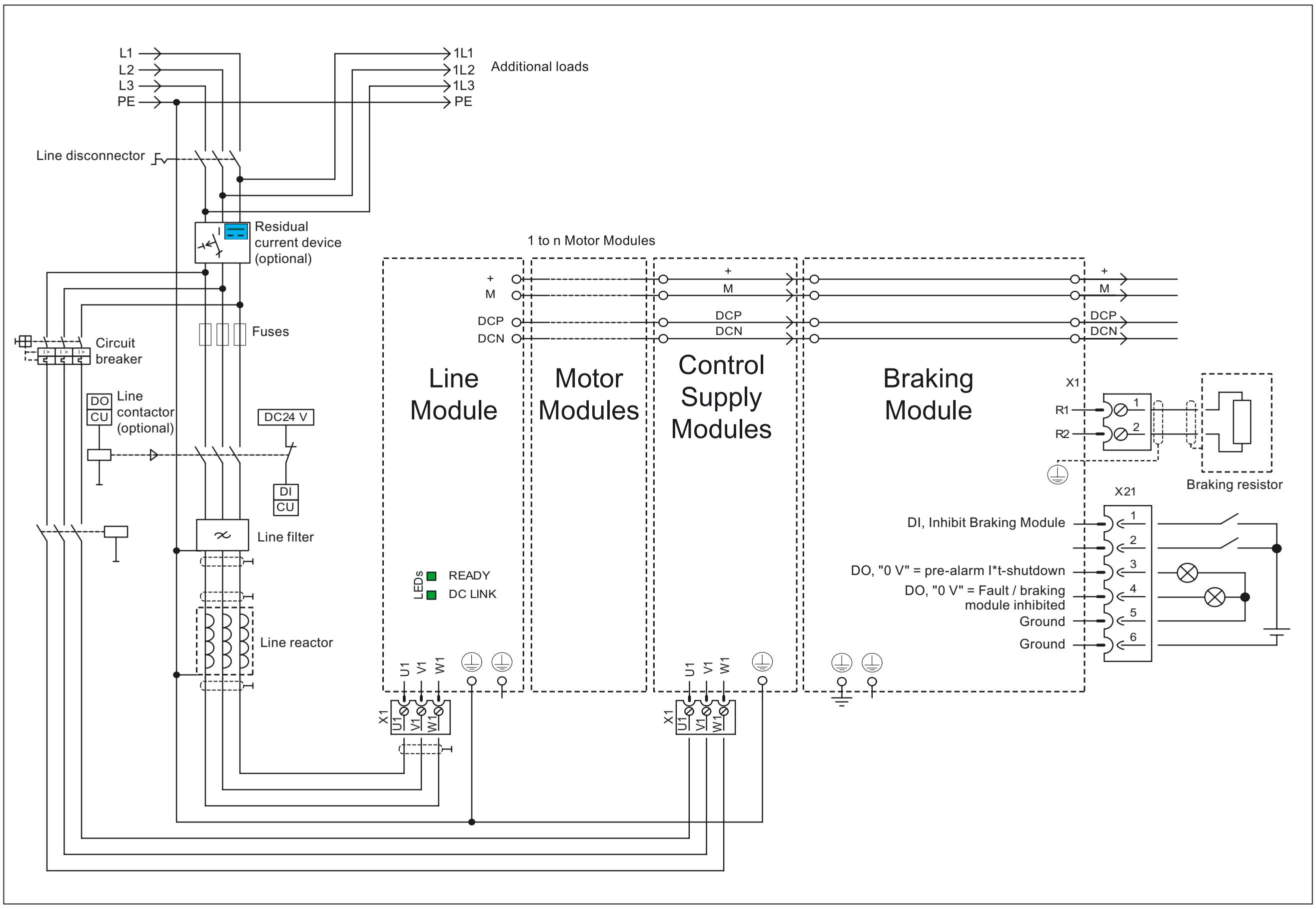


Figure 11-8 Example: interconnection of emergency stop due to power failure or emergency off

In addition to the component wiring shown above, each drive object that is to carry out an emergency stop if the power fails needs to be parameterized. If parameterization is not carried out, the drive coasts down once a DC link undervoltage has been identified (OFF2). To implement the OFF3 function (emergency stop), the following parameters need to be set:

- p1240 = 5 (activates VDC_min monitoring)

  As well as the DC link monitor, which is always active, this activates another variable alarm threshold, which should be set to a value above the undervoltage shutdown threshold of 360 V +/–2% in p1248.

- p1248 = Active Line Module <= 570 V, Smart Line Module <= 510 V

  (alarm threshold in V). When this threshold is reached, fault 7403 is triggered. This threshold indicates that the set value has been undershot.

- p2100.0 = 7403

  (Number of the fault for which a response is to be defined.)

- p2101.0 = 3 (OFF3) response to the fault entered in p2100.0

Basic information about the drive system 12

12.1 Parameter

Parameter types

The following adjustable and display parameters are available:

- Adjustable parameters (write/read)

  These parameters have a direct impact on the behavior of a function.

  Example: Ramp-up and ramp-down time of a ramp function generator
- Display parameters (read only)

  These parameters are used to display internal variables.

  Example: Current motor current

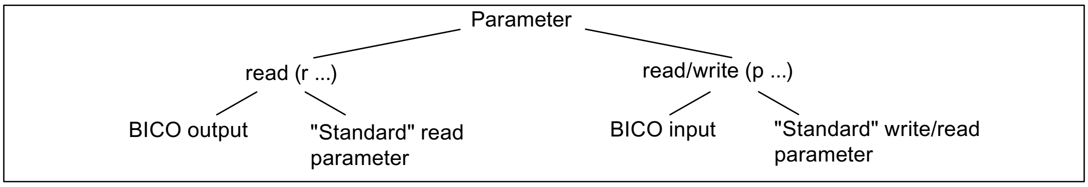


Figure 12-1 Parameter types

All these drive parameters can be read and changed via PROFIBUS using the mechanisms defined in the PROFIdrive profile.

Parameter categories

The parameters of the individual drive objects are categorized into data sets as follows:

- Data-set-independent parameters

  These parameters exist only once per drive object.
- Data-set-dependent parameters

  These parameters can exist several times for each drive object and can be addressed via the parameter index for reading and writing. A distinction is made between various types of data set:
  - CDS: Command Data Set

    By parameterizing several command data sets and switching between them, the drive can be operated with different pre-configured signal sources.

– DDS: Drive Data Set

  The drive data set contains the parameters for switching between different drive control configurations.

The CDS and DDS can be switched over during normal operation. Further types of data set also exist, however these can only be activated indirectly by means of a DDS switchover.

- EDS Encoder Data Set
- MDS Motor Data Set

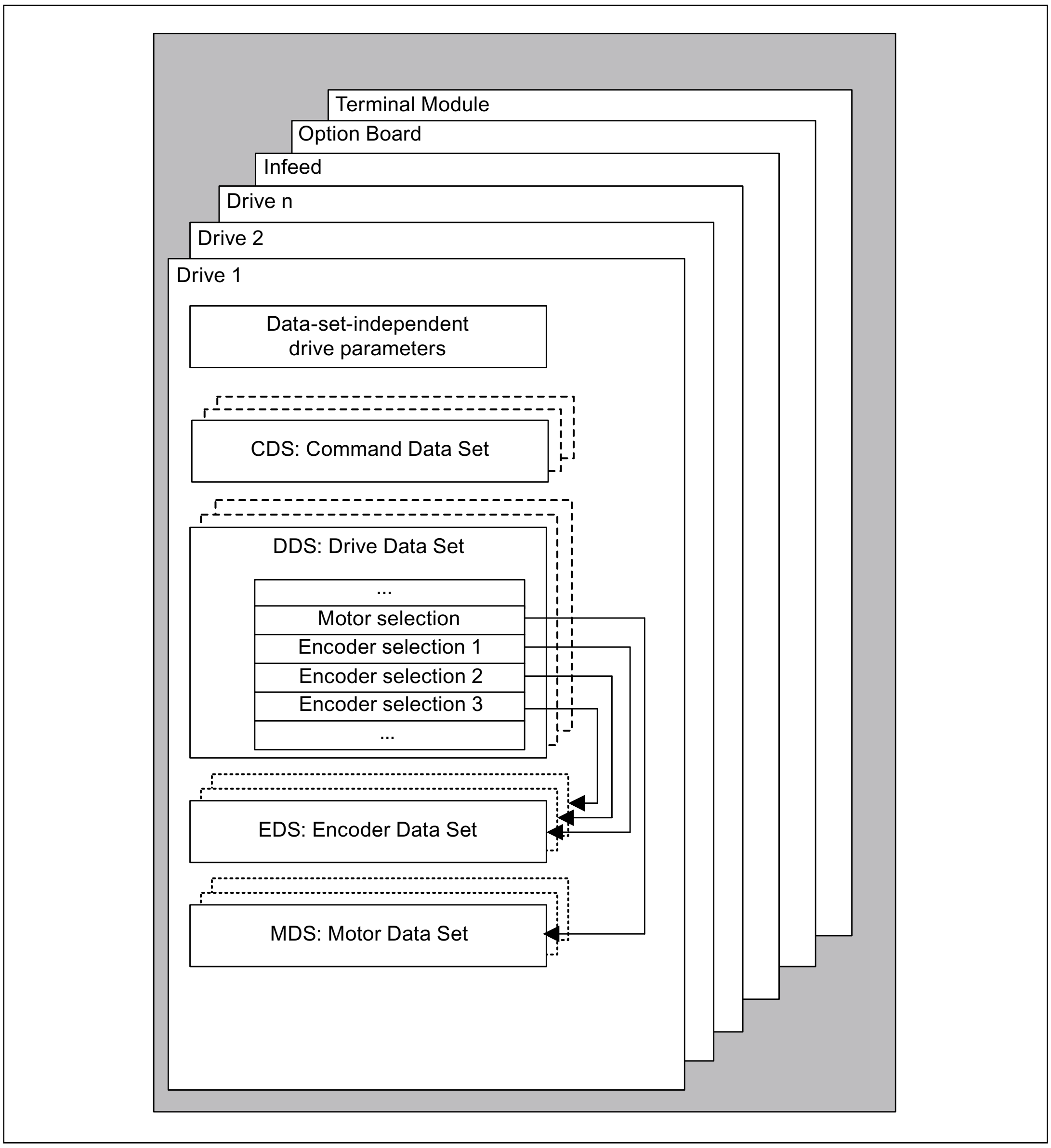


Figure 12-2 Parameter categories

Saving parameters in a non-volatile memory

The modified parameter values are stored in the volatile RAM. When the drive system is switched off, this data is lost.

The data has to be saved as follows in a non-volatile manner on the CompactFlash card so that it is available the next time the drive is switched on.

- Save parameters - device and all drives

  p0977 = 1; automatically reset to 0
- Save the parameters with STARTER

  See "Copy RAM to ROM" function

Resetting parameters

The parameters can be reset to the factory setting as follows:

- Reset parameters - current drive object

  p0970 = 1; automatically reset to 0
- Reset parameters - all parameters drive object "Control Unit"

  p0009 = 30 parameter reset

  p0976 = 1; automatically reset to 0

Access level

The parameters are subdivided into access levels. The SINAMICS S List Manual specifies in which access level the parameter is displayed and can be changed. The required access levels 0 to 4 can be set in p0003.

Table 12-1 Access levels

Access level	Remark
0 User-defined	Parameter from the user-defined list (p0013)
1 Standard	Parameters for the simplest operator functions (e.g. p1120 = ramp function generator ramp-up time).
2 Extended	Parameters to handle the basic functions of the device.
3 Expert	Expert knowledge is already required for this parameter (e.g. knowledge about BICO parameterization).
4 Service	Please contact your local Siemens office for the password for parameters with access level 4 (Service). It must be entered into p3950.

Note

Parameter p0003 is CU-specific (belongs to Control Unit).

12.2 Data sets

12.2.1 CDS: Command Data Set

CDS: Command Data Set

The BICO parameters (binector and connector inputs) are grouped together in a command data set. These parameters are used to interconnect the signal sources of a drive.

By parameterizing several command data sets and switching between them, the drive can be operated with different pre-configured signal sources.

A command data set contains the following (examples):

- Binector inputs for control commands (digital signals)
  - ON/OFF, enable signals (p0844, etc.)
  - Jog (p1055, etc.)
- Connector inputs for setpoints (analog signals)
  - Voltage setpoint for V/f control (p1330)
  - Torque limits and scaling factors (p1522, p1523, p1528, p1529)

A drive object can – depending on the type – manage up to 4 command data sets. The number of command data sets is configured with p0170.

The following parameters are available for selecting command data sets and for displaying currently selected command data sets - e.g. in the vector mode, the following parameters are available:

Binector inputs p0810 to p0811 are used to select a command data set. They represent the number of the command data set (0 to 3) in binary format (where p0811 is the most significant bit).

- p0810 BI: Command data set selection CDS bit 0
- p0811 BI: Command data set selection CDS bit 1

If a command data set that does not exist is selected, the current data set remains active. The selected data set is displayed using parameter (r0836).

Example: Switching between command data set 0 and 1

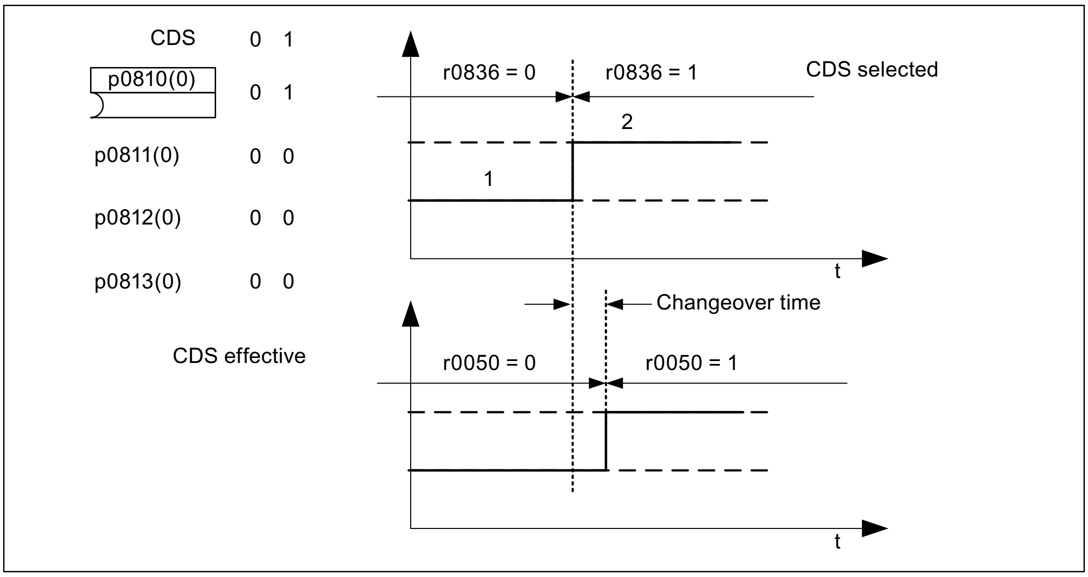


Figure 12-3 Switching the command data set (example)

12.2.2 DDS: Drive Data Set

DDS: Drive Data Set

A drive data set contains various adjustable parameters that are relevant with respect to open and closed-loop drive control:

- Numbers of the assigned motor and encoder data sets:
  - p0186: assigned motor data set (MDS)
  - p0187 to p0189: up to 3 assigned encoder data sets (EDS)
- Various control parameters, e.g.:
  - Fixed speed setpoints (p1001 to p1015)
  - Speed limits min./max. (p1080, p1082)
  - Characteristic data of ramp-function generator (p1120 ff)
  - Characteristic data of controller (p1240 ff)
  - ...

The parameters that are grouped together in the drive data set are identified in the SINAMICS S List Manual by "Data Set DDS" and are assigned an index [0..n].

More than one drive data set can be parameterized. You can switch easily between different drive configurations (control type, motor, encoder) by selecting the corresponding drive data set.

One drive object can manage up to 32 drive data sets. The number of drive data sets is configured with p0180.

Binector inputs p0820 to p0824 are used to select a drive data set. They represent the number of the drive data set (0 to 31) in binary format (where p0824 is the most significant bit).

- p0820 BI: Drive data set selection DDS, bit 0
- p0821 BI: Drive data set selection DDS, bit 1
- p0822 BI: Drive data set selection DDS, bit 2
- p0823 BI: Drive data set selection DDS, bit 3
- p0824 BI: Drive data set selection DDS, bit 4

Supplementary conditions and recommendations

- Recommendation for the number of drive data sets for a drive

  The number of drive data sets for a drive should correspond to the options for switchover. The following must, therefore, apply:

  p0180 (DDS) ≥ max. (p0120 (PDS), p0130 (MDS))
- Maximum number of DDS for one drive object = 32 DDS

12.2.3 EDS: Encoder Data Set

EDS: Encoder Data Set

An encoder data set contains various adjustable parameters describing the connected encoder for the purpose of configuring the drive.

- Adjustable parameters, e.g.:
  - Encoder interface component number (p0141)
  - Encoder component number (p0142)
  - Encoder type selection (p0400)

The parameters that are grouped together in the encoder data set are identified in the parameter list by "Data Set EDS" and are assigned an index [0..n].

A separate encoder data set is required for each encoder controlled by the Control Unit. Up to 3 encoder data sets are assigned to a drive data set via parameters p0187, p0188, and p0189.

An encoder data set can only be changed over using a DDS changeover.

An encoder data set changeover without pulse inhibit (motor running under current) may only be performed on adjusted encoders (pole position ID performed or commutation angle determined for absolute encoders).

Each encoder may only be assigned to one drive and within a drive must - in each drive data set - either always be encoder 1, always encoder 2 or always encoder 3.

Using a power unit for the alternating operation of several motors would be an EDS changeover application. Contactors are changed-over so that the power unit can be connected to the different motors. Each of the motors can be equipped with an encoder or can also be operated without an encoder (sensorless operation). Each encoder must be connected to its own SMx.

If encoder 1 (p0187) is changed over via DDS, then an MDS must also be changed over.

One drive object can manage up to 16 encoder data sets. The number of encoder data sets configured is specified in p0140.

When a drive data set is selected, the assigned encoder data sets are also selected.

12.2.4 MDS: Motor Data Set

MDS: Motor Data Set

A motor data set contains various adjustable parameters describing the connected motor for the purpose of configuring the drive (see table 6-2). It also contains certain visualization parameters with calculated data.

- Adjustable parameters, e.g.:
  - Motor component number (p0131)
  - Motor type selection (p0300)
  - Rated motor data (p0304 ff)
  - ...
- Visualization parameters, e.g.:
  - Calculated rated data (p0330 ff)
  - ...

The parameters that are grouped together in the motor data set are identified in the SINAMICS S List Manual by "Data Set MDS" and are assigned an index [0..n].

A separate motor data set is required for each motor that is controlled by the Control Unit via a Motor Module. The motor data set is assigned to a drive data set via parameter p0186.

A motor data set can only be changed using a DDS changeover. The motor data set changeover is, for example, used for:

- Switching over different motors
- Switching over different windings in a motor (e.g. star-delta switchover)
- Adapting the motor data

If several motors are operated alternately on a Motor Module, a matching number of drive data sets must be created. For further information about motor changeover, see the "Motor switchover" section in the Function Manual.

One drive object can manage up to 16 motor data sets. The number of motor data sets in p0130 must not exceed the number of drive data sets in p0180.

For the 611U interface mode (p2038 = 1), the drive data sets are divided into groups of eight (1-8; 8-16;...). Within a group, the assignment to the motor data set must be identical:

p0186[0] = p0186[1] = ... = p0186[7]
p0186[8] = p0186[9] = ... = p0186[15]

p0186[16] = p0186[17] = ... = p0186[23]
p0186[24] = p0186[25] = ... = p0186[31]

If this rule is not observed, alarm A07514 is output. If you need a precise representation of the data set structure of the 611U, 32 drive data sets and 4 motor data sets must be configured.

Examples for a data set assignment

Table 12-2 Example, data set assignment

DDS	Motor (p0186)	Encoder 1 (p0187)	Encoder 2 (p0188)	Encoder 3 (p0189)
DDS 0	MDS 0	EDS 0	EDS 1	EDS 2
DDS 1	MDS 0	EDS 0	EDS 3	-
DDS 2	MDS 0	EDS 0	EDS 4	EDS 5
DDS 3	MDS 1	EDS 6	-	-

Copying a command data set

Set parameter p0809 as follows:

1. p0809[0] = Number of the command data set to be copied (source)
2. p0809[1] = Number of the command data to which the data is to be copied (target)
3. p0809[2] = 1

Start copying.

Copying is finished when p0809[2] = 0.

Note

In STARTER, you can copy the command data sets (Drive -> Configuration -> "Command data sets" tab page).

You can select the displayed command data set in the relevant STARTER screens.

Copying a drive data set

Set parameter p0819 as follows:

1. p0819[0] = Number of the drive data set to be copied (source)
2. p0819[1] = Number of the drive data set to which the data is to be copied (target)
3. p0819[2] = 1

Start copying.

Copying is finished when p0819[2] = 0.

Note

In STARTER, you can copy the drive data sets (Drive -> Configuration -> "Drive data sets" tab page).

You can select the displayed drive data set in the relevant STARTER screens.

Copying the motor data set

Set parameter p0139 as follows:

1. p0139[0] = Number of the motor data set that is to be copied (source)
2. p0139[1] = Number of the motor data set which should be copied into (target)
3. p0139[2] = 1

Start copying.

Copying has been completed, if p0139[2] = 0.

Note

In STARTER, you can set the drive data sets via the drive configuration.

12.2.5 Integration

Function diagrams (see SINAMICS S List Manual)

- 8560 Command Data Sets (CDS)
- 8565 Drive Data Sets (DDS)
- 8570 Encoder data sets (EDS)
- 8575 Motor Data Sets (MDS)

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p0120 Power unit data sets (PDS) number
- p0130 Motor data sets (MDS) number
- p0139 Copy motor data set (MDS)
- p0140 Encoder data sets (EDS) number
- p0170 Command data set (CDS) number
- p0180 Drive data sets (DDS) number
- p0186 Motor data set (MDS) number

- p0187 Encoder 1 encoder data set number
- p0188 Encoder 2 encoder data set number
- p0189 Encoder 3 encoder data set number
- p0809 Copy command data set (CDS)
- p0810 BI: Command data set selection CDS bit 0
- p0811 BI: Command data set selection CDS bit 1
- p0812 BI: Command data set selection CDS bit 2
- p0813 BI: Command data set selection CDS bit 3
- p0819[0...2] Copy drive data set DDS
- p0820 BI: Drive data set selection DDS, bit 0
- p0821 BI: Drive data set selection DDS, bit 1
- p0822 BI: Drive data set selection DDS, bit 2
- p0823 BI: Drive data set selection DDS, bit 3
- p0824 BI: Drive data set selection DDS, bit 4

12.3 Drive objects

A drive object is a self-contained software function with its own parameters and, if necessary, its own faults and alarms. Drive objects can be provided as standard (e.g. I/O evaluation), or you can add single (e.g. terminal board) or multiple objects (e.g. drive control).

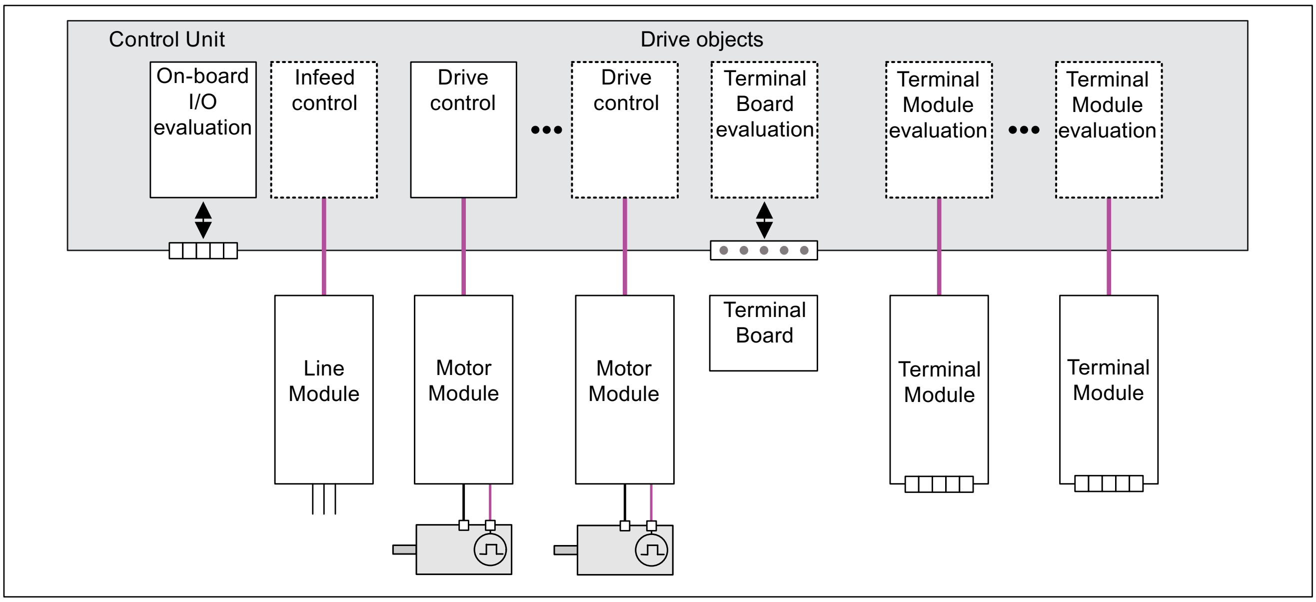


Figure 12-4 Drive objects

Overview of drive objects

- Drive control

  The drive control handles closed-loop control of the motor. At least 1 Motor Module and at least 1 motor and up to 3 sensors are assigned to the drive control.

  Various types of drive control can be configured (e.g. servo control, vector control, etc.).

  Several drive controls can be configured, depending on the performance of the Control Unit and the demands made on the drive control system.
- Control Unit, inputs/outputs

  The I/Os on the Control Unit are evaluated within a drive object. High-speed inputs for probes are processed here in addition to bidirectional digital I/Os.
- Properties of a drive object
  - Separate parameter space
  - Separate window in STARTER
  - Separate fault/alarm system
  - Separate PROFIdrive telegram for process data
- Supply: Line Module infeed control with DRIVE-CLiQ interface

  If an Active Line Module with a DRIVE-CLiQ interface is used for the infeed in a drive system, open-loop/closed-loop control is implemented on the Control Unit within a corresponding drive object.
- Supply: Line Module infeed control with DRIVE-CLiQ interface

  If a Line Module without a DRIVE-CLiQ interface is used for the infeed in a drive system, the Control Unit must handle activation and evaluation of the corresponding signals (RESET, READY).
- Option Board evaluation

  A further drive object is responsible for evaluating an installed Option Board. The specific method of operation depends on the type of Option Board installed.
- Terminal Module evaluation

  A separate drive object handles evaluation of the respective optional Terminal Modules.

Configuring drive objects

During initial commissioning in STARTER, the drive objects processed by means of software in the Control Unit are created via configuration parameters. Various drive objects can be created within a Control Unit.

The drive objects are configurable function blocks and are used to execute specific drive functions.

If you need to configure additional drive objects or delete existing ones after initial commissioning, the drive system must be switched to configuration mode.

The parameters of a drive object cannot be accessed until the drive object has been configured and you have switched from configuration mode to parameterization mode.

Note

Each installed drive object is allocated a number between 0 and 63 during initial commissioning for unique identification.

Overview of key parameters (see SINAMICS S List Manual)

Adjustable parameters

- p0101 Drive object numbers
- p0107 Drive object type
- p0108 Drive object configuration

Display parameters

- r0102 Number of drive objects

12.4 BICO technology: interconnecting signals

12.4.1 Description

Description

Every drive contains a large number of interconnectable input and output variables and internal control variables.

BICO technology (Binector Connector Technology) allows the drive to be adapted to a wide variety of conditions.

Digital and analog signals, which can be interconnected as required by means of BICO parameters, are identified by the prefix BI, BO, CI, or CO in their parameter name.

These parameters are identified accordingly in the parameter list or in the function diagrams.

Note

The STARTER parameterization and commissioning tool is recommended when using BICO technology.

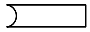
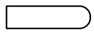
12.4.2 Binectors, connectors

Binectors, BI: Binector Input, BO: Binector Output

A binector is a digital (binary) signal without a unit which can assume the value 0 or 1.

Binectors are subdivided into binector inputs (signal sink) and binector outputs (signal source).

Table 12-3 Binectors

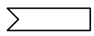
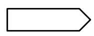
Abbreviation	Symbol	Name	Description
BI		Binector input Binector input (signal sink)	Can be interconnected to a binector output as source. The number of the binector output must be entered as a parameter value.
BO		Binector output Binector output (signal source)	Can be used as a source for a binector input.

Connectors, CI: Connector Input, CO: Connector Output

A connector is a digital signal, e.g. in the 32-bit format. It can be used to emulate words (16 bit), double words (32 bit) or analog signals. Connectors are subdivided into connector inputs (signal sink) and connector outputs (signal source).

The options for interconnecting connectors are restricted to ensure that performance is not adversely affected.

Table 12-4 Connectors

Abbreviation	Symbol	Name	Description
CI		Connector input Connector input (signal sink)	Can be interconnected to a connector output as source. The number of the connector output must be entered as a parameter value.
CO		Connector output Connector output (signal source)	Can be used as a source for a connector input.

12.4.3 Interconnecting signals using BICO technology

To interconnect two signals, a BICO input parameter (signal sink) must be assigned to the required BICO output parameter (signal source).

The following information is required for connecting a binector/connector input to a binector/connector output:

- Binectors: Parameter number, bit number, and drive object ID
- Connectors with no index: Parameter number and drive object ID
- Connectors with index: Parameter number, index, and drive object ID
- Data type (signal source for connector output parameter)

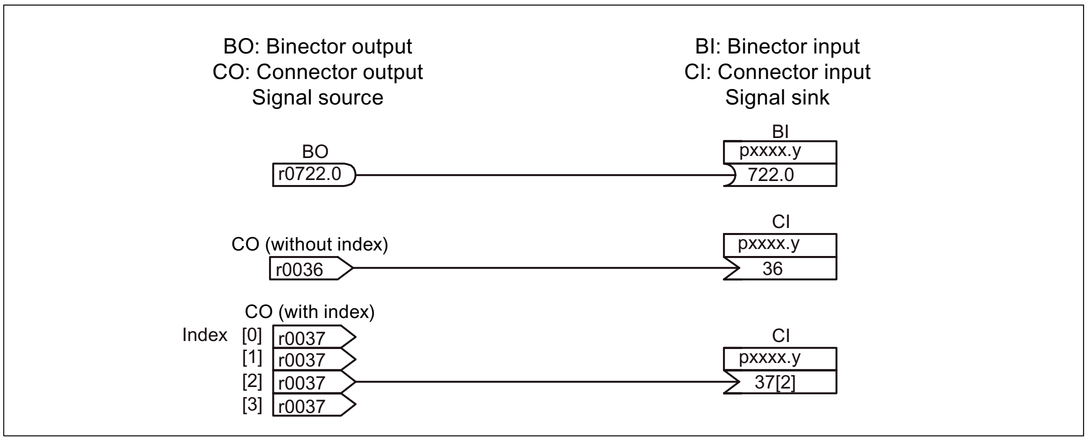


Figure 12-5 Interconnecting signals using BICO technology

Note

A connector input (CI) cannot be interconnected with any connector output (CO, signal source). The same applies to the binector input (BI) and binector output (BO).
For each CI and BI parameter, the parameter list shows under "data type" the information on the data type of the parameter and the data type of the BICO parameter.
For CO parameters and BO parameters, only the data type of the BICO parameter is shown.
Notation:
Data types BICO input: Data type parameter / Data type BICO parameter
Example: Unsigned32 / Integer16
Data types BICO output: Data type BICO parameter
Example: FloatingPoint32

The possible interconnections between the BICO input (signal sink) and the BICO output (signal source) are listed in the following documents:
References: /LH1/ SINAMICS S List Manual
Chapter "Explanations on parameter list" in table "Possible combinations for BICO interconnection".

The BICO parameter interconnection can be implemented in different command data sets (CDS). The different interconnections are activated by switching data sets. Interconnections across drive objects are also possible.

12.4.4 Internal encoding of the binector/connector output parameters

The internal codes are required for writing BICO input parameters via PROFIBUS, for example.

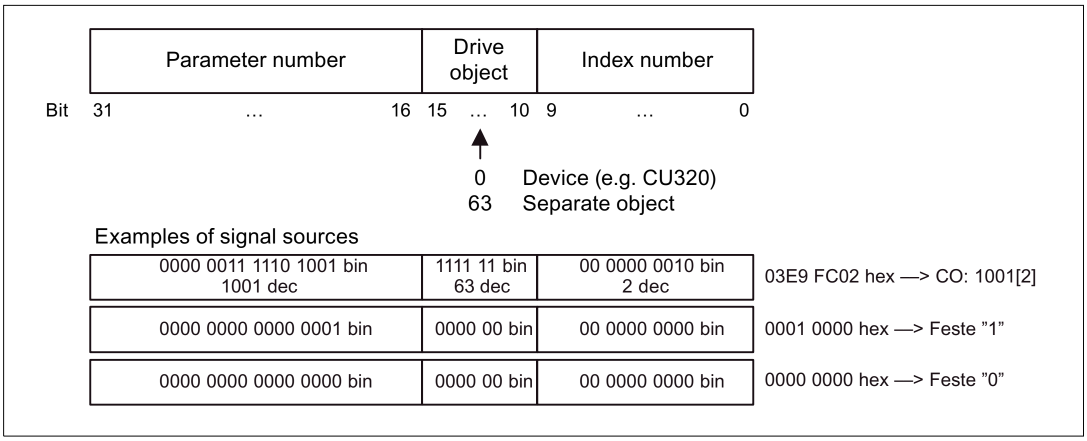


Figure 12-6 Internal encoding of the binector/connector output parameters

12.4.5 Sample interconnections

Example 1: Interconnection of digital signals

Suppose you want to operate a drive via terminals DI 0 and DI 1 on the Control Unit using jog 1 and jog 2.

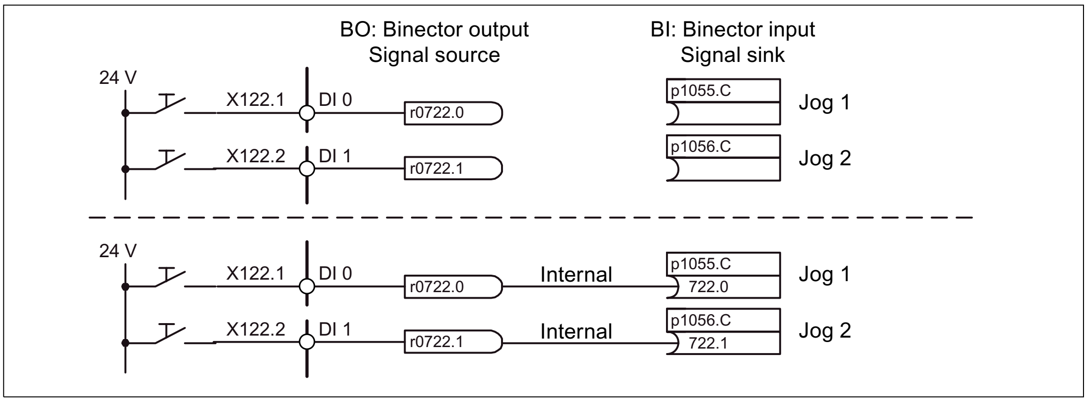


Figure 12-7 Interconnection of digital signals (example)

Example 2: Connection of OFF3 to several drives

The OFF3 signal is to be connected to two drives via terminal DI 2 on the Control Unit.

Each drive has a binector input 1. OFF3 and 2. OFF3. The two signals are processed via an AND gate to STW1.2 (OFF3).

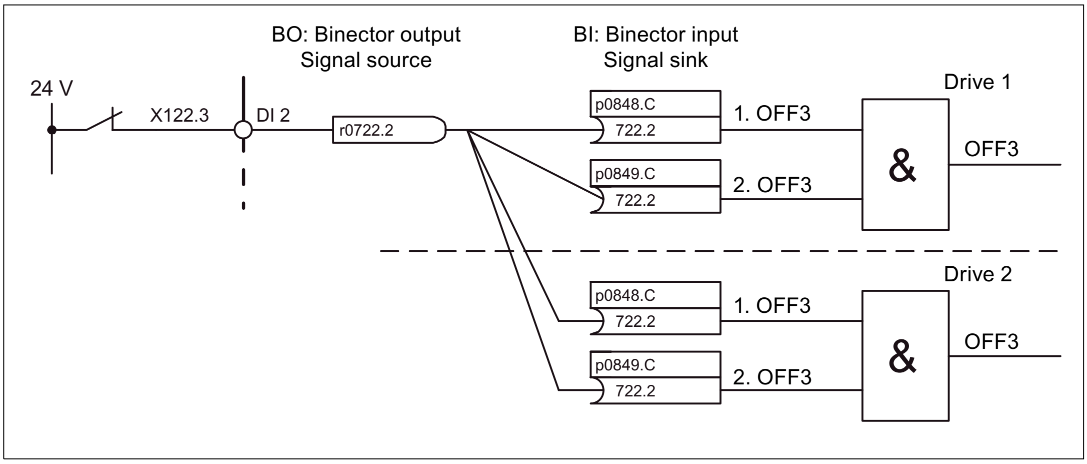


Figure 12-8 Connection of OFF3 to several drives (example)

12.4.6 BICO technology

BICO interconnections to other drives

The following parameters are available for BICO interconnections to other drives:

- r9490 Number of BICO interconnections to other drives
- r9491[0...15] BI/CI of BICO interconnections to other drives
- r9492[0...15] BO/CO of BICO interconnections to other drives
- p9493[0...15] Reset BICO interconnections to other drives

Copying drives

When a drive is copied, the interconnection is copied with it.

Binector-connector converters and connector-binector converters

Binector-connector converter

- Several digital signals are converted to a 32-bit integer double word or to a 16-bit integer word.
- p2080[0...15] BI: PROFIdrive PZD send bit-serial

Connector-binector converter

- A 32-bit integer double word or a 16-bit integer word is converted to individual digital signals.
- p2099[0...1] CI: PROFIdrive PZD selection receive bit-serial

Fixed values for interconnection using BICO technology

The following connector outputs are available for interconnecting any fixed value settings:

- p2900[0...n] CO: Fixed value_%_1
- p2901[0...n] CO: Fixed value_%_2
- p2930[0...n] CO: Fixed value_M_1

Example:

These parameters can be used to interconnect the scaling factor for the main setpoint or to interconnect an additional torque.

12.4.7 Scaling

Signals for the analog outputs

Table 12-5 List of signals for analog outputs

Signal	Parameter	Unit	Normalization (100 % = ...)
Speed setpoint before the setpoint filter	r0060	RPM	p2000
Speed actual value motor encoder	r0061	RPM	p2000
Actual speed	r0063	RPM	p2000
Drive output frequency	r0066	Hz	Reference frequency
Absolute current actual value	r0068	Aeff	p2002
Actual DC link voltage value	r0070	V	p2001
Total torque setpoint	r0079	Nm	p2003
Actual active power	r0082	kW	r2004
Control deviation	r0064	RPM	p2000
Modulation depth	r0074	%	Reference control factor
Current setpoint, torque-generating	r0077	A	p2002
Current actual value, torque-generating	r0078	A	p2002
Flux setpoint	r0083	%	Reference flux
Flux actual value	r0084	%	Reference flux
Speed controller PI torque output	r1480	Nm	p2003
Speed controller I torque output	r1482	Nm	p2003

Changing scaling parameters p2000 to p2007

CAUTION
If a referenced form is selected and the reference parameters (e.g. p2000) are changed retrospectively, the referenced values of some of the control parameters are also adjusted to ensure that the control behavior is unaffected.

12.5 Inputs/outputs

12.5.1 Overview of inputs/outputs

The following digital/analog inputs/outputs are available:

Table 12-6 Overview of inputs/outputs

Component	Digital			Analog	
	Inputs	Bidirectional inputs/outputs	Outputs	Inputs	Outputs
CU310	4 1)	4 3)			
CU320	8 1)	8 2)			
TB30	4	-	4	2	2
TM15	-	24	-	-	-
TM31	8	4	-	2	2
	Relay outputs: 2 Temperature sensor input: 1				
TM41	4	4	-	1	-
	Incremental encoder emulation: 1 (see also the Function Manual)				
1) Variable: floating or non-floating 2) 6 of these are "high-speed inputs" 3) 3 of these are "high-speed inputs"					

Note

For detailed information about the hardware properties of I/Os, please refer to:
Reference: /GH1/ SINAMICS S120 Equipment Manual: Control Units

For detailed information about the structural relationships between all I/Os of a component and their parameters, please refer to the function diagrams in:
Reference: /LH1/ SINAMICS S List Manual

12.5.2 Digital inputs/outputs

Digital inputs

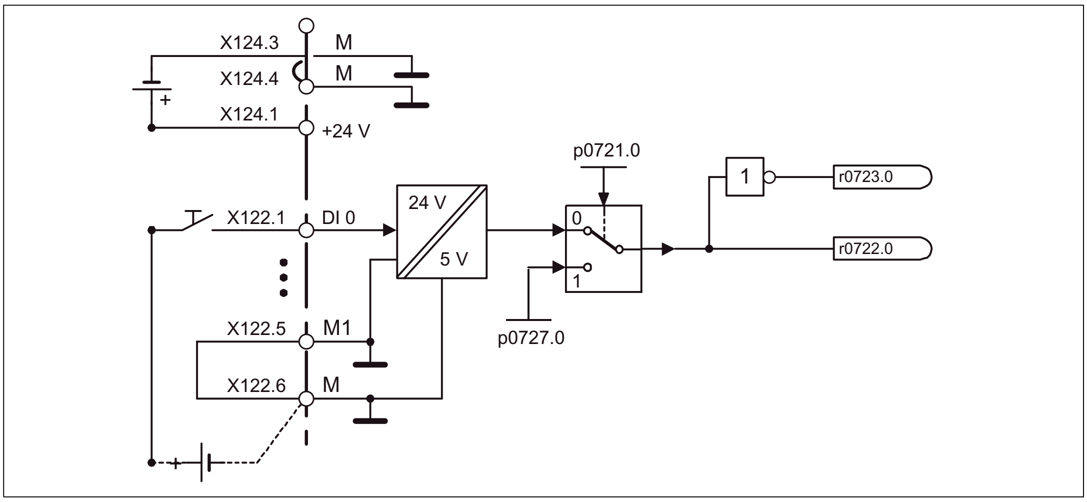


Figure 12-9 Digital inputs: signal processing using DI 0 of CU320 as an example

Properties

- The digital inputs are "high active".
- An open input is interpreted as "low".
- Fixed debouncing setting

  Delay time = 1 to 2 current controller cycles (p0115[0])
- Availability of the input signal for further interconnection
  - inverted and not inverted as a binector output
  - as a connector output
- Simulation mode settable and parameterizable.
- CU320: Isolation block by block, set by jumper.
  - Jumper open: electrically isolated.
    The digital inputs function only if a reference ground is connected.
  - Jumper closed, non-floating.
    The reference potential of the digital inputs is the ground of the Control Unit.
- Sampling time for digital inputs/outputs adjustable on CU320 (p0799)

Function diagrams (see SINAMICS S List Manual)

- 2020 Digital inputs, electrically isolated (DI 0 ... DI 3)
- 2120 Digital inputs, electrically isolated (DI 0 ... DI 3)
- 2121 Digital inputs, electrically isolated (DI 4 ... DI 7)

- 9100 Digital inputs, electrically isolated (DI 0 ... DI 3)
- 9400 Digital inputs/outputs, bidirectional (DI 0 ... DI 7)
- 9401 Digital inputs/outputs, bidirectional (DI 8 ... DI 15)
- 9402 Digital inputs/outputs, bidirectional (DI 16 ... DI 23)
- 9550 Digital inputs, electrically isolated (DI 0 ... DI 3)
- 9552 Digital inputs, electrically isolated (DI 4 ... DI 7)
- 9660 Digital inputs, electrically isolated (DI 0 ... DI 3)

Digital outputs

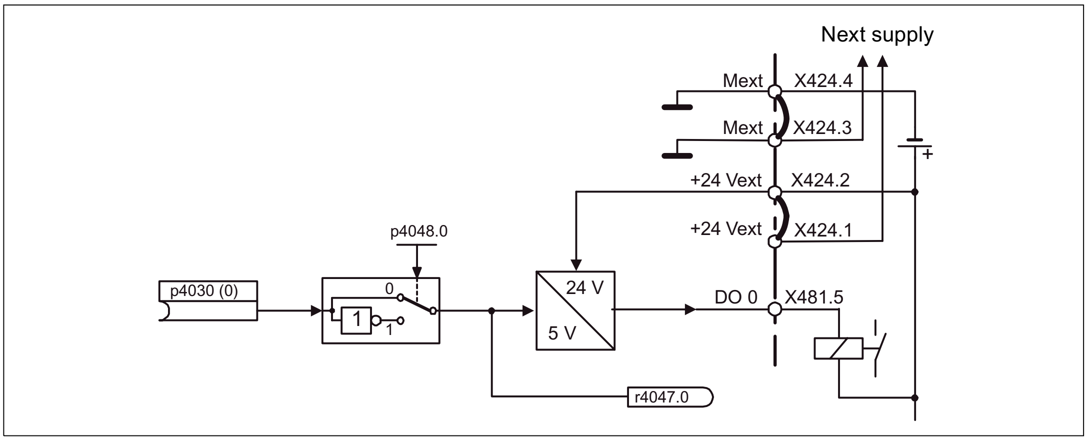


Figure 12-10 Digital outputs: signal processing using DO 0 of TB30 as an example

Properties

- Separate power supply for the digital outputs.
- Source of output signal can be selected by parameter.
- Signal can be inverted by parameter.
- Status of output signal can be displayed
  - as a binector output
  - as a connector output

> **Note**
>
> Before the digital outputs can function, their own electronics power supply must be connected.

Function diagrams (see SINAMICS S List Manual)

- 9102 Electrically isolated digital outputs (DO 0 to DO 3)
- 9556 Digital relay outputs, electrically isolated (DO 0 and DO 1)

Bidirectional digital inputs/outputs

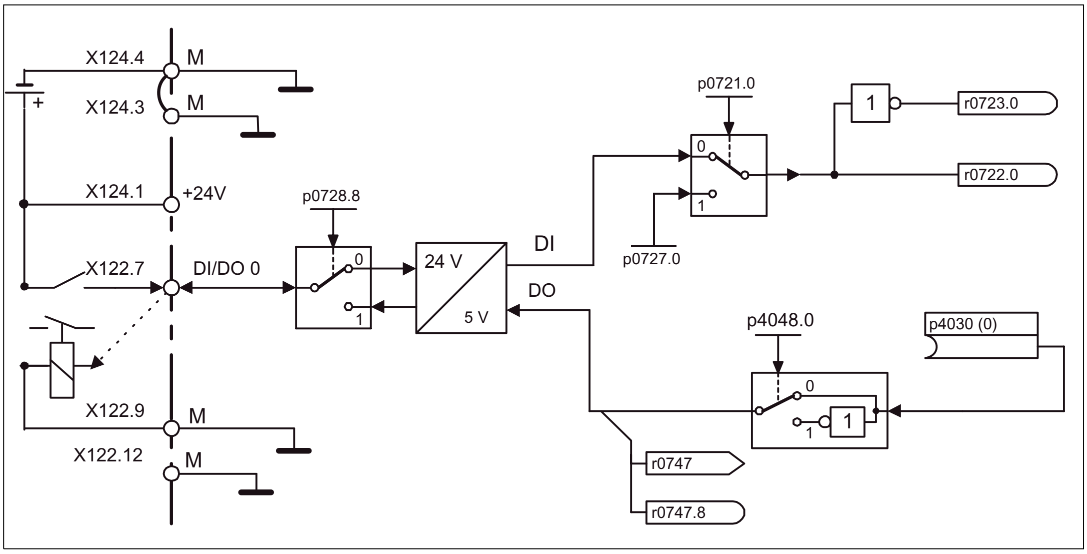


Figure 12-11 Bidirectional inputs/outputs: signal processing using DI/DO 0 of CU320 as an example

Properties

- Can be parameterized as digital input or output.
- When set as digital input:
  - Six "high-speed inputs" on Control Unit 320

    If these inputs are used, for example, for the "flying measurement" function, they act as "high-speed inputs" with virtually no time delay when the actual value is saved.
  - The properties of the "pure" digital outputs apply.
- When set as digital output:
  - The properties of the "pure" digital outputs apply.

Function diagrams (see SINAMICS S List Manual)

- 2030 Bidirectional digital inputs/outputs (DI/DO 8 ... DI/DO 9)
- 2031 Bidirectional digital inputs/outputs (DI/DO 10 ... DI/DO 11)
- 2130 Bidirectional digital inputs/outputs (DI/DO 8 and DI/DO 9)
- 2131 Bidirectional digital inputs/outputs (DI/DO 10 and DI/DO 11)
- 2132 Bidirectional digital inputs/outputs (DI/DO 12 and DI/DO 13)
- 2133 Bidirectional digital inputs/outputs (DI/DO 14 and DI/DO 5)
- 9400 Bidirectional digital inputs/outputs (DI/DO 0 ... DI/DO 7)
- 9401 Bidirectional digital inputs/outputs (DI/DO 8 ... DI/DO 15)
- 9402 Bidirectional digital inputs/outputs (DI/DO 16 ... DI/DO 23)
- 9560 Bidirectional digital inputs/outputs (DI/DO8 and DI/DO 9)

- 9562 Bidirectional digital inputs/outputs (DI/DO 10 and DI/DO 1)
- 9661 Bidirectional digital inputs/outputs (DI/DO 0 and DI/DO 1)
- 662 Bidirectional digital inputs/outputs (DI/DO 2 and DI/DO 3)

12.5.3 Analog inputs

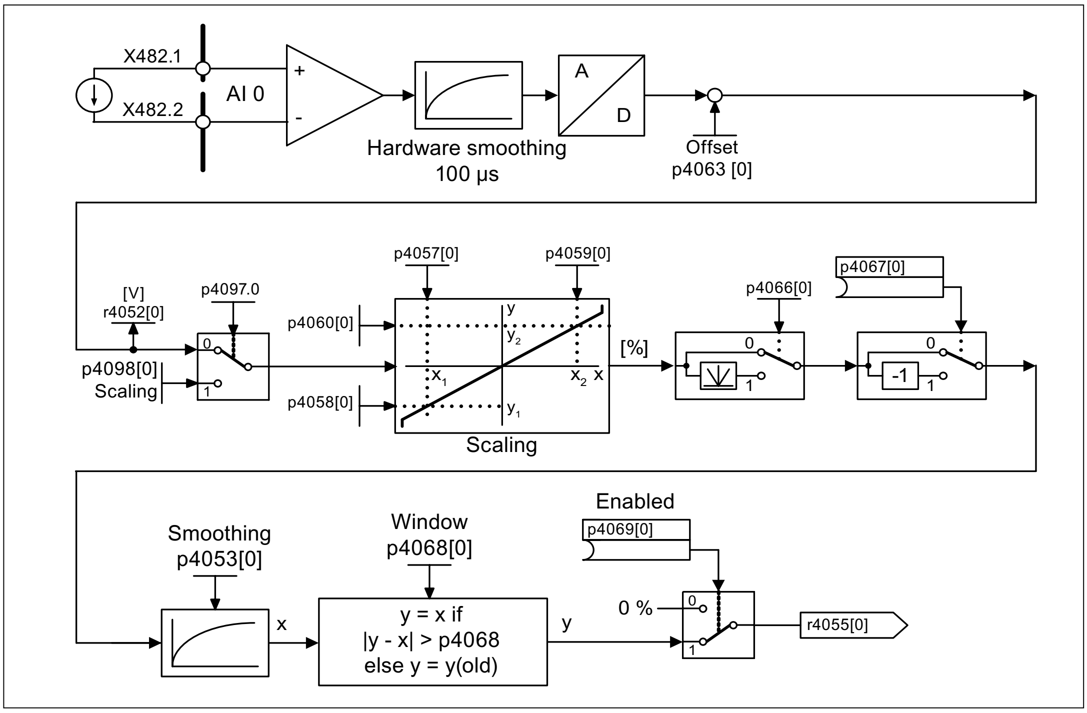


Figure 12-12 Analog inputs: Signal processing using AI0 of the TB30

Properties

- Hardware input filter set permanently
- Simulation mode parameterizable
- Adjustable offset
- Signal can be inverted via binector input
- Adjustable absolute-value generation
- Noise suppression (p4068)
- Enabling of inputs via binector input
- Output signal available via connector output
- Scaling
- Smoothing

NOTICE
Parameters p4057 to p4060 of the scaling do not limit the voltage values/current values (for TM31, the input can be used as current input).

Function diagrams (see SINAMICS S List Manual)

- 9104 Analog inputs (AI 0 and AI 1)
- 9566 Analog input 0 (AI 0)
- 9568 Analog input 1 (AI 1)
- 9663 Analog input (AI 0)

12.5.4 Analog outputs

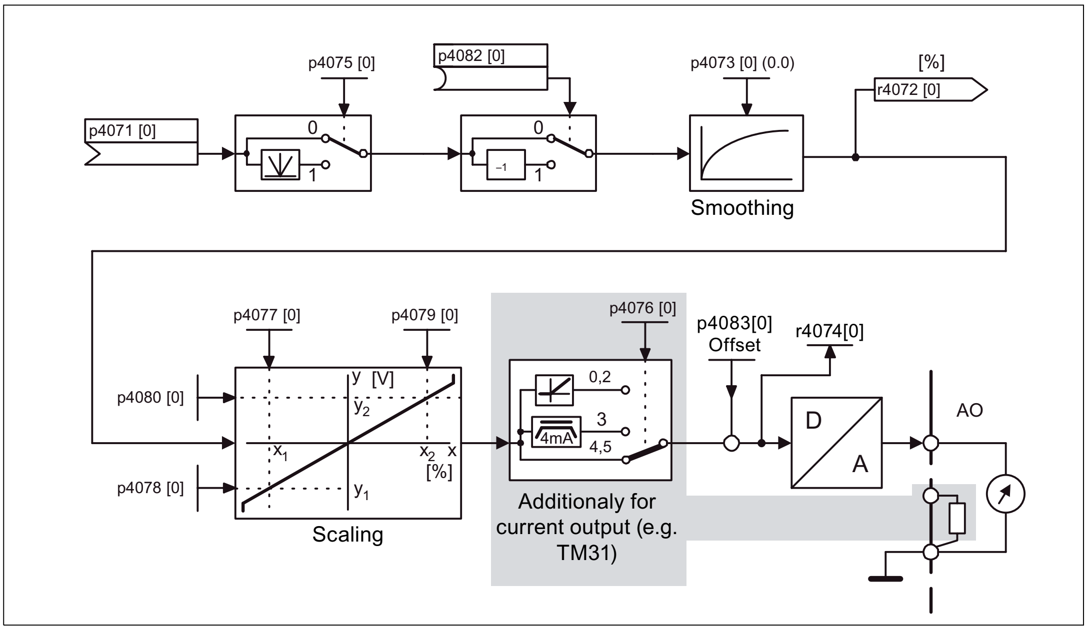


Figure 12-13 Analog outputs: Signal processing using AO 0 of TB30/TM31 as an example

Properties

- Adjustable absolute-value generation
- Inversion via binector input
- Adjustable smoothing
- Adjustable transfer characteristic
- Output signal can be displayed via visualization parameter

NOTICE
Parameters p4077 to p4080 of the scaling do not limit the voltage values/current values (for TM31, the input can be used as current input).

Function diagrams (see SINAMICS S List Manual)

- 9106 Analog outputs (AO 0 and AO 1)
- 9572 Analog outputs (AO 0 and AO 1)

12.6 Parameterizing using the BOP20 (Basic Operator Panel 20)

12.6.1 General information about the BOP20

With the BOP20, drives can be powered-up and powered-down during the commissioning phase and parameters can be displayed and modified. Faults can be diagnosed as well as acknowledged.

The BOP20 is snapped onto the Control Unit; to do this the dummy cover must be removed (for additional information on mounting, please refer to the Equipment Manual).

Overview of displays and keys

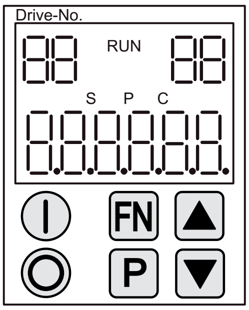


Figure 12-14 Overview of displays and keys

Information on the displays

Table 12-7 LED

Display	Meaning
top left 2 positions	The active drive object of the BOP is displayed here. The displays and key operations always refer to this drive object.
RUN	Lit if at least one drive in the drive line-up is in the RUN state (in operation). RUN is also displayed via bit r0899.2 of the drive.
top right 2 positions	The following is displayed in this field: • More than 6 digits: Characters that are still present but are invisible (e.g. "r2" —> 2 characters to the right are invisible, "L1" —> 1 character to the left is invisible) • Faults: Selects/displays other drives with faults • Designation of BICO inputs (bi, ci) • Designation of BICO outputs (bo, co) • Source object of a BICO interconnection to a drive object different than the active one.
S	Is (bright) if at least one parameter was changed and the value was not transferred into the non-volatile memory.
P	Is lit (bright) if, for a parameter, the value only becomes effective after pressing the P key.
C	Is light (bright) if at least one parameter was changed and the calculation for consistent data management has still not been initiated.
Below, 6 digit	Displays, e.g. parameters, indices, faults and alarms.

Information on the keys

Table 12-8 Keys

Key	Name	Meaning
I	ON	Power-up the drives for which the command "ON/OFF1" should come from the BOP. Binector output r0019.0 is set using this key.
O	OFF	Powering-down the drives for which the commands "ON/OFF1", "OFF2" or "OFF3" should come from the BOP. The binector outputs r0019.0, .1 and .2 are simultaneously reset when this key is pressed. After the key has been released, binector outputs r0019.1 and .2 are again set to a "1" signal. **Note**: The effectiveness of these keys can be defined by appropriately parameterizing the BICO (e.g. using these keys it is possible to simultaneously control all of the existing drives).
FN	Functions	The significance of these keys depends on the actual display. **Note**: The effectiveness of this key to acknowledge faults can be defined using the appropriate BiCo parameterization.
P	Parameters	The significance of these keys depends on the actual display. If this key is pressed for 3 s, the "Copy RAM to ROM" function is executed. The "S" displayed on the BOP disappears.
▲	Raise	The keys depend on the current display and are used to either raise or lower values.
▼	Lower	

BOP20 functions

Table 12-9 Functions

Name	Description
Backlighting	The backlighting can be set using p0007 in such a way that it switches itself off automatically after the set time if no actions are carried out.
Changeover active drive	From the BOP perspective the active drive is defined using p0008 or using the keys "FN" and "Arrow up".
Units	The units are not displayed on the BOP.
Access level	The access level for the BOP is defined using p0003. The higher the access level, the more parameters can be selected using the BOP.
Parameter filter	Using the parameter filter in p0004, the available parameters can be filtered corresponding to their particular function.
Selecting the operating display	Actual values and setpoints are displayed on the operating display. The operating display can be set using p0006.
User parameter list	Using the user parameter list in p0013, parameters can be selected for access.
Unplug while voltage is present	The BOP can be withdrawn and inserted under voltage. • The ON and OFF keys have a function. When withdrawing, the drives are stopped. Once the BOP has been inserted, the drives must be switched on again. . • ON and OFF keys have no function Withdrawing and inserting has no effect on the drives.
Actuating keys	The following applies to the "P" and "FN" keys: • When used in a combination with another key, "P" or "FN" must be pressed first and then the other key.

Parameters for BOP

All drive objects

- p0005 BOP operating display selection
- p0006 BOP operating display mode
- p0013 BOP user-defined list
- p0971 Drive object, save parameters

Drive object, Control Unit

- r0000 BOP operating display
- p0003 BOP access level
- p0004 BOP display filter
- p0007 BOP background lighting
- p0008 BOP drive object selection

- p0009 Device commissioning, parameter filter
- p0011 BOP password input (p0013)
- p0012 BOP password confirmation (p0013)
- r0019 CO/BO: Control word, BOP
- p0977 Save all parameters

Other drive objects (e.g. SERVO, VEKTOR, INFEED, TM41 etc.)

- p0010 Commissioning parameter filter

12.6.2 Displays and using the BOP20

Features

- Operating display
- Changing the active drive object
- Displaying/changing parameters
- Displaying/acknowledging faults and alarms
- Controlling the drive using the BOP20

Operating display

The operating display for each drive object can be set using p0005 and p0006. Using the operating display, you can change into the parameter display or to another drive object. The following functions are possible:

- Changing the active drive object
  - Press key "FN" and "Arrow up" -> the drive object number at the top left flashes
  - Select the required drive object using the arrow keys
  - Acknowledge using the "P" key
- Parameter display
  - Press the "P" key.
  - The required parameters can be selected using the arrow keys.
  - Press the "FN" key -> parameter r0000 is displayed
  - Press the "P" key -> changes back to the operating display

Parameter display

The parameters are selected in the BOP20 using the number. The parameter display is reached from the operating display by pressing the "P" key. Parameters can be searched for using the arrow keys. The parameter value is displayed by pressing the "P" key again. You can toggle between the drive objects by simultaneously pressing the keys "FN" and the arrow keys. You can toggle between r0000 and the parameter that was last displayed by pressing the "FN" key in the parameter display.

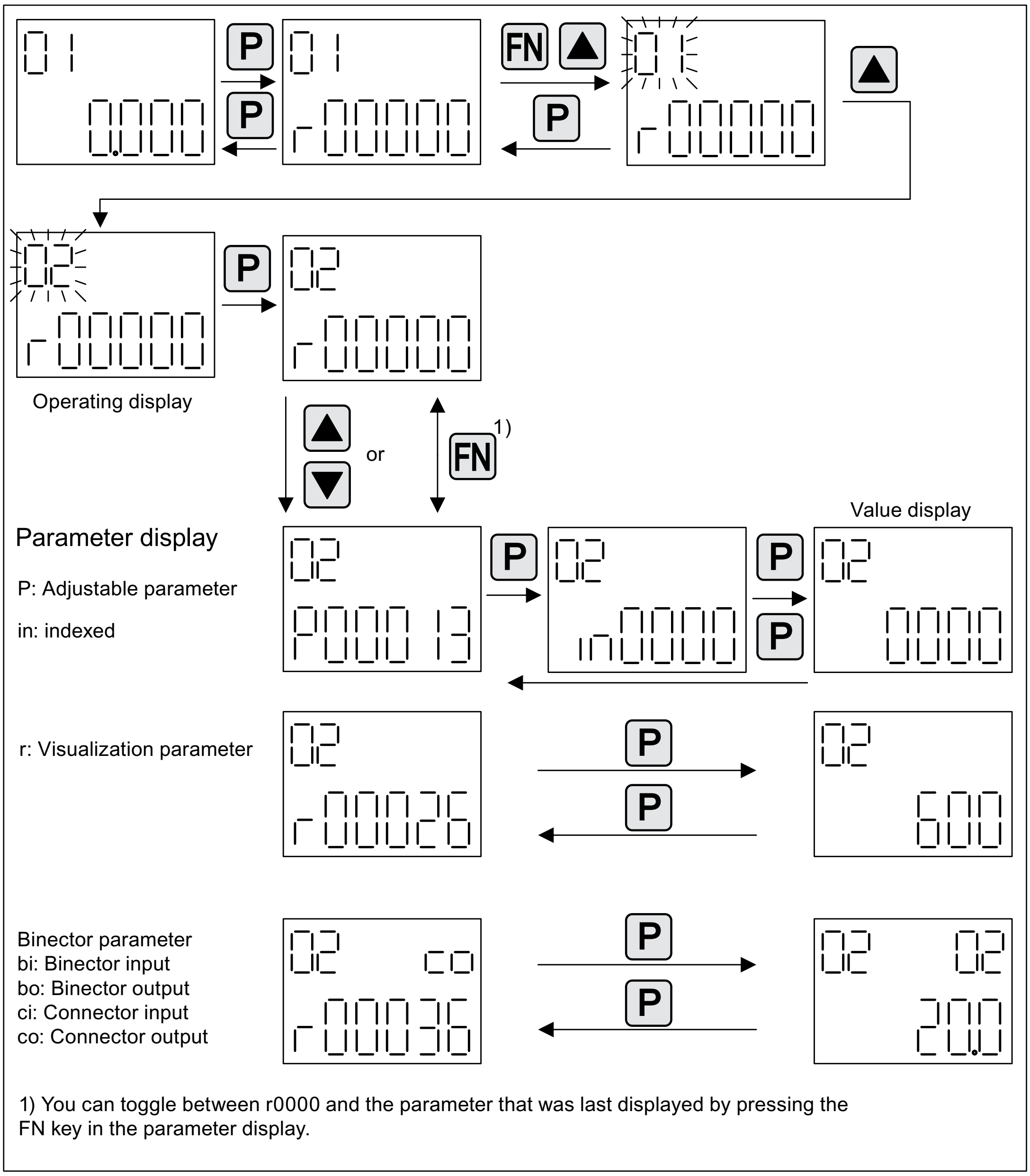


Figure 12-15 Parameter display

Value display

To switch from the parameter display to the value display, press the "P" key. In the value display, the values of the adjustable parameters can be increased and decreased using the arrow. The cursor can be selected using the "FN" key.

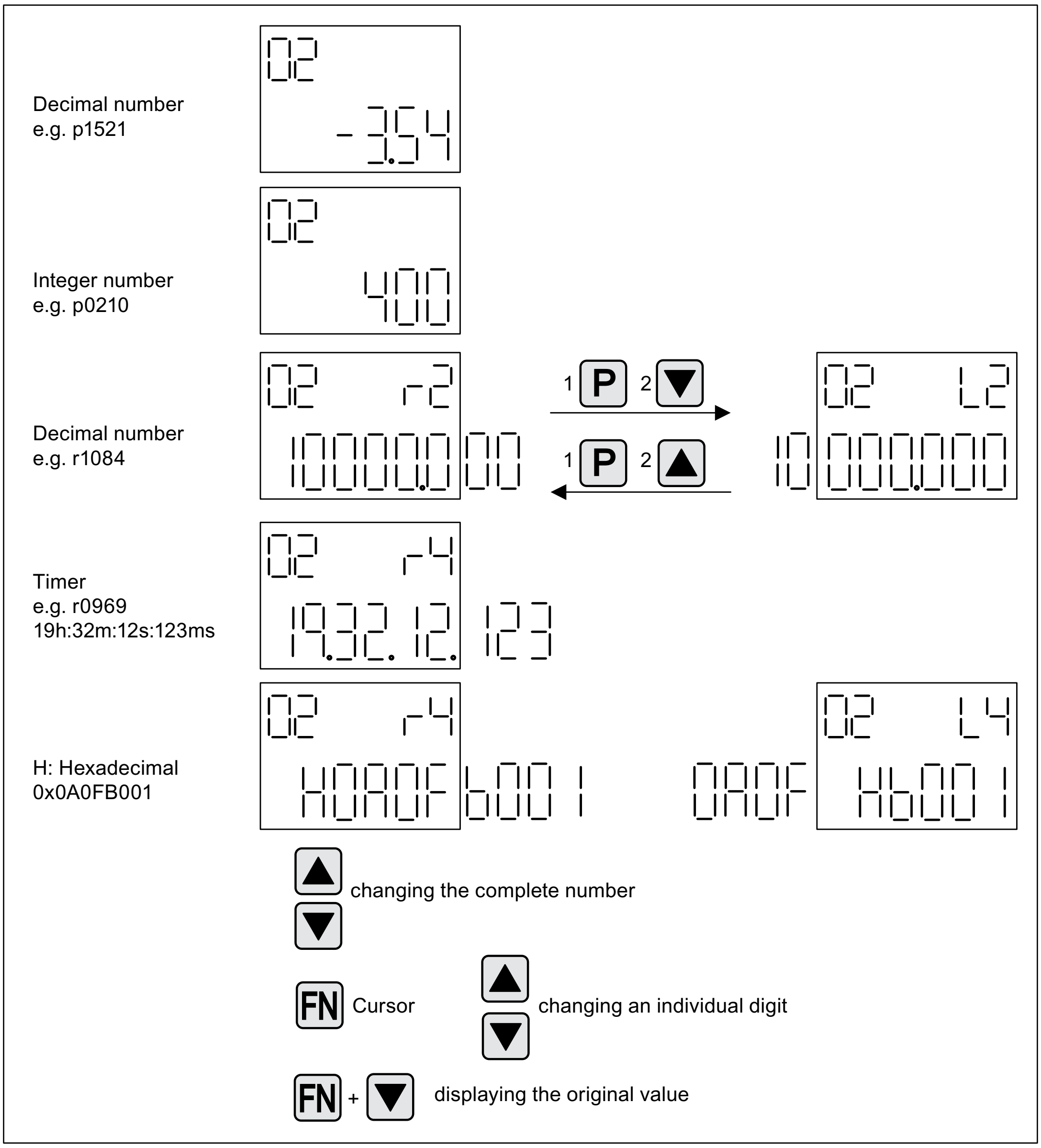


Figure 12-16 Value display

Example: Changing a parameter

Precondition: The appropriate access level is set
(for this particular example, p0003 = 3).

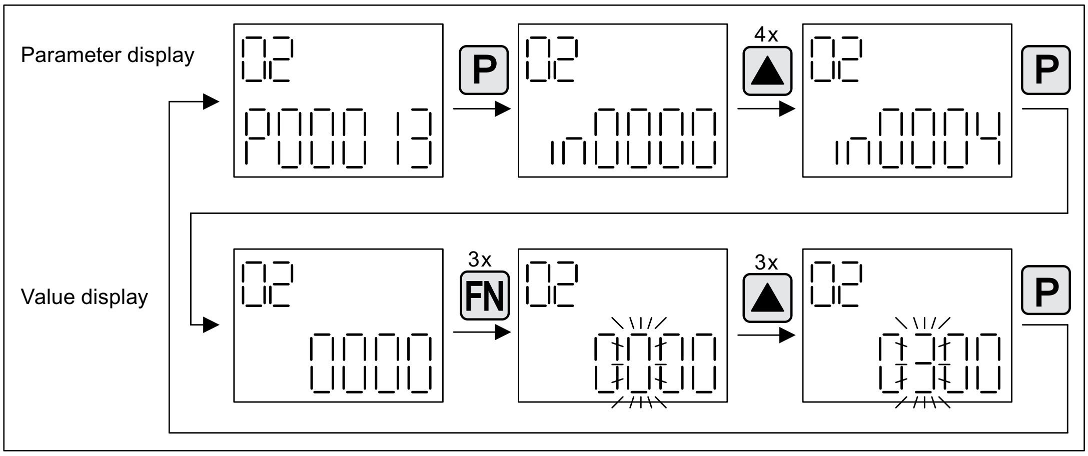


Figure 12-17 Example: Changing p0013[4] from 0 to 300

Example: Changing binector and connector input parameters

For the binector input p0840[0] (OFF1) of drive object 2 binector output r0019.0 of the Control Unit (drive object 1) is interconnected.

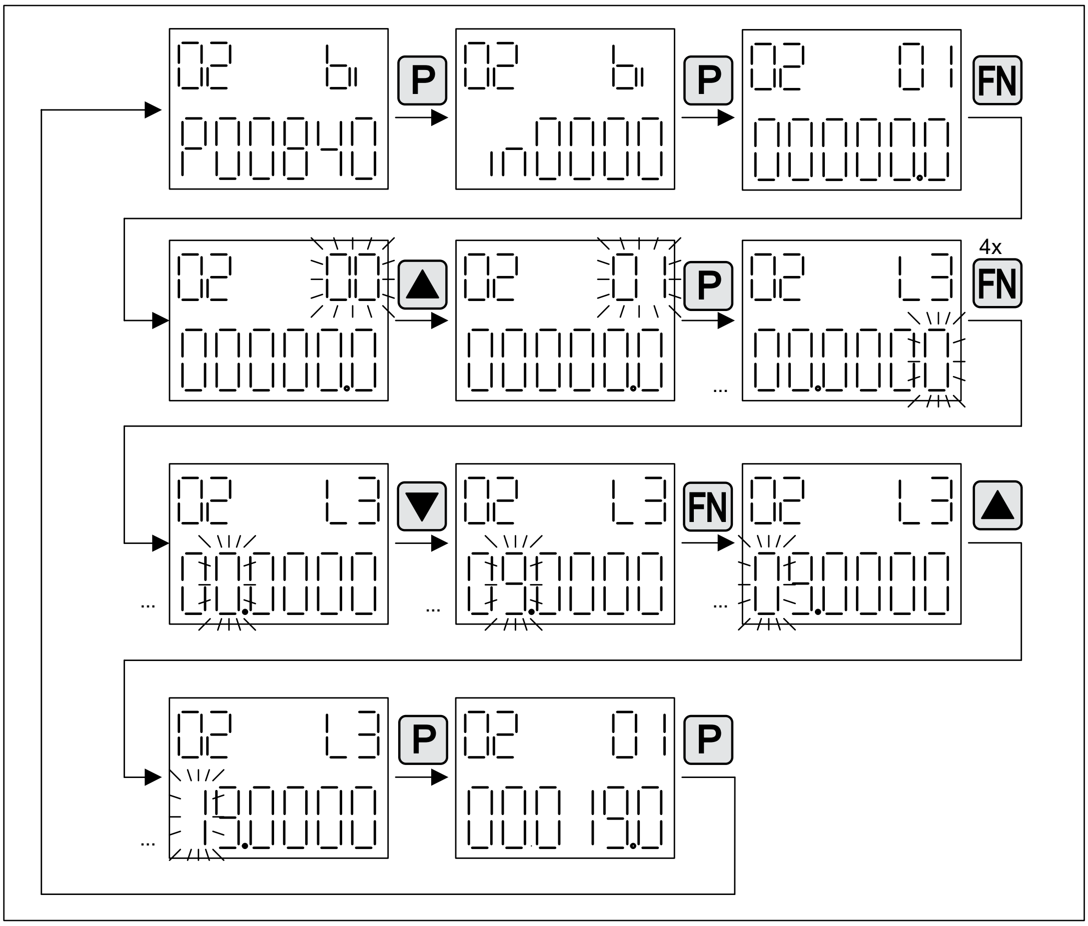


Figure 12-18 Example: Changing indexed binector parameters

12.6.3 Fault and alarm displays

Displaying faults

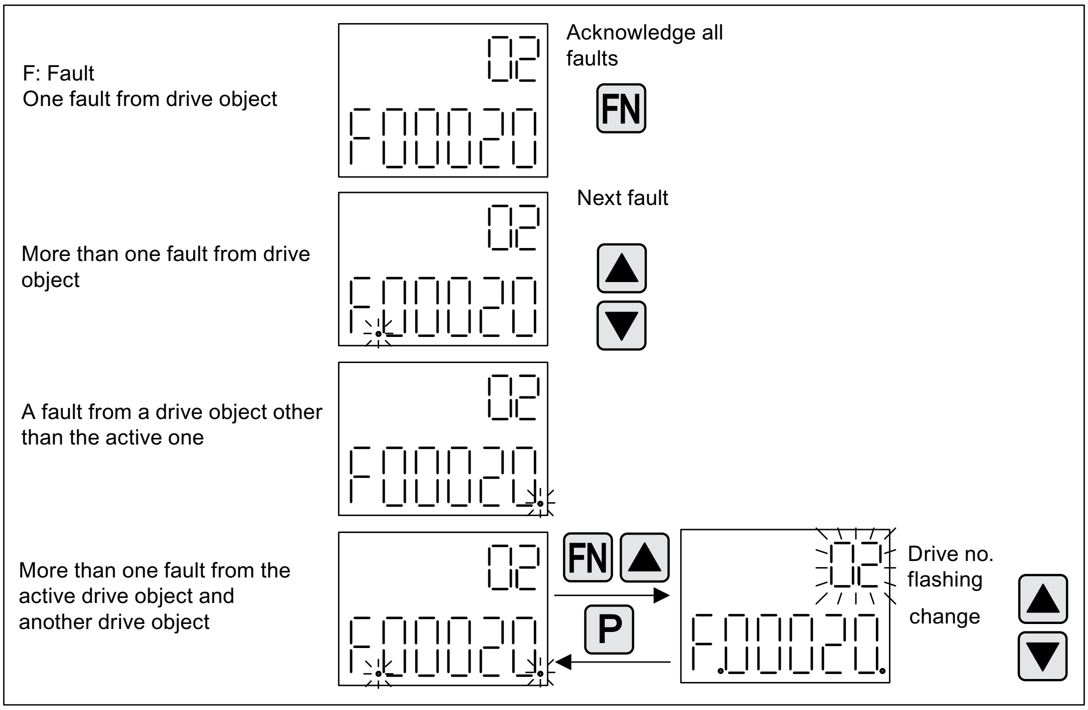


Figure 12-19 Faults

Displaying alarms

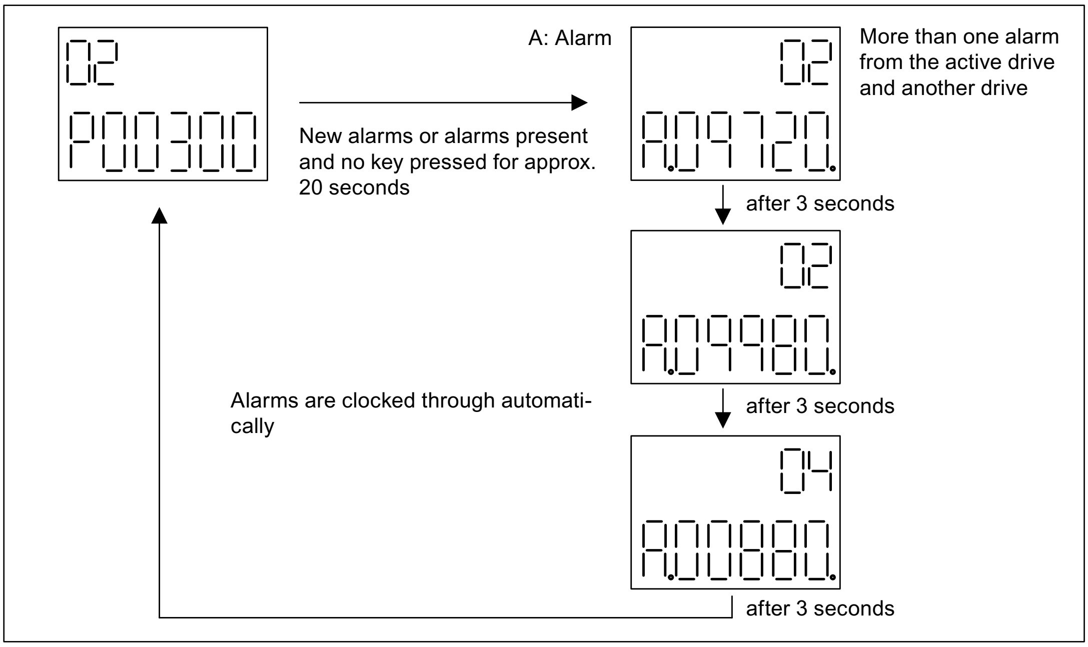


Figure 12-20 Alarms

12.6.4 Controlling the drive using the BOP20

Description

When commissioning the drive, it can be controlled via the BOP20. A control word is available on the Control Unit drive object (r0019) that can be interconnected with the appropriate binector inputs e.g. of the drive or the infeed.

The interconnections do not function if a standard PROFIdrive telegram was selected as its interconnection cannot be disconnected.

Table 12-10 BOP20 control word

Bit (r0019)	Name	Example, interconnection parameters
0	ON / OFF (OFF1)	p0840
1	No coast down/coast down (OFF2)	p0844
2	No fast stop/fast stop (OFF3)	p0848
Note: For simple commissioning, only bit 0 should be interconnected. When interconnecting bits 0 ... 2, then the system is powered-down according to the following priority: OFF2, OFF3, OFF1.		
7	Acknowledge fault (0 -> 1)	p2102
13	Motorized potentiometer, raise	p1035
14	Motorized potentiometer, lower	p1036

12.7 Examples of replacing components

Note

To ensure that the entire functionality of a firmware version can be used, it is recommended that all the components in a drive line-up have the same firmware version.

Description

If the type of comparison is set to the highest setting, the following examples apply.

A distinction is made between the following scenarios:

- Component with a different order number
- Components with identical order number
  - Topology comparison component replacement active (p9909 = 1)
  - Topology comparison component replacement inactive (p9909 = 0)

For p9909 = 1, the serial number and the hardware version of the new replaced component are automatically transferred from the actual topology into the target topology and then saved in a non-volatile manner.

For p9909 = 0, serial numbers and hardware versions are not automatically transferred. In this case, when the data in the electronic type plate match, the transfer is realized using p9904 = 1 or p9995 = 1.

For the components that have been replaced, the electronic type plate must match as far as the following data is concerned:

- Component type (e.g. "SMC20")
- Order No. (e.g. "6SL3055–0AA0–5Bxx")

Example: Replacing a component with a different order number

Precondition:

- The replaced component has a different order number

Table 12-11 Example: Replacing a component with a different order number

Action	Reaction	Comments
• Switch off the power supply • Replace the defective component and connect the new one • Switch on the power supply	Alarm A01420	

Action	Reaction	Comments
• Load the project from the Control Unit to the STARTER (PG) • Configure the replacement drive and select the current component • Load the project to the Control Unit (target system)	• Alarm disappears	The new order number is stored in the RAM of the Control Unit and has to be copied to the non-volatile memory with p0971 or p0977.
The component has been successfully replaced		

Example: (p9909 = 1) Replacing a defective component with an identical order number

Precondition:

- The replaced component has an identical order number
- The serial number of the new replacement component must not be contained in the stored target topology of the Control Unit.
- Topology comparison component replacement active p9909 = 1.

Sequence:

During startup of the Control Unit, the serial number of the new component is automatically transferred to the target topology and saved.

Example: (p9909 = 0) Replacing a defective component with an identical order number

Precondition:

- The replaced component has an identical order number
- Topology comparison component replacement inactive p9909 = 0.

Table 12-12 Example: Replacing a Motor Module

Action	Reaction	Comments
• Switch off the power supply • Replace the defective component and connect the new one • Switch on the power supply	Alarm A01425	

Action	Reaction	Comments
• Set p9905 to "1"	• Alarm disappears • The serial number is copied to the target topology	The serial number is stored in the RAM of the Control Unit and has to be copied to the non-volatile memory with p0971 or p0977.
The component has been successfully replaced		

Example: Replacing a Motor Module/Power Module with a different power rating

Precondition:

The replaced power unit has a different power rating

Vector: Power rating of the Motor Module/Power Module not greater than 4 * motor current

Table 12-13 Example: Replacing a power unit with a different power rating

Action	Reaction	Comments
• Switch off the power supply • Replace the defective component and connect the new one • Switch on the power supply	Alarm A01420	
• Drive Object CU: – p0009 = 1 – p9906 = 2 – p0009 = 0 – p0977 = 1	• Device configuration • Component comparison • Completing the configuration • Data Backup	For p9906=2: Caution Topology monitoring for all (!) components heavily reduced so that DRIVE-CLiQ lines may be hidden by mistake.
• Drive Object component: – p0201 = r0200 – p0010 = 0 – p0971 = 1	• Use the code number • Completing commissioning • Data Backup	The new order number is stored in the RAM of the Control Unit and has to be copied to the non-volatile memory with p0971 or p0977.
The component has been successfully replaced		

12.8 Exchanging a SINAMICS Sensor Module Integrated

The motor and encoder data required for the operation of a motor with DRIVE-CLiQ are stored in their as-delivered condition on the EEPROM of the SINAMICS Sensor Module Integrated (DRIVE-CLiQ at the Motor). Therefore, no data must be entered for the commissioning of motors with DRIVE-CLiQ.

NOTICE
The user is responsible for backing up the data of the Sensor Module Integrated. Data is not backed up automatically, the backup of this data on the CompactFlash card is therefore mandatory. Backup the data of the SINAMICS Sensor Module Integrated on the CompactFlash card after every topology modification.

12.8.1 Data backup on CompactFlash card

The data of the SINAMICS Sensor Module Integrated can be saved in a non-volatile manner on the CompactFlash card.

- **Backup the data of all SINAMICS Sensor Modules Integrated with p4692 = 1**
- **Selective backup of the data of one (1) SINAMICS Sensor Module Integrated:**

1. Enter the component number (stored in p0141) in p4690.
2. Activate the data backup via p4691 = 1.

File names and storage location for the data

The data is saved in two files on the CompactFlash Card.

- for motor data: SMIn0xb1.bin
- for encoder data: SMIn0xb2.bin

  "...n..." indicates the version of the SINAMICS Sensor Module Integrated:

  – "...1..." for SMI10
    (encoder evaluation for resolver),

  – "...2..." for SMI20
    (encoder evaluation for incremental encoder sin/cos 1 Vpp and absolute encoder Endat)

Example:

The two files of a SINAMICS Sensor Module Integrated with the component number 7 are saved on a CU3x0 at the following file path:

/USER/SINAMICS/DATA/SMI_DATA/C07/...

12.8.2 Replacing a device

Order number SINAMICS Sensor Module Integrated:

– SMI10: 6SL3055-0AA00-5NA0

– SMI20: 6SL3055-0AA00-5MA0

In the case of spare part installation, transfer the data previously saved on the CompactFlash card to the new Sensor Module.

Data transfer from CompactFlash card to Sensor Module

1. Enter the component number of the new Sensor Module (p0141) in p4690.
2. Activate the data backup via p4691 = 2.
3. Execute POWER ON for all DRIVE-CLiQ components.
4. Backup the data of all SINAMICS Sensor Modules Integrated with p4692 = 1.

NOTICE
Only consistent compliance with the procedures and with their systematic, complete documentation in the LOGBOOK enables a reproduction of all service steps, extensions or alterations to the drive system.

Supplementary conditions

- The Sensor Module files are stored in a block structure. These blocks are placed directly next to each other (internal data of the SINAMICS Sensor Module Integrated | encoder block | motor block). If a Sensor Module already contains an encoder block and motor block, and these stored blocks are smaller than the blocks that are to be backed up, then the backup is rejected.

  Backup is also rejected when only one of the two files is stored on the Sensor Module.
- The Sensor Module must be empty before the exchange.

Overview of key parameters (see SINAMICS S List Manual)

- p4690 SMI component number
- p4691 Backup SMI data
- p4692 Backup all SMI data

12.9 DRIVE-CLiQ topology

Introduction

The term topology is used in SINAMICS to refer to a wiring harness with DRIVE-CLiQ cables. A unique component number is allocated to each component during the start-up phase.

DRIVE-CLiQ (Drive Component Link with IQ) is a communication system for connecting the various components in SINAMICS (e.g. Control Unit, Line Module, Motor Modules, motors, and encoders).

DRIVE-CLiQ supports the following properties:

- Automatic detection of components by the Control Unit
- Standard interfaces to all components
- Standardized diagnostics down to component level
- Standardized service down to component level

Electronic rating plate

The electronic type plate contains the following data:

- Component type (e.g. SMC20)
- Order number (e.g. 6SL3055-0AA0-5BA0)
- Manufacturer (e.g. SIEMENS)
- Hardware version (e.g. A)
- Serial number (e.g. "T-PD3005049)
- Technical specifications (e.g. rated current)

Actual topology

The actual topology is the actual DRIVE-CLiQ wiring harness.

When the drive system components are started up, the actual topology is detected automatically via DRIVE-CLiQ.

Target topology

The target topology is stored on the CompactFlash card on the Control Unit and is compared with the actual topology when the Control Unit is started up.

The target topology can be specified in two ways and saved on the CompactFlash card:

- Via STARTER
  by creating the configuration and loading it onto the drive
- Via quick commissioning (automatic configuration):
  the actual topology is read and the target topology written to the CompactFlash card.

Comparison of topologies at Power On

Comparing the topologies prevents a component from being controlled/evaluated incorrectly (e.g. drive 1 and 2).

When the drive system is started, the Control Unit compares the detected actual topology and the electronic type plates with the target topology stored on the CompactFlash card.

You can specify how the electronic type plates are compared for all the components of a Control Unit via p9906. The type of comparison can be changed subsequently for each individual component. You can use p9908 for this or right-click in the topology view in the STARTER tool. All data on the electronic type plate is compared by default.

The following data in the target and actual topologies is compared depending on the settings made in p9906/9908:

- p9906/9908 = 0: component type, order number, manufacturer, serial number
- p9906/9908 = 1: component type, order number
- p9906/9908 = 2: component type
- p9906/9908 = 3: component class (e.g. Sensor Module or Motor Module)

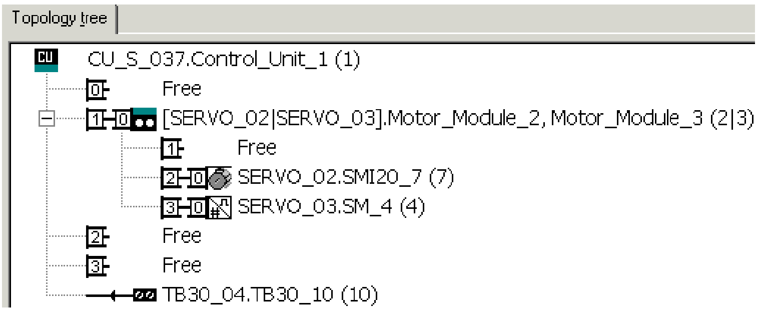


Figure 12-21 Topology view in the STARTER tool

NOTICE
The Control Unit and the Option Board are not monitored. The system automatically accepts new components and does not output a message.

12.10 Rules for wiring with DRIVE-CLiQ

The following rules apply for wiring components with DRIVE-CLiQ. The rules are subdivided into **DRIVE-CLiQ rules**, which must be observed, and **recommended rules**, which, when observed, do not require any subsequent changes to the topology created offline in STARTER.

The maximum number of DRIVE-CLiQ components and the possible wiring form depend on the following points:

- The binding DRIVE-CLiQ wiring rules
- The number and type of activated drives and functions on the Control Unit in question
- The computing power of the Control Unit in question

- The set processing and communication cycles

Below you will find the binding wiring rules and some other recommendations as well as a few sample topologies for DRIVE-CLiQ wiring.

The components used in these examples can be removed, replaced with others or supplemented. If components are replaced by another type or additional components are added, the SIZER tool should be used to check the topology.

If the actual topology does not match the topology created offline by STARTER, the offline topology must be changed accordingly before it is downloaded.

12.10.1 General rules

DRIVE-CLiQ rules

The wiring rules below apply to standard cycle times (servo 125 µs, vector 400 µs). For cycle times that are shorter than the corresponding standard cycle times, additional restrictions apply due to the computing power of the CU (configuration via the SIZER tool).

The rules below apply on a general basis, unless limited, as a function of the firmware version.

Note

A Double Motor Module, a DMC20, a TM54F and a CUA32 each correspond to two DRIVE-CLiQ participants. This also applies to Double Motor Modules, of which just one drive is configured.

- A maximum of 14 nodes can be connected to a DRIVE-CLiQ line on the Control Unit.
- Up to 8 nodes can be connected in a row. A row is always seen from the perspective of the Control Unit.
- Ring wiring is not permitted.
- Components must not be double-wired.
- The TM54F must not be operated on the same DQ line as Motor Modules.
- The Terminal Modules TM15, TM17 and TM41 have faster sample cycles than the TM31 and TM54F. For this reason, the two groups of Terminal Modules must be connected in separate DRIVE-CLiQ lines.

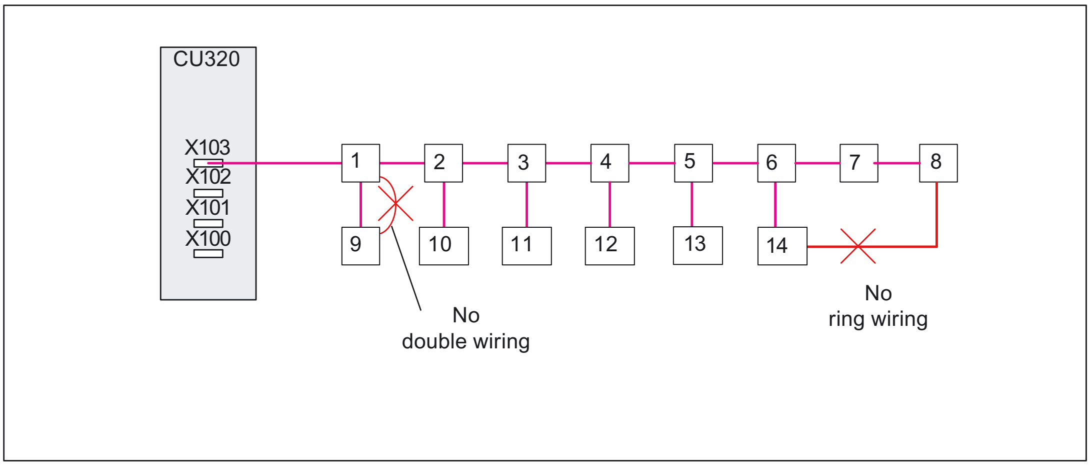


Figure 12-22 Example: DRIVE-CLiQ line on a CU320 X103

- Only one Line Module (or if connected in parallel, several) can be connected to a Control Unit.
- If using Chassis design components, no more than one Smart Line Module and one Basic Line Module may be jointly operated on one Control Unit (mixed operation on a DRIVE-CLiQ line).
- The default sampling times may be changed.
- Mixed operation of servo and vector is not permitted.
- Mixed operation (servo with vector V/f) is possible.
- During mixed operation of servo and vector V/f, separate DRIVE-CLiQ lines must be used for Motor Modules (mixed operation is not permissible on Double Motor Modules).
- With vector V/f control, more than four nodes can only be connected to one DRIVE-CLiQ line on the Control Unit.
- A maximum of 9 encoders can be connected.
- A maximum of 8 Terminal Modules can be connected.
- The Active Line Module (booksize) and Motor Modules (booksize)
  - can be connected to one DRIVE-CLiQ line in **servo** mode.
  - must be connected to separate DRIVE-CLiQ lines in **vector** mode.
- The Line Module (chassis) (ALM, BLM, SLM) and the Motor Modules (chassis) must be connected to separate DRIVE-CLiQ lines.
- Motor Modules (chassis) with different pulse frequencies must be connected to separate DRIVE-CLiQ lines. For this reason, chassis Motor Modules and booksize Motor Modules must be connected to separate DRIVE-CLiQ lines.
- The Voltage Sensing Module (VSM) should be connected to a free DRIVE-CLiQ port of the Active Line Module (due to the automatic assignment of the VSM).
- The sampling times (p0115[0] and p4099) of all components that are connected to a DRIVE-CLiQ line (DQS) must be divisible by one another with an integer result. If the current controller sampling time on a DO has to be changed to another pattern that does not match the other DOs on the DQS, the following options are available:
  - Change over the DO to another, separate DQS.

– Also change the current controller sampling time and the sampling time of the inputs/outputs of the DOs not involved so that they again fit into the time grid.

Note

You can call up the "Topology" screen in STARTER to change and/or check the DRIVE-CLiQ topology for each drive unit.

Note

To enable the function "Automatic configuration" to assign the encoders to the drive, the recommended rules below must be observed.

Recommended rules

- The DRIVE-CLiQ cable from the Control Unit must be connected to X200 on the first booksize power section or X400 on the first chassis power section.
- The DRIVE-CLiQ connections between the power sections must each be connected from interface X201 to X200/from X401 to X400 on the follow-on component.
- A Power Module with the CUA31 should be connected to the end of the DRIVE-CLiQ line.

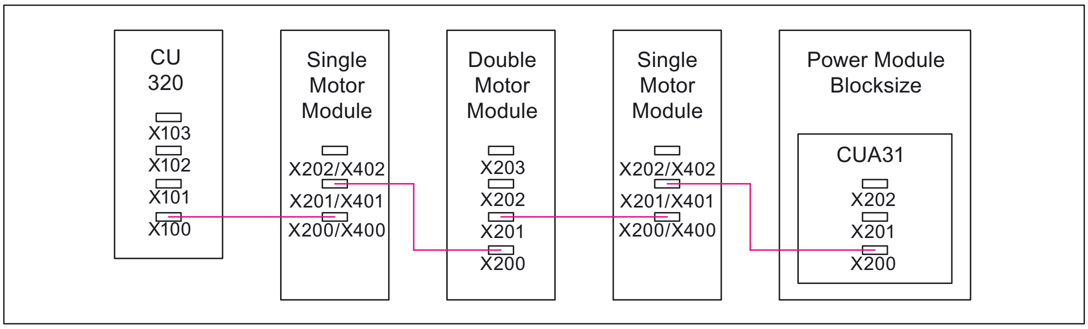


Figure 12-23 Example: DRIVE-CLiQ line

- The motor encoder must be connected to the associated power unit.

Table 12-14 Connecting the motor encoder via DRIVE-CLiQ

Component	Connecting the motor encoder via DRIVE-CLiQ
Single Motor Module Booksize	X202
Double Motor Module (booksize)	• Motor connection X1: Encoder at X202 • Motor connection X2: Encoder at X203
Single Motor Module Chassis	X402
Power Module Blocksize	• CUA31: Encoder at X202 • CU310: Encoder at X100 or via TM31 at X501
Power Module Chassis	X402

Note

If an additional encoder is connected to a Motor Module, it is assigned to this drive as encoder 2 in the automatic configuration.

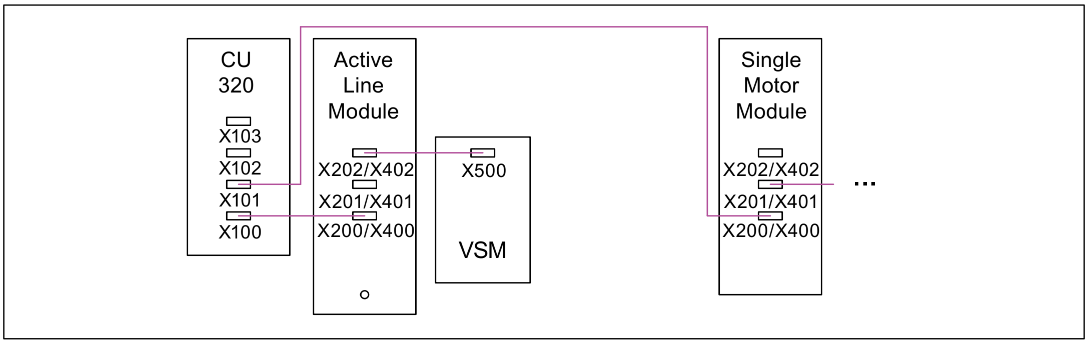


Figure 12-24 Example of a topology with VSM for Booksize and Chassis components

Table 12-15 VSM connection

Component	VSM connection
Active Line Module Booksize	X202
Active Line Module (chassis)	X402
Power Modules	The VSM is not supported.
Important! All of the nodes on the DRIVE-CLiQ line must have the same sampling time in p0115[0]. otherwise the VSM must be connected to a separate DRIVE-CLiQ interface on the Control Unit.	

- Only one final node should ever be connected to free DRIVE-CLiQ ports of components within a DRIVE-CLiQ line (e.g. Motor Modules wired in series), e.g. one Sensor Module or one Terminal Module without forwarding to additional components.
- If possible, Terminal Modules and Sensor Modules of direct measuring systems should not be connected to the DQ line of Motor Modules but rather to free DRIVE-CLiQ ports of the Control Unit.

12.10.2 Rules for different firmware releases

Rules for FW2.1

- Only one Active Line Module can be connected to a Control Unit.
- The default sampling times must not be changed.
- A Double Motor Module must not be operated as a single drive.
- Mixed operation of servo and vector V/f is not permitted.
- The Active Line Module and the Motor Modules must be connected to separate DRIVE-CLiQ lines, both for vector and for servo.

Table 12-16 Maximum number of drives that can be controlled by a Control Unit 320

<table>
<tr><th></th><th>Servo</th><th>Vector</th></tr>
<tr><td>Number of components</td><td>1 Active Line Module +
6 Motor Modules</td><td>1 Active Line Module +
2 Motor Modules
(scanning frequency of current controller 250 µs /
speed controller 1000 µs)</td></tr>
<tr><td colspan="3">Note:
In addition, the "Safe Standstill" function can be activated and a TM31 connected.</td></tr>
</table>

Rules for FW2.2

- Only one Active Line Module can be connected to a Control Unit.
- The default sampling times must not be changed.
- A Double Motor Module must not be operated as a single drive.

Table 12-17 Maximum number of drives that can be controlled by a Control Unit 320

<table>
<tr><th></th><th>Servo</th><th>Vector V/f (=vector without speed control function module)</th><th>Vector</th></tr>
<tr><td rowspan="2">Number of components</td><td>1 Active Line Module +
6 Motor Modules</td><td>1 Active Line Module +
4 Motor Modules
(sampling time of current controller 250 µs)
1 Active Line Module +
6 Motor Modules
(sampling time of current controller 400 µs)</td><td rowspan="2">1 Active Line Module +
2 Motor Modules
(sampling time of current controller 250 µs / speed controller 1000 µs)
1 Active Line Module +
4 Motor Modules
(sampling time of current controller 400 µs / speed controller 1600 µs)</td></tr>
<tr><td colspan="2">Servo and vector V/f:
1 Active Line Module + 5 Motor Modules
(servo: Current controller 125 µs / speed controller 125 µs vector V/f:
sampling time of current controller 250 µs with max. 2 V/f drives. Sampling time of current controller 400 µs with more than 2 V/f drives)</td></tr>
</table>

<table>
<tr><th></th><th>Servo</th><th>Vector V/f (=vector without speed control function module)</th><th>Vector</th></tr>
<tr><td colspan="4">Notes on the maximum number of drives that can be controlled by a CU320:
• In addition, the "Safe Standstill" function can be activated and a TM31 connected.
• No function modules must be activated.</td></tr>
</table>

Rules for FW2.3

- The default sampling times must not be changed.

Table 12-18 Maximum number of drives that can be controlled by a Control Unit 320

<table>
<tr><th></th><th>Servo</th><th>Vector V/f (=vector without speed control function module)</th><th>Vector</th></tr>
<tr><td rowspan="2">Number of components</td><td>1 Active Line Module +
6 Motor Modules</td><td>1 Active Line Module +
4 Motor Modules
(sampling time of current controller 250 μs / speed controller 1000 μs)
1 Active Line Module +
6 Motor Modules
(sampling time of current controller 400 μs / speed controller 1600 μs)
1 Active Line Module +
10 Motor Modules
(sampling time of current controller 500 μs / speed controller 4000 μs)</td><td rowspan="2">1 Active Line Module +
2 Motor Modules
(sampling time of current controller 250 μs / speed controller 1000 μs)
1 Active Line Module +
4 Motor Modules
(sampling time of current controller 400 μs / speed controller 1600 μs)</td></tr>
<tr><td colspan="2">Servo and vector V/f:
1 Active Line Module + 5 Motor Modules
(servo: Current controller 125 μs / speed controller 125 μs vector V/f:
sampling time of current controller 250 μs with max. 2 V/f drives
Sampling time of current controller 400 μs with more than 2 V/f drives)</td></tr>
<tr><td colspan="4">Notes on the maximum number of drives that can be controlled by a CU320:
• In addition, the "Safe Standstill" function can be activated and a TM31 connected.
• No function modules must be activated.</td></tr>
</table>

Rules for FW2.4

- The Voltage Sensing Module (VSM) must be connected to a dedicated DRIVE-CLiQ port of the Control Unit.
- If possible, the CUA31 should be connected at the end of the line.

Table 12-19 Maximum number of drives that can be controlled by a Control Unit 320

<table>
<tr><th></th><th>Servo</th><th>Vector V/f (=vector without speed control function module and without encoder)</th><th>Vector</th></tr>
<tr><td rowspan="2">Number of components</td><td>1 Active Line Module +
6 Motor Modules 1)</td><td>1 Active Line Module +
4 Motor Modules 1)
(sampling time of current controller 250 µs / speed controller 1000 µs)

1 Active Line Module +
6 Motor Modules 1)
(sampling time of current controller 400 µs / speed controller 1600 µs)

1 Active Line Module +
8 Motor Modules 1)
(sampling time of current controller 500 µs / speed controller 4000 µs)</td><td rowspan="2">1 Active Line Module +
2 Motor Modules 1)
(sampling time of current controller 250 µs / speed controller 1000 µs)

1 Active Line Module +
4 Motor Modules 1)
(sampling time of current controller 400 µs / speed controller 1600 µs)</td></tr>
<tr><td colspan="2">Servo and vector V/f:
1 Active Line Module + 5 Motor Modules 1)
(servo: Current controller 125 µs / speed controller 125 µs
Vector V/f:
sampling time of current controller 250 µs / speed controller 1000 µs
with max. 2 V/f drives
sampling time of current controller 400 µs / speed controller 1600 µs with more than 2 V/f drives)</td></tr>
<tr><td colspan="4">Notes on the maximum number of drives that can be controlled by a CU320:
• In addition, the "Safe Standstill" function can be activated and a TM31 connected.
• No function modules must be activated.</td></tr>
<tr><td colspan="4">1) If a CUA31 is connected as the first module to the Control Unit, then the maximum number is decreased by one.</td></tr>
</table>

Rules for FW2.5 SP1:

- The Voltage Sensing Module (VSM) must be connected to a dedicated DRIVE-CLiQ port of the Control Unit.
- If possible, the CUA31 should be connected at the end of the line.
- Restrictions for Safety Extended Functions:
  - Maximum of 5 servo axes with Extended Functions for standard settings of cycle times (monitoring cycle: 12 ms; application cycle: 125 µs).
  - Maximum of 2 vector axes with Extended Functions for standard settings of cycle times (monitoring cycle: 12 ms; application cycle: 250 µs).
  - TM54F must not be connected in line with the Motor Modules.
  - A maximum of 4 Motor Modules with Extended Functions in line.

Table 12-20 Maximum number of drives that can be controlled by a Control Unit 320

<table>
<tr><th></th><th>Servo</th><th>Vector V/f (=vector without speed control function module and without encoder)</th><th>Vector</th></tr>
<tr><td rowspan="2">Number of components</td><td>1 Active Line Module +
6 Motor Modules[1]</td><td>1 Active Line Module +
4 Motor Modules[1]
(sampling time of current controller 250 µs / speed controller 1000 µs)
1 Active Line Module +
6 Motor Modules[1]
(sampling time of current controller 400 µs / speed controller 1600 µs)
1 Active Line Module +
8 Motor Modules[1]
(sampling time of current controller 500 µs / speed controller 4000 µs)</td><td rowspan="2">1 Active Line Module +
2 Motor Modules[1]
(sampling time of current controller 250 µs / speed controller 1000 µs)
1 Active Line Module +
4 Motor Modules[1]
(sampling time of current controller 400 µs / speed controller 1600 µs)</td></tr>
<tr><td colspan="2">Servo and vector V/f:
1 Active Line Module + 5 Motor Modules [1]
(servo: Current controller 125 µs / speed controller 125 µs
Vector V/f:
sampling time of current controller 250 µs / speed controller 1000 µs
with max. 2 V/f drives
sampling time of current controller 400 µs / speed controller 1600 µs with more than 2 V/f drives)</td></tr>
<tr><td colspan="4">Notes on the maximum number of drives that can be controlled by a CU320:
• In addition, the "Safe Standstill" function can be activated and a TM31 connected.
• No function modules must be activated.</td></tr>
<tr><td colspan="4">1) If a CUA31 is connected as the first module to the Control Unit, then the maximum number is decreased by one.</td></tr>
</table>

12.10.3 Sample wiring for vector drives

Drive line-up comprising three Motor Modules (chassis) with identical pulse frequencies or vector (booksize)

Motor Modules (chassis) with identical pulse frequencies or vector (booksize) can be connected to a DRIVE-CLiQ interface on the Control Unit.

In the following diagram, three Motor Modules are connected to interface X101.

Note

This topology does not match the topology created offline by STARTER and must be changed.

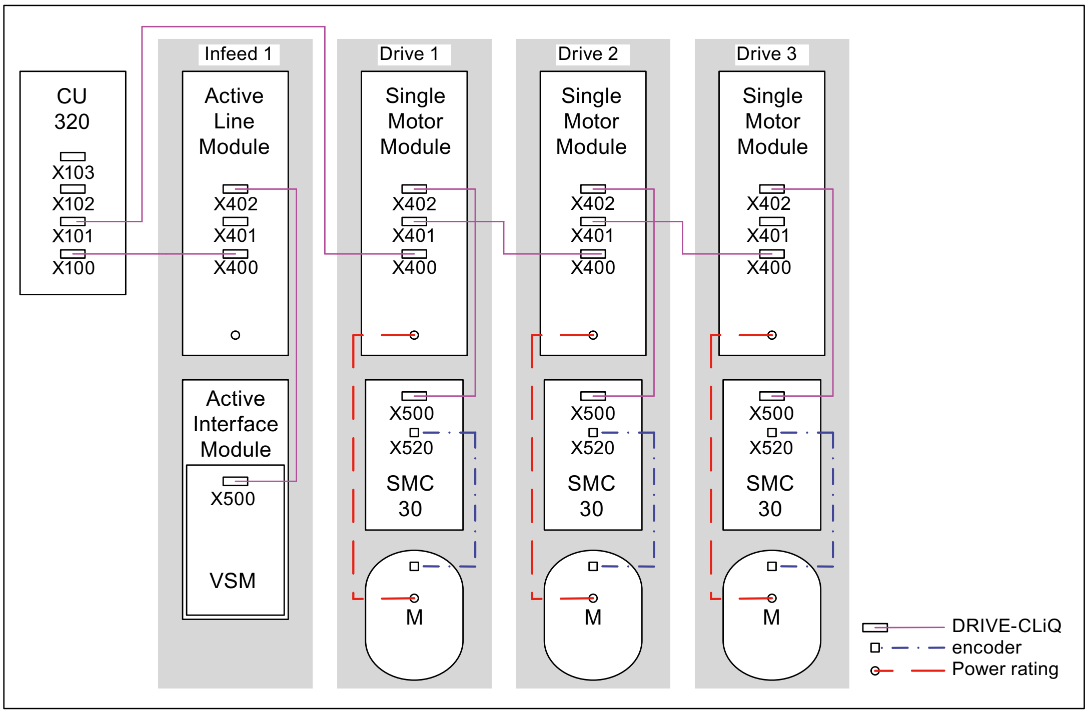


Figure 12-25 Drive line-up (chassis) with identical pulse frequencies

Drive line-up comprising four Motor Modules (chassis) with different pulse frequencies

Motor Modules with different pulse frequencies must be connected to different DRIVE-CLiQ interfaces on the Control Unit.

In the following diagram, two Motor Modules (400 V, output ≤ 250 kW, pulse frequency 2 kHz) are connected to interface X101 and two Motor Modules (400 V, output > 250 kW, pulse frequency 1.25 kHz) are connected to interface X102.

Note

This topology does not match the topology created offline by STARTER and must be changed.

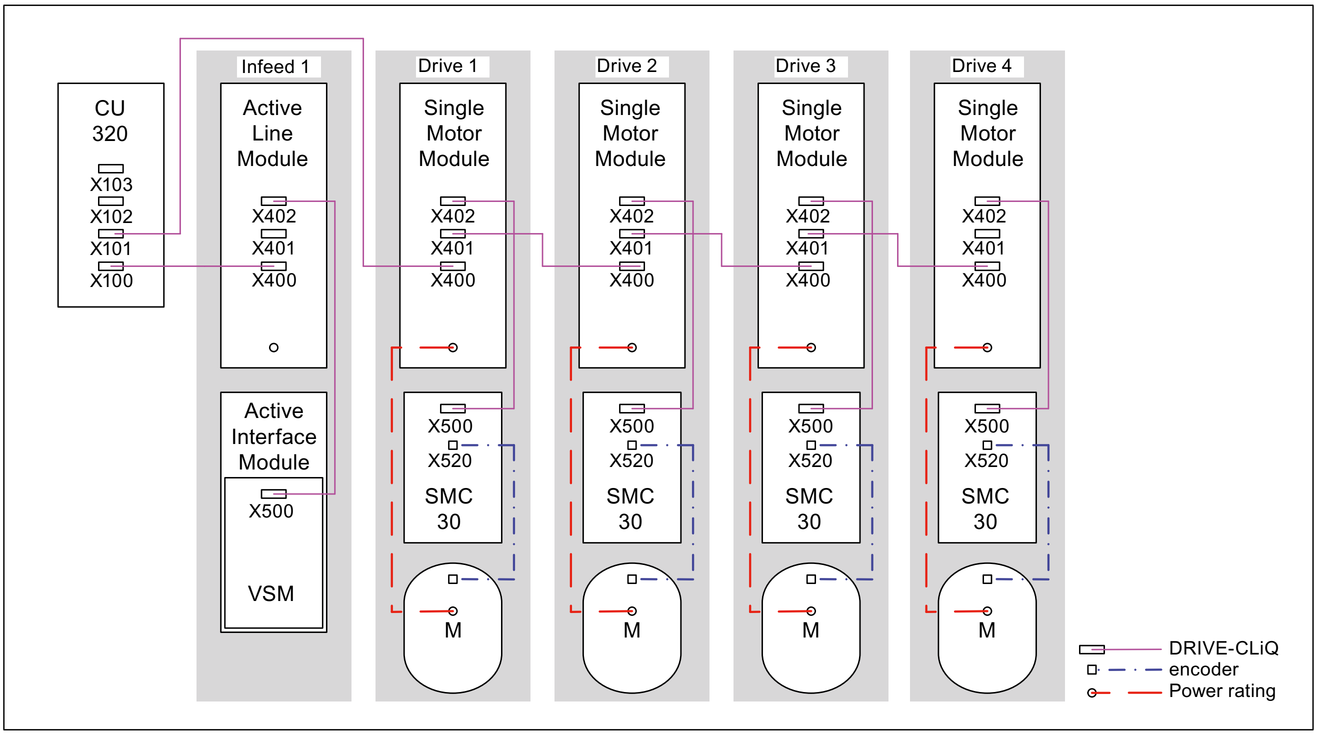


Figure 12-26 Drive line-up (chassis) with different pulse frequencies

12.10.4 Sample wiring of Vector drives connected in parallel

Drive line-up with two parallel-connected Line Modules and Motor Modules (chassis) of the same type

Parallel-connected Line Modules (chassis) and Motor Modules (chassis) of the same type can be connected to a DRIVE-CLiQ interface of the Control Unit.

In the following diagram, two Active Line Modules and two Motor Modules are connected to the X100 and X101 interface.

For further information about parallel connection, see the Function Manual.

Note

This topology does not match the topology created offline by STARTER and must be changed.

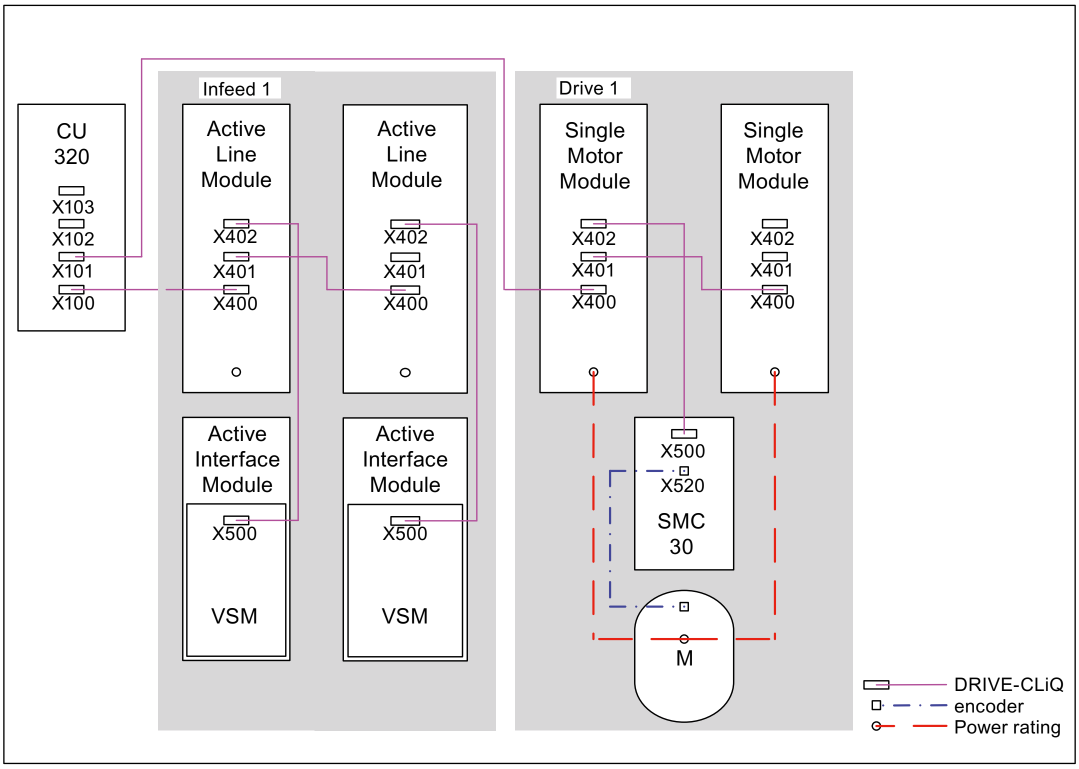


Figure 12-27 Drive line-up with parallel-connected power units (chassis)

12.10.5 Sample wiring: Power Modules

Blocksize

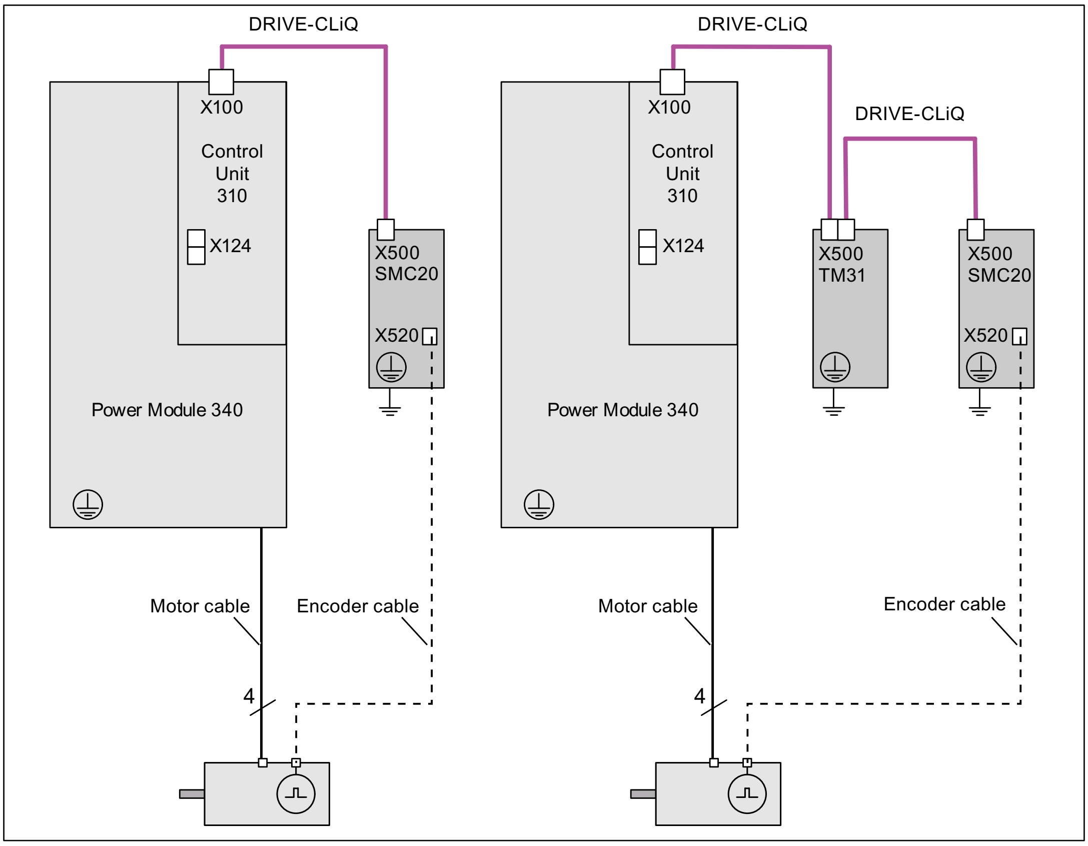


Figure 12-28 Wiring example for Power Modules Blocksize

Chassis

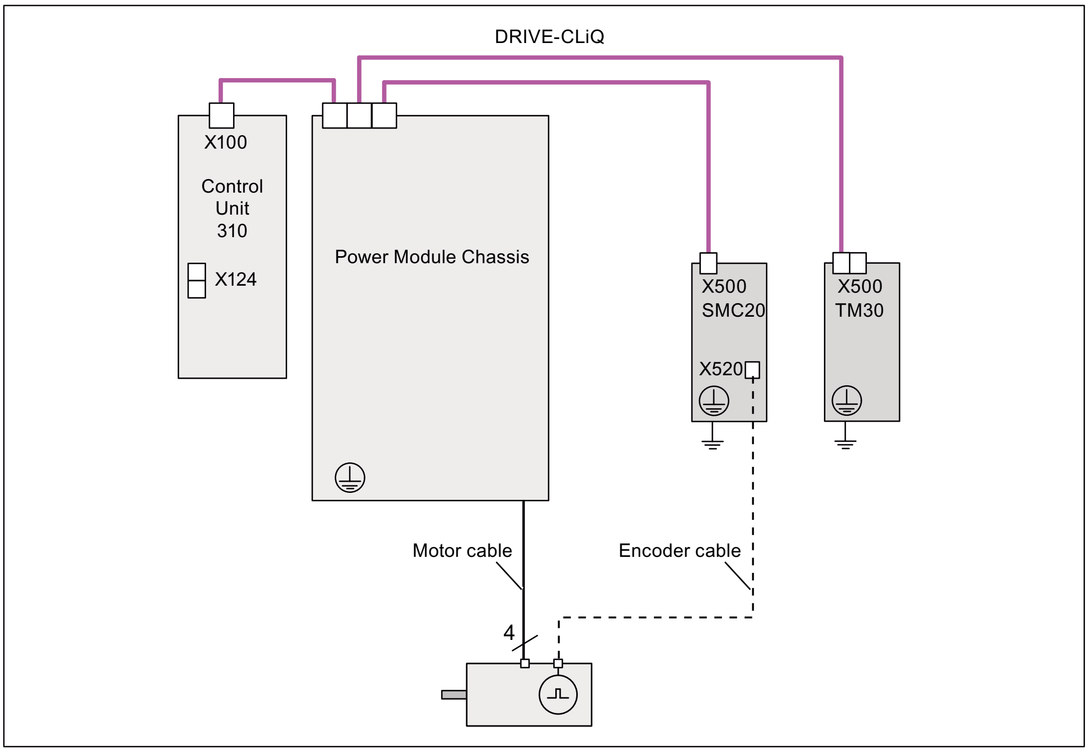
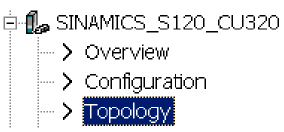
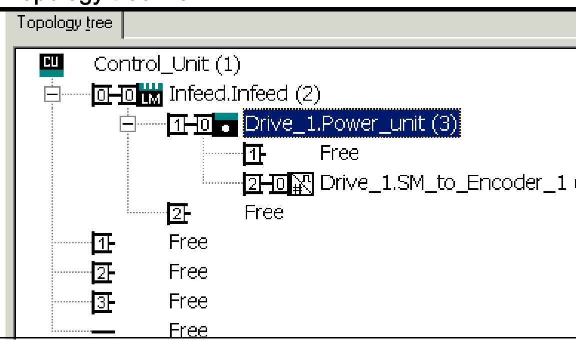


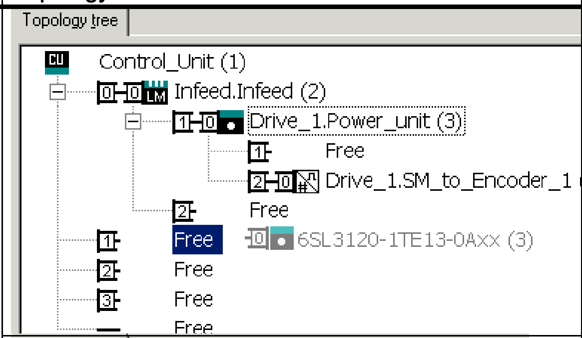
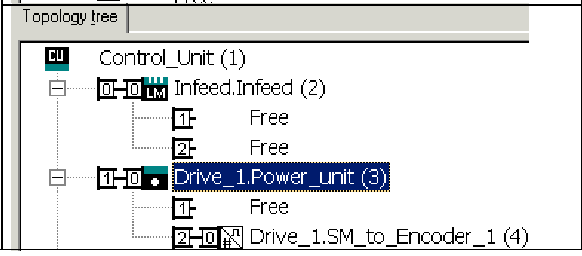
Figure 12-29 Wiring example for Power Modules Chassis

12.10.6 Changing the offline topology in STARTER

The device topology can be changed in STARTER by moving the components in the topology tree.

Table 12-21 Example: changing the DRIVE-CLiQ topology

	Topology tree view	Comment
		Select the DRIVE-CLiQ component.

	Topology tree view	Comment
		Keeping the mouse button depressed, drag the component to the required DRIVE-CLiQ interface and release the mouse button.
		You have changed the topology in STARTER.

12.10.7 Sample wiring for servo drives

The following diagram shows the maximum number of controllable servo drives and extra components. The sampling times of individual system components are:

- Active Line Module: p0115[0] = 250 µs
- Motor Modules: p0115[0] = 125 µs
- Terminal Module/Terminal Board p4099 = 1 ms

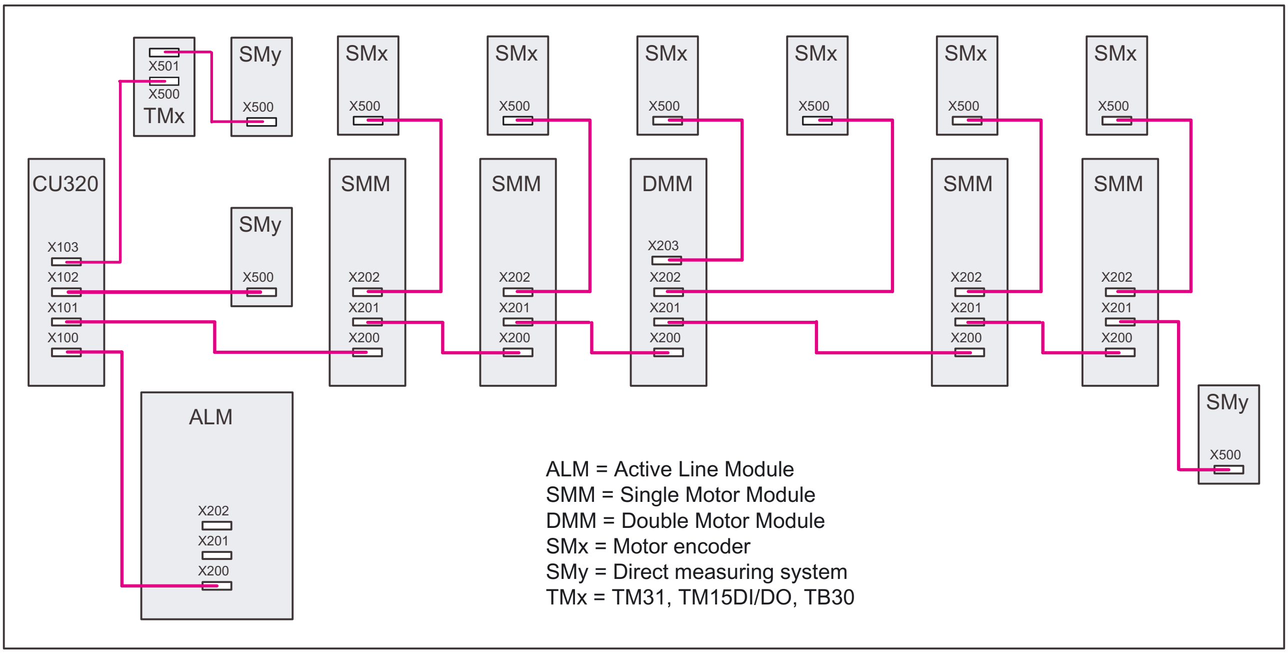


Figure 12-30 Sample servo topology

12.10.8 Sample wiring for vector U/f drives

The following diagram shows the maximum number of controllable vector U/f drives and extra components. The sampling times of individual system components are:

- Active Line Module: p0115[0] = 250 μs
- Motor Modules: p0115[0] = 125 μs
- Terminal Module/Terminal Board p4099 = 1 ms

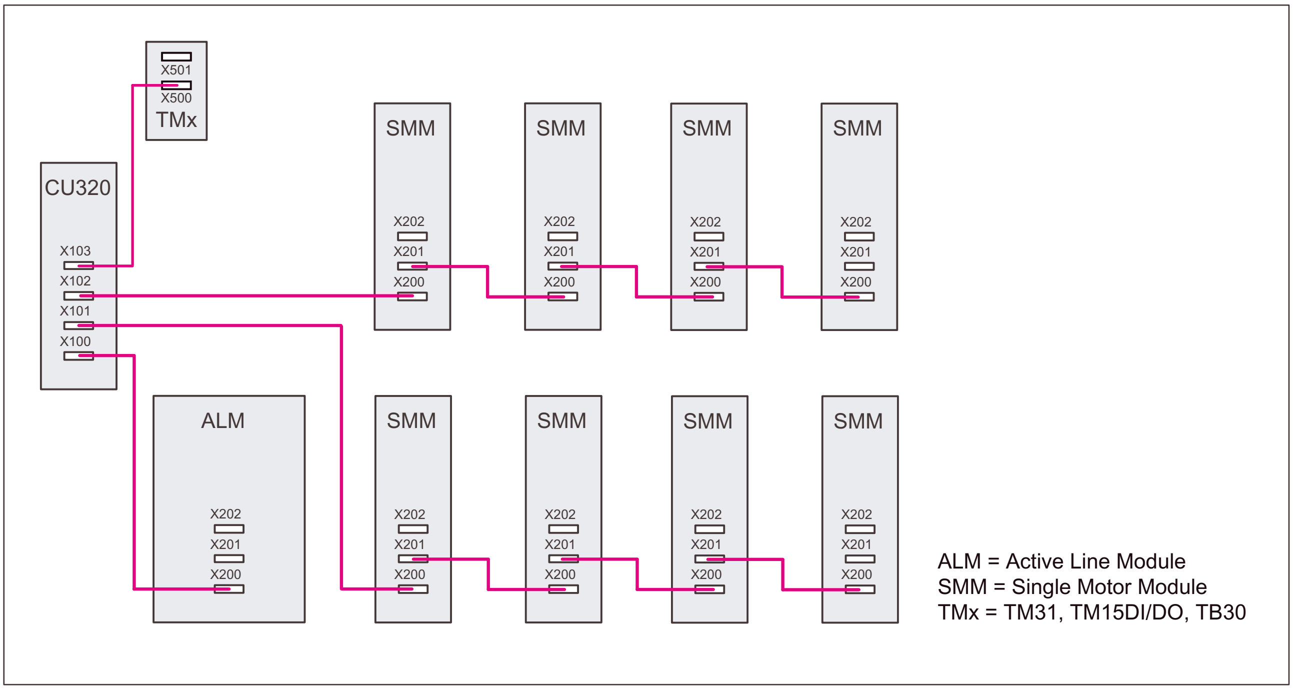


Figure 12-31 Sample vector U/f topology

12.11 Notes on the number of controllable drives

12.11.1 Introduction

The number and type of controlled drives and the extra activated functions on a Control Unit can be scaled by configuring the firmware. The maximum possible functionality depends on the computing power of the Control Unit used and may be checked in each case using the SIZER projecting tool.

12.11.2 Number of controllable drives

The following specifications provide a rough guide to the potential drive numbers for each Control Unit CU320 as a function of the current and speed controller clock cycles and the sampling times of the frequency/voltage channels with vector V/f.

Servo control

- Servo without extra function modules (e.g. setpoint channel):
  PROFIBUS-DP cycle >=1 ms
  - 6 drives (sampling times: current controller 125 µs / speed controller 125 µs), of which max. 2 induction motors or
    2 drives (sampling times: current controller 62.5 µs / speed controller 62.5 µs), both also induction motors
  - 6 motor measuring systems
  - 3 direct measuring systems
  - 1 Terminal Module TM31 or 1 Terminal Board TB30 with 1 ms sampling time
  - 1 Active Line Module with 250 µs sampling time without Voltage Sensing Module
- Servo without extra function modules (e.g. setpoint channel):
  PROFIBUS-DP cycle >= 500 µs and < 1 ms, valid for integrated SINAMICS drives for SIMOTION and SINUMERIK
  - 5 drives (sampling times: current controller 125 µs / speed controller 125 µs), of which max. 2 induction motors or
    2 drives (sampling times: current controller 62.5 µs / speed controller 62.5 µs), both also induction motors
  - Remaining modules as above
- Servo with CBE20 function module:
  PROFINET-IO bus cycle time > = 1 ms
  - 5 drives (sampling times: current controller 125 µs / speed controller 125 µs), of which max. 2 induction motors or
    1 drive (sampling times: current controller 62.5 µs / speed controller 62.5 µs), induction motor also possible
  - 5 motor measuring systems
  - 2 direct measuring systems
  - 1 Terminal Module TM31 or 1 Terminal Board TB30 with 1 ms sampling time
  - 1 Active Line Module with 250 µs sampling time without Voltage Sensing Module
- Servo with CBE20 function module:
  PROFINET-IO bus cycle time > = 500 µs and < 1 ms
  - 4 drives (sampling times: current controller 125 µs / speed controller 125 µs), of which max. 2 induction motors or
    1 drive (sampling times: current controller 62.5 µs / speed controller 62.5 µs), induction motor also possible
  - Remaining modules as above
- Servo with EPOS function module
  - 3 drives (sampling times: current controller 125 µs / speed controller 125 µs / position controller 1 ms / positioning 4 ms)
  - 3 motor measuring systems
  - 1 Active Line Module with 250 µs sampling time without Voltage Sensing Module

Vector control (cycles for EPOS: Position controller cycle = 1 ms / IPO cycle = 4 ms)

- Vector without additional Function Modules
  - 2 drives (sampling times: current controller 250 μs / speed controller 1000 μs)
  - 4 drives (sampling times: current controller 500 μs / speed controller 2000 μs)
- Vector with Function Module basic positioner (EPOS)
  - 2 drives (sampling times: current controller 250 μs / speed controller 1000 μs)
  - 3 drives (sampling times: current controller 500 μs / speed controller 2000 μs)
- Vector V/f without additional Function Modules
  - 6 drives (sampling times: current controller 400 μs / speed controller 1600 μs)
  - 8 drives (sampling times: current controller 500 μs / speed controller 2000 μs)

The details for the vector drives include:

- 1 Active Line Module with 250 μs (also applies to Chassis)
- 1 motor encoder per drive (not with vector U/f)
- 1 Terminal Module TM31 or 1 Terminal Board TB30 with 1 ms sampling time

Mixed operation

- Mixed operation: servo and vector V/f
  - 5 drives (sampling times: current controller 125 μs / speed controller 125 μs, current controller 400 μs / speed controller 1600 μs)
- Mixed operation: vector and vector V/f
  - 2 drives (sampling times: current controller 250 μs / speed controller 1000 μs, current controller 250 μs / speed controller 1000 μs)
  - 4 drives (sampling times: current controller 500 μs / speed controller 2000 μs, current controller 500 μs / speed controller 2000 μs)

12.12 System sampling times

12.12.1 Description

The software functions installed in the system are executed cyclically at different sampling times (p0115, p0799, p4099).

The sampling times of the functions are automatically pre-assigned when configuring the drive unit.

The settings are based on the selected mode (vector/servo), the number of connected components, and the functions activated.

The sampling times can be adjusted using parameter p0112 (sampling times, pre-setting p0115), p0113 (pulse frequency, minimum selection) or directly using p0115.

For p0092 = 1, the sampling times are pre-assigned so that isochronous operation together with a control is possible. If isochronous operation is not possible due to incorrect sampling time settings, then an appropriate message is output (A01223, A01224). Before the automatic configuration, parameter p0092 must be set to "1" in order that the sampling times are appropriately pre-set.

Note

Any change to the preset sampling times should only be performed by experts.

12.12.2 Setting the sampling times

Introduction

Setting the sampling times via p0112

The sampling times for:

- Current controller (p0115[0])
- Speed controller (p0115[1])
- Flux controller (p0115[2])
- Setpoint channel (p0115[3])
- Position controller (p0115[4])
- Positioner (p0115[5])
- Technology controller (p0115[6])

are set by selecting the appropriate values in p0112 for the closed-loop control configuration and are copied to p0115[0...6] depending on the performance levels required. The performance levels range from xLow to xHigh.

The sampling times are shown in the following table.

Table 12-22 For Active Infeed, the sampling time is set using p0112 (p0112 = 1 not for p0092 = 1)

p0112	p0115[0]	p0115[1]	p0115[2]	p0115[3]	p0115[4]	p0115[5]	p0115[6]
1: xLow	400	-	-	1600	-	-	-
2: Low	250	-	-	2000	-	-	-
3: Standard	125	-	-	2000	-	-	-
4: High	125	-	-	1000	-	-	-
5: xHigh	125	-	-	500	-	-	-

Table 12-23 For Smart Infeed, the sampling time is set using p0112 (p0112 = 1 not for p0092 = 1)

p0112	p0115[0]	p0115[1]	p0115[2]	p0115[3]	p0115[4]	p0115[5]	p0115[6]
1: xLow	400	-	-	1600	-	-	-

p0112	p0115[0]	p0115[1]	p0115[2]	p0115[3]	p0115[4]	p0115[5]	p0115[6]
2: Low	250	-	-	2000	-	-	-
3: Standard	250	-	-	2000	-	-	-
4: High	250	-	-	1000	-	-	-
5: xHigh	-	-	-	-	-	-	-

Table 12-24 For Basic Infeed Booksize, the sampling time is set using p0112

p0112	p0115[0]	p0115[1]	p0115[2]	p0115[3]	p0115[4]	p0115[5]	p0115[6]
1: xLow	-	-	-	-	-	-	-
2: Low	-	-	-	-	-	-	-
3: Standard	-	-	-	-	-	-	-
4: High	250	-	-	2000	-	-	-
5: xHigh	-	-	-	-	-	-	-

Table 12-25 For Basic Infeed Chassis, the sampling time is set using p0112

p0112	p0115[0]	p0115[1]	p0115[2]	p0115[3]	p0115[4]	p0115[5]	p0115[6]
1: xLow	2000	-	-	2000	-	-	-
2: Low	2000	-	-	2000	-	-	-
3: Standard	2000	-	-	2000	-	-	-
4: High	250	-	-	2000	-	-	-
5: xHigh	-	-	-	-	-	-	-

Table 12-26 For Servo, the sampling time is set using p0112

p0112	p0115[0]	p0115[1]	p0115[2]	p0115[3]	p0115[4]	p0115[5]	p0115[6]
1: xLow	250	250	250	4000	2000	8000	4000
2: Low	125	250	250	4000	2000	8000	4000
3: Standard	125	125	125	4000	1000	4000	4000
4: High	62.5	62.5	62.5	1000	1000	2000	1000
5: xHigh	-	-	-	-	-	-	-

Table 12-27 For Vector, the sampling time is set using p0112 (p0112 = 1 not for p0092 = 1 and not for PM340)

p0112	p0115[0]	p0115[1]	p0115[2]	p0115[3]	p0115[4]	p0115[5]	p0115[6]
1: xLow	400	1600	1600	3200	3200	3200	3200
2: Low	250	1000	2000	1000	2000	4000	4000
3: Standard	250	1000	1000	1000	2000	4000	4000
4: High	250	500	1000	500	1000	2000	2000
5: xHigh	250	250	1000	250	1000	2000	1000

Setting the pulse frequency via p0113 when STARTER is in online mode

The minimum pulse frequency can be entered in p0113. The parameter can only be changed for p0112 = 0 (Expert). The current controller sampling time (p0115[0]) is set to the inverse value of twice the minimum pulse frequency. The current controller sampling time (p0115[0]) calculated from the pulse frequency is set in the 1.25 µs time grid.

- Servo:

  When p0113 = 2.0 kHz, p0115[0] is set to 250 µs; when p0113 = 4.0 kHz, p0115[0] is set to 125 µs.
- Vector:

  When p0113 = 1.0 kHz, p0115[0] is set to 500 µs; when p0113 = 2.0 kHz, p0115[0] is set to 250 µs.

When commissioning is exited (p0009 = p0010 = 0), the effective pulse frequency (p1800) is appropriately pre-assigned, depending on p0113, and can be subsequently modified.

Setting the sampling times using p0115

If sampling times are required, which cannot be set using p0112 1, then the sampling times can be directly set using p0115. To do so, p0112 must be set to 0 (Expert).

If p0115 is changed online, then the values of higher indices are automatically adapted.

We do not recommend that p0115 is changed when STARTER is in the offline mode. The reason for this is that if the parameterization is incorrect, then the project download is interrupted.

12.12.3 Rules for setting the sampling time

The following rules apply when setting the sampling times:

1. The current controller sampling times of the drive objects (DOs) and the sampling times of the inputs/outputs of the Control Unit, TM and TB modules must be a multiple integer of 1.25 µs.
2. The sampling times (p0115[0] and p4099) of all components that are connected to a DRIVE-CLiQ line (DQS) must be divisible by one another with an integer result. If the current controller sampling time on a DO has to be changed to another pattern that does not match the other DOs on the DQS, the following options are available:
   - Change over the DO to another, separate DQS.
   - Also change the current controller sampling time and the sampling time of the inputs/outputs of the DOs not involved so that they again fit into the time grid.
3. The sampling times of the inputs/outputs (4099[0..2]) of a TB30 must be an integer multiple of the current controller sampling time (p0115[0]) of a drive object connected to a DRIVE-CLiQ group.
   - Sampling time of the inputs/outputs p4099[0..2]: for TB30
4. When Safety Integrated Extended Functions are used (see Safety Integrated Function Manual), the sampling time of the current controller (p0115[0]) may be 62.5 µs, 125 µs or 250 µs.

5. For Active Line Modules (ALM) in booksize format, only a current controller sampling time of 125.0 µs or 250.0 µs can be set.
6. For ALMs in chassis format, only a current controller sampling time of 250.0 µs or 400.0 µs / 375.0 µs (375 µs when p0092 = 1) can be set.
7. For Basic Line Modules (BLM), only a current controller sampling time of 2000 µs can be set.
8. For Motor Modules in chassis format, a current controller sampling time of minimum 250 µs can be set (250 µs ≤ p0115[0] ≤ 500 µs).
9. For Motor Modules in blocksize format (PM340), a current controller sampling time of 62.5 µs, 125.0 µs, 250.0 µs, or 500.0 µs can be set (only pulse frequencies in multiples of 2 kHz permitted).
10. When a chassis unit is connected to a DQS, the smallest current controller sampling time must be at least 250 µs.

    Example:
    Mixture of chassis and booksize units on a DQS
11. A current controller sampling time between 62.5 µs and 250.0 µs can be set for servo drives (62.5 µs ≤ p0115[0] ≤ 250.0 µs).
12. A current controller sampling time between 250,0 µs and 500,0 µs can be set for servo drives (250,0 µs ≤ p0115[0] ≤ 500,0 µs).
13. For servo drives with a current controller sampling time of p0115[0] = 62.5 µs, the following applies:
    – Only possible in booksize and blocksize format.

    Maximum number of components/devices:
    – Booksize: 2 servo with p0115[0] = 62.5 µs + Line Module (connected to another DQS)
    – Blocksize: 1 servo with p0115[0] = 62.5 µs
    – Booksize servo drives can be combined on one DQS with a servo with p0115[0] = 125.0 µs, but with the same quantity framework.
    – A DQ hub DMC20 cannot be operated on a DQS with servo drives with p0115[0] = 62.5 µs but must be connected to a separate DQS.
14. Synchronous PROFIBUS operation (set p0092 to 1):
    – Servo, vector and vector-V/f control objects must have the same current controller sampling time.
    Exception: 125.0 µs can be mixed with 62,5 µs and 125.0 µs can be mixed with 250.0 µs.
    – The current controller sampling time must also be a multiple integer of 125.0 µs or equal to 62.5 µs.
15. For vector and vector-V/f control drive types, and when using a sinusoidal filter (p0230 > 0), it is only permissible to change the current controller sampling time of the DO involved in multiple integer steps of the default value.
16. The following applies when using a Voltage Sensing Module (VSM):

    All current controller sampling times at the DQS must be the same.
17. For 3 vector drives (speed control: r0108.2 = 1), a minimum current controller sampling time of 375.0 µs can be set
    (375.0 µs ≤ p0115[0] ≤ 500 µs).

This rule also applies for parallel connection (3 or 4 Motor Modules connected in parallel)

18. For 4 vector drives (speed control: r0108.2 = 1), a minimum current controller sampling time of 400.0 µs can be set
(400.0 µs ≤ p0115[0] ≤ 500 µs).

19. When servo is operated together with vector-V/f, a maximum of 5 DOs is possible (ALM, TB and TM additionally possible):

    Examples:

    – 1 servo + 4 vector-V/f (vector-V/f: 400 µs ≤ p0115[0] ≤ 500 µs)
    – 2 servo + 3 vector-V/f (vector-V/f: 400 µs ≤ p0115[0] ≤ 500 µs)
    – 3 servo + 2 vector-V/f (vector-V/f: 250 µs ≤ p0115[0] ≤ 500 µs)
    – 4 servo + 1 vector-V/f (vector-V/f: 250 µs ≤ p0115[0] ≤ 500 µs)

20. A maximum of two DRIVE-CLiQ lines are possible in the unit where the lowest sampling times are not integer multiples of one another.

    Example 1:

    At CU-X100: ALM with 250 µs
    At CU-X101: 1 vector drive object with 455 µs (p0113=1.098 kHz)
    This setting is allowed.
    Other DQS must have minimum sampling time of 250 µs or 455 µs.

12.12.4 Default settings for the sampling times

When commissioning for the first time, the current controller sampling times (p0115[0]) are automatically pre-set with these default values as follows:

Table 12-28 Default settings

Construction type	Number	p0112	p0115[0]	p1800
Active Infeed and Smart Infeed				
Booksize	1	2 (Low)	250 µs	-
Chassis 400 V / ≤ 300 kW 690 V / ≤ 330 kW	1	2 (Low)	250 µs	-
Chassis 400 V / > 300 kW 690 V / > 330 kW	1	0 (Expert) 1 (xLow)	375 µs (p0092 = 1) 400 µs (p0092 = 0)	- -
Basic Infeed				
Booksize	1	3 (High)	250 µs	-
Chassis	1	3 (Standard)	2000 µs	-
Servo				
Booksize	1 to 6	3 (Standard)	125 µs	4 kHz
Chassis	1 to 6	1 (xLow)	250 µs	2 kHz
Blocksize	1 to 5	3 (Standard)	125 µs	4 kHz
Vector				

<table>
<tr><th>Construction type</th><th>Number</th><th>p0112</th><th>p0115[0]</th><th>p1800</th></tr>
<tr><td>Booksize</td><td rowspan="2">1 to 2 only n_ctrl
1 to 4 only V/f
1 to 2 n_ctrl and V/f mixed</td><td rowspan="2">3 (Standard)</td><td rowspan="2">250 µs</td><td>4 kHz</td></tr>
<tr><td>Chassis
400 V / ≤ 250 kW</td><td>2 kHz</td></tr>
<tr><td>Booksize</td><td rowspan="2">3 to 4 only n_ctrl
5 to 6 only V/f
3 to 4 n_ctrl and V/f mixed</td><td rowspan="2">0 (Expert)</td><td rowspan="2">500 µs</td><td>4 kHz</td></tr>
<tr><td>Chassis
400 V / ≤ 250 kW</td><td>2 kHz</td></tr>
<tr><td rowspan="2">Chassis
> 250 kW
690 V</td><td>1 to 3 only n_ctrl
1 to 6 only V/f
1 to 3 n_ctrl and V/f mixed</td><td>0 (Expert)
1 (xLow)</td><td>375 µs (p0092 = 1)
400 µs (p0092 = 0)</td><td>1.333 kHz
1.25 kHz</td></tr>
<tr><td>4 only n_ctrl
4 n_ctrl and V/f mixed</td><td>0 (Expert)
1 (xlow)</td><td>500 µs (p0092 = 1)
400 µs (p0092 = 0)</td><td>2 kHz
1.25 kHz</td></tr>
<tr><td>Booksize</td><td rowspan="2">> 6 only V/f</td><td rowspan="2">0 (Expert)</td><td rowspan="2">500 µs</td><td>4 kHz</td></tr>
<tr><td>Chassis</td><td>2 kHz</td></tr>
<tr><td rowspan="2">Blocksize</td><td>1 to 2 only n_ctrl
1 to 4 only V/f</td><td>3 (Standard)</td><td>250 µs</td><td>4 kHz</td></tr>
<tr><td>> 2 n_ctrl (min. 1)
> 4 only V/f</td><td>0 (Expert)</td><td>500 µs</td><td>4 kHz</td></tr>
<tr><td colspan="5">Caution
If a Power Module Blocksize is connected to a Control Unit, the sampling times of all vector drives are set according to the rules for Power Modules Blocksize (only 250 µs or 500 µs possible).</td></tr>
</table>

12.12.5 Examples when changing sampling times / pulse frequencies

Example: Changing the current controller sampling time from 62.5 µs with p0112

Preconditions:

- Maximum 2 drives, Booksize format
- Servo motor control type

Procedure:

1. p0009 = 3 (not for offline operation)
2. Switch to the first servo drive object
3. p0112 = 4
4. Switch to the second servo drive object and repeat step 3.
5. p0009 = 0 (not for offline operation)
6. When STARTER is in offline mode: Download into the drive.

7. Save the parameter changes in a non-volatile fashion using the function "Copy RAM to ROM" (see also the Commissioning Manual).
8. We recommend that the controller settings are re-calculated (p0340 = 4).

Example: Changing the pulse frequency with p0113

Preconditions:

- STARTER is in the online mode.

Assumption:

- A TB30 has been installed.
- Servo motor control type

Procedure:

1. p0009 = 3 (not for offline operation)
2. Switch to the first servo drive object
3. p0112 = 0
4. Enter the required minimum pulse frequency in p0113.

   If this conflicts with rule 1 for setting the sampling times ("The current controller sampling times of the drive objects (DOs) and the sampling times of the inputs/outputs of the Control Unit, TM, and TB modules must be an integer multiple of 1.25 µs."), an alarm is output and a suitable pulse frequency is proposed in p0114. This can be entered in p0113 (remember to take into account the rules for setting the sampling times).
5. Switch to the second servo drive object and repeat steps 3 and 4.
6. Change into the drive object TB30
7. Set the three sampling times p4099[0..2] to a multiple of the current controller sampling time of a servo drive.
8. p0009 = 0
   Note: The pulse frequency in p1800 is automatically adapted.
9. Save the parameter changes in a non-volatile fashion using the function "Copy RAM to ROM" (see also the Commissioning Manual).
10. We recommend that the controller settings are re-calculated (p0340 = 4).

12.12.6 Overview of key parameters (see SINAMICS S List Manual)

- p0009 Device commissioning, parameter filter
- p0092 Isochronous PROFIBUS operation, pre-assignment/check
- p0097 Selects the drive object type
- r0110 [0..2] DRIVE-CLiQ basis sampling times

- r0111 DRIVE-CLiQ basis sampling time selection
- p0112 Sampling times pre-setting p0115
- p0113 Selects the minimum pulse frequency
- r0114 Recommended minimum pulse frequency
- p0115[0..6] Sampling times for internal control loops
- r0116 Recommended drive sampling time
- p0118 Current controller computation deadtime
- p0799 CU inputs/outputs sampling time
- p1800 Pulse frequency
- p4099 Inputs/outputs sampling time
- r9780 SI monitoring clock cycle (Control Unit)
- r9880 SI monitoring clock cycle (Motor Module)

12.13 Licensing

Description

To use the SINAMICS S120 drive system and the activated options, you need to assign the corresponding licenses to the hardware. When doing so, you receive a license key, which electronically links the relevant option with the hardware.

The license key is an electronic license stamp that indicates that one or more software licenses are owned.

Actual customer verification of the license for the software that is subject to license is called a certificate of license.

Note

Refer to the order documentation (e.g. catalogs) for information on basic functions and functions subject to license.

An insufficient license is indicated via the following alarm and LED on the Control Unit:

- A13000 License not sufficient
- READY LED Flashes green/red at 0.5 Hz

NOTICE
The drive can only be operated with an insufficient license during commissioning and servicing. The drive requires a sufficient license in order for it to operate normally.

Information regarding the Performance 1 option (this is not valid for Control Unit CU310)

The option Performance 1 (Order No.: 6SL3074-0AA01-0AA0) is required from a computation time utilization greater than 50%. The remaining computation time is displayed in parameter r9976[2]. As of a CPU runtime utilization greater than 50%, alarm A13000 is output and the READY LED on the Control Unit flashes green/red at 0.5 Hz.

Properties of the license key

- Assigned to a specific CompactFlash card.
- Is stored on the non-volatile CompactFlash card.
- Is not transferable.
- Can be acquired using the "WEB License Manager" from a license database.

Generating a license key via the "WEB License Manager"

The following information is required:

- Serial number of the CompactFlash card (on CF card)
- License number, delivery note number, and the license (on the Certificate of License)

1. Call up the "WEB License Manager".

   http://www.siemens.com/automation/license
2. Choose "Direct access".
3. Enter the license number and delivery note number of the license.

   --> Click "Next".
4. Enter the serial number of the CompactFlash card.
5. Select the product e.g. "SINAMICS S CU320".

   --> Click "Next".
6. Choose "Available license numbers".

   --> Click "Next".
7. Check the assignment.

   --> Click "Assign".
8. When you are sure that the license has been correctly assigned, click "OK".
9. The license key is displayed and can be entered.

Entering the license key

Example of a license key:

E1MQ-4BEA = 69 49 77 81 45 52 66 69 65 dec (ASCII characters)

Procedure for entering a license key (see example):

1. p9920[0] = 69 1st character

   ...

2. p9920[8] = 65 9th character
3. p9920[9] = 0 No character

   ...

4. p9920[19] = 0 No character

Note

When changing p9920[x] to the value 0, all of the following indices are also set to 0.

After the license key has been entered, it has to be activated as follows:

- p9921 = 1 Licensing, activate license key

  The parameter is automatically reset to 0

In the table below, you can enter the characters in the license key and the associated decimal numbers.

Table 12-29 License key table

Letter/ number												
decimal												

ASCII code

Table 12-30 Excerpt of ASCII code

Letter/number	decimal	Letter/number	decimal
-	45	I	73
0	48	J	74
1	49	K	75
2	50	L	76
3	51	M	77
4	52	N	78
5	53	O	79
6	54	P	80
7	55	Q	81
8	56	R	82
9	57	S	83
A	65	T	84
B	66	U	85
C	67	V	86
D	68	W	87
E	69	X	88
F	70	Y	89
G	71	Z	90
H	72	Blanks	32

Overview of key parameters (see SINAMICS S List Manual)

- p9920 Licensing, enter license key
- p9921 Licensing, activate license key
- p9976[0...2] Remaining computation time

Appendix A

A.1 Availability of hardware components

Table A-1 Hardware components available as of 03.2006

No.	HW component	Order number	Version	Revisions
1	AC Drive (CU310, PM340)	refer to the Catalog		new
2	SMC30	6SL3055–0AA00–5CA1		with SSI support
3	DMC20	6SL3055–0AA00–6AAx		new
4	TM41	6SL3055–0AA00–3PAx		new
5	SME120 SME125	6SL3055–0AA00–5JAx 6SL3055–0AA00–5KAx		new
6	BOP20	6SL3055–0AA00–4BAx		new
7	CUA31	6SL3040-0PA00-0AAx		new

Table A-2 Hardware components available as of 08.2007

No.	HW component	Order number	Version	Revisions
1	TM54 F	6SL3055-0AA00-3BAx		new
2	Active Interface Module (Booksize)	6SL3100-0BExx-xABx		new
3	Basic Line Module (Booksize)	6SL3130-1TExx-0AAx		new
4	DRIVE-CLiQ encoder	6FX2001-5xDxx-0AAx		new
5	CUA31 for Safety dbI1/2	6SL3040-0PA00-0AA1		new
6	CUA32	6SL3040-0PA01-0AAx		new
7	SMC30 (30 mm wide)	6SL3055-0AA00-5CA2		new
8	CU310 for SSI and temperature evaluation on terminal X23	6SL3040-0LA00-0AA1		new

A.2 Availability of SW functions

Table A-3 New functions FW 2.2

No.	SW function	Servo	Vector	HW component
1	Technology controller	x	x	
2	2 command data sets	-	x	
3	Extended brake control	x	x	
4	Automatic restart for Vector and Smart Line Modules 5/10 kW	-	x	
5	The ability to mix servo and vector V/f modes on one CU	x	x	
6	Regulated $V_{DC\ link}$ up to 480 V input voltage can be parameterized for Active Line Modules	x	x	
7	Smart Mode for Active Line Modules booksize format	x	x	
8	Extended setpoint channel can be activated	x	-	
9	Evaluation, linear measuring systems	x	-	
10	Synchronous motors 1FT6/1FK6/1FK7 with DRIVE-CLiQ resolver	x	-	

Table A-4 New functions FW 2.3

No.	SW function	Servo	Vector	HW component
1	Motor data set changeover (8 motor data sets)	x	x	
2	Buffer for faults/alarms	x	x	
3	Rotor/pole position identification	x	x	
4	Booting with partial topology, parking axis/encoder, de-activating/activating components	x	x	
5	Friction characteristic with 10 points along the characteristic, automatic characteristic plot	x	x	
6	Utilization display	x	x	
7	Evaluation of distance-coded zero marks for higher-level controls	x	-	
8	Hanging/suspended axes/electronic weight equalization for higher-level controls	x	-	
9	SIMATIC S7 OPs can be directly coupled	x	x	
10	PROFIBUS NAMUR standard telegrams	-	x	
11	Parallel circuit configuration	-	x	For chassis drive units
12	Edge modulation	x	x	For chassis drive units
13	Servo control type	x	-	also chassis drive units
14	Terminal Module TM15 (DI/DO functionality)	x	x	
15	1FN1, 1FN3 linear motors	x	-	
16	1FW6 torque motors	x	-	
17	1FE1 synchronous built-in motors	x	-	
18	2SP1 synchronous spindles	x	-	
19	1FU8 SIMOSYN Motors	x	-	
20	1FS6 explosion-protected motors	x	-	

No.	SW function	Servo	Vector	HW component
21	SME20/25 external Sensor Modules for incremental and absolute encoder evaluation	x	x	

Table A-5 New functions FW 2.4

No.	SW function	Available since FW	Servo	Vector	HW component
1	SINAMICS S120 functionality for AC DRIVE (CU310DP/PN)	2.4	x	x	
2	Basic positioning	2.4 SP1	x	x	
3	Encoder data set changeover (3 EDS encoder data sets per drive data set)	2.4	x	x	
4	2 command data sets (CDS)	2.4	x	x	
5	Units changeover SI / US / %	2.4	x	x	
6	Motor data identification servo	2.4	x	since FW2.1	
7	Increased torque accuracy for synchronous motors (kt estimator)	2.4	x	-	
8	Hub functionality (hot plugging, distributed encoder, star structure via DMC20)	2.4	x	x	
9	Basic Operator Panel BOP20	2.4	x	x	
10	Evaluation of SSI encoder (SMC30)	2.4	x	x	6SL3055–0AA00–5CA1
11	Pulse encoder emulation TM41	2.4	x	x	
12	Automatic restart with Active Line Module	2.4	x	x	
13	PROFIBUS extensions: – Peer-to-peer data transfer – Y link – telegram 1 also for servo – telegrams 2, 3, 4 - also for vector	2.4	 x x x since FW2.1	 x x since FW2.1 x	
14	Safety Integrated Stop category 1 (SS1) with safety-related time	2.4	x	x	
15	Measuring gearbox	2.4	x	x	
16	Setting the pulse frequency grid in fine steps	2.4	x	x	
17	Controller clock cycles that can be set	2.4	x	x	
18	Possibility of mixing clock cycles on a DRIVE-CLiQ line	2.4	x	x	
19	Clockwise/counter clockwise bit (the same as changing the rotating field	2.4	x	x	
20	Sensor Module for 1FN, 1FW6 with protective separation (SME120/125)	2.4	x	-	
21	Real time stamps for alarms	2.4	x	x	CU320, 6SL3040-....- 0AA1 and Version C or higher
22	Sensorless closed-loop speed control for torque motors	2.4	-	x	

No.	SW function	Available since FW	Servo	Vector	HW component
23	Separately-excited synchronous motors with encoder	2.4	-	x	
24	Drive converter/drive converter, drive converter/line supply (bypass) synchronizing	2.4	x	x	For chassis drive units
25	Voltage Sensing Module (VSM) for Active Line Module	2.4			also for booksize drive units
26	Armature short-circuit braking, synchronous motors	2.4	x	-	
27	CANopen extensions (vector, free process data access, profile DS301)	2.4	x	x	
28	PROFINET IO communication with Option Module CBE20	2.4	x	x	
29	New hardware components are supported (AC DRIVE, SME120/125, BOP20, DMC20, TM41)	2.4	x	x	
30	Position tracking for torque motors (not for EPOS)	2.4	x	x	CU320, 6SL3040-....- 0AA1 and Version C or higher
31	1FW3 torque motors	2.4	x	-	

Table A-6 New functions FW 2.5 or 2.5 SP1

No.	SW function	available since FW	Servo	Vector	HW component
1	DCC (Drive Control Chart) with graphical interconnection editor (DCC-Editor): • graphically configurable modules (logic, calculation and control functions) • module types that can be freely instantiated (flexible number of components/devices) • can be run on SIMOTION and SINAMICS controllers (DCC SINAMICS, DCC SIMOTION)	2.5 SP1	x	x	

No.	SW function	available since FW	Servo	Vector	HW component
2	Safety Integrated extended functions: • Safety functionality integrated in the drive, controllable via PROFIsafe (PROFIBUS) or secure terminal module TM54F • STO Safe torque off (previously Safe Standstill (SH) • SBC Safe Brake Control • SS1 Safe Stop 1, STO after a delay time has expired, standstill without torque • SOS Safe Operating Stop, safe standstill with full torque • SS2 Safe Stop 2; SOS after a delay time has expired, standstill with full torque • SLS Safely Limited Speed • SSM Safe Speed Monitor, safe speed monitor feedback (n < nx) on a secure output **Note:** The Safety Integrated Basic Functions STO and SBC have been implemented since V2.1 and SS1 since V2.4 (control via onboard terminals).	2.5 SP1	x	x	Safety Integrated Extended functions only for: • DAC Motor Modules (6SL3xxx-xxxxx-0AA3) • CUA31 (6SL3040-0PA00-0AA1)
3	EPOS function extensions: • Traversing blocks / new task: "Travel to fixed stop" • Traversing blocks / new continuation conditions: "External block relaying" • Completion of position tracking for absolute encoder (load gear) • Jerk limitation • "Set reference point" also with intermediate stop (Traversing blocks and MDI) • Reversing cam functionality also with reference run without reference cam	2.5	x	x	
4	Support of new motor series/types • 1FT7 (synchronous servo motor) • 1FN3 continuous load (linear motor for continuous load) • 1PL6 (functionality released since V2.1, now available as list motor)	2.5	x	1PL6 only	
5	Support of new components • Basic Line Module (BLM) in booksize format	2.5	x	x	
6	Support of new components • Active Interface Module (AIM), booksize format • TM54F (Terminal Module Failsafe) • CUA32 (Control Unit Adapter for PM340) • DRIVE-CLiQ encoder (machine encoder)	2.5 SP1	x	x	
7	Save data (motor and encoder data) from the Sensor Module on motor with DRIVE-CLiQ on CF card and backup on "empty" Sensor Module	2.5	x	x	
8	Evaluation of SSI encoders on AC drive controller CU310 (onboard interface)	2.5 SP1	x	x	only for CU310 (6SL3040-0LA00-0AA1)

No.	SW function	available since FW	Servo	Vector	HW component
9	Edge modulation (higher output voltages) in the vector control type, also with booksize devices	2.5	-	x	only for DAC Motor Modules (6SL3xxx-xxxxx-0AA3)
10	DC braking	2.5 SP1	x	x	
11	Armature short-circuit: Internal	2.5 SP1	x	x	
12	Armature short-circuit: Intermittent voltage protection	2.5	x	-	only for DAC Motor Modules (6SL3xxx-xxxxx-0AA3)
13	Automatic firmware update for DRIVE-CLiQ components	2.5	x	x	
14	Save STARTER project direct to CF card	2.5	x	x	
15	The terminal area for booksize infeeds (BLM, SLM, ALM) can be parameterized to 230 V 3 AC	2.5 SP1	x	x	only for booksize DAC infeeds (6SL3xxx-xxxxx-0AA3)
16	Automatic speed controller setting	2.5	x	since FW2.1	
17	Technological pump functions	2.5	-	x	
18	Simultaneous cyclical operation of PROFIBUS and PROFINET on CU320	2.5 SP1	x	x	
19	Automatic restart also with servo	2.5 SP1	x	since FW2.2	
20	Operates at 500 µs PROFINET I/O	2.5 SP1	x	-	
21	Absolute position information (X_IST2) with resolver	2.5	x	x	
22	DC link voltage monitoring depending on the line voltage	2.5	x	x	
23	Automatic line frequency detection	2.5	x	x	
24	Acceleration signal at the ramp function generator output	2.5	x	x	
25	Reset the drive device via parameter (p0972)	2.5	x	x	
26	Alteration of the basic sampling time during the automatic readjustment of the sampling times depending on the number of drives on CU320 with vector (from 400 µs to 500 µs)	2.5	-	x	
27	Dynamic energy management, extension of the Vdc_min, Vdc_max control	2.5	x	x	
28	Endless trace	2.5	x	x	
29	Extended PROFIBUS monitoring with timer and binector	2.5	x	x	
30	Indexed actual value acquisition Simultaneous evaluation of multiple encoders	2.5 SP1	x	x	

A.3 List of abbreviations

Abbreviation	German meaning	English meaning
A		
A...	Warnung	Alarm
AC	Wechselstrom	Alternating Current
ADC	Analog-Digital-Konverter	Analog Digital Converter
AI	Analogeingang	Analog Input
AIM	Active Interface Module	Active Interface Module
ALM	Active Line Module	Active Line Module
AO	Analogausgang	Analog Output
AOP	Advanced Operator Panel	Advanced Operator Panel
APC	Advanced Positioning Control	Advanced Positioning Control
ASC	Ankerkurzschluss	Armature Short-Circuit
ASCII	Amerikanische Code-Norm für den Informationsaustausch	American Standard Code for Information Interchange
ASM	Asynchronmotor	Induction motor
B		
BB	Betriebsbedingung	Operating condition
BERO	Firmenname für einen Näherungsschalter	Tradename for a type of proximity switch
BI	Binektoreingang	Binector Input
BIA	Berufsgenossenschaftliches Institut für Arbeitssicherheit	German Institute for Occupational Safety
BICO	Binektor-Konnektor-Technologie	Binector Connector Technology
BLM	Basic Line Module	Basic Line Module
BOP	Basic Operator Panel	Basic Operator Panel
C		
C	Kapazität	Capacitance
C...	Safety-Meldung	Safety message
CAN	Serielles Bussystem	Controller Area Network
CBC	Kommunikationsbaugruppe CAN	Communication Board CAN
CD	Compact Disc	Compact Disc
CDS	Befehlsdatensatz	Command Data Set
CF	CompactFlash	CompactFlash
CI	Konnektoreingang	Connector Input
CNC	Computerunterstützte numerische Steuerung	Computer Numerical Control
CO	Konnektorausgang	Connector Output
CO/BO	Konnektor-/Binektorausgang	Connector Output/Binector Output
COB-ID	CAN Object-Identification	CAN Object Identification
COM	Mittelkontakt eines Wechselkontaktes	Common contact of a change-over relay
CP	Kommunikationsprozessor	Communications Processor
CPU	Zentrale Recheneinheit	Central Processing Unit
CRC	Checksummenprüfung	Cyclic Redundancy Check

Abbreviation	German meaning	English meaning
CSM	Control Supply Module	Control Supply Module
CU	Control Unit	Control Unit
D		
DAC	Digital-Analog-Konverter	Digital Analog Converter
DC	Gleichstrom	Direct Current
DCB	Drive Control Block	Drive Control Block
DCC	Drive Control Chart	Drive Control Chart
DCN	Gleichstrom negativ	Direct Current Negative
DCP	Gleichstrom positiv	Direct Current Positive
DDS	Antriebsdatensatz	Drive Data Set
DI	Digitaleingang	Digital Input
DI/DO	Digitaleingang/-ausgang bidirektional	Bidirectional Digital Input/Output
DMC	DRIVE-CLiQ Module Cabinet (Hub)	DRIVE-CLiQ Module Cabinet (Hub)
DO	Digitalausgang	Digital Output
DO	Antriebsobjekt	Drive Object
DP	Dezentrale Peripherie	Decentralized Peripherals (Distributed I/Os)
DPRAM	Speicher mit beidseitigem Zugriff	Dual-Port Random Access Memory
DRAM	Dynamischer Speicher	Dynamic Random Access Memory
DRIVE-CLiQ	Drive Component Link with IQ	Drive Component Link with IQ
DSC	Dynamic Servo Control	Dynamic Servo Control
E		
EASC	Externer Ankerkurzschluss	External Armature Short-Circuit
EDS	Geberdatensatz	Encoder Data Set
EGB	Elektrostatisch gefährdete Baugruppen	Electrostatic Sensitive Devices (ESD)
ELP	Erdschlussüberwachung	Earth Leakage Protection
EMK	Elektromagnetische Kraft	Electromagnetic Force (EMF)
EMV	Elektromagnetische Verträglichkeit	Electromagnetic Compatibility (EMC)
EN	Europäische Norm	European Standard
EnDat	Geber-Schnittstelle	Encoder-Data-Interface
EP	Impulsfreigabe	Enable Pulses
EPOS	Einfachpositionierer	Basic positioner
ES	Engineering System	Engineering System
ESB	Ersatzschaltbild	Equivalent circuit diagram
ESR	Erweitertes Stillsetzen und Rückziehen	Extended Stop and Retract
F		
F...	Störung	Fault
FAQ	Häufig gestellte Fragen	Frequently Asked Questions
FBL	Freie Funktionsblöcke	Free Blocks
FCC	Function Control Chart	Function Control Chart
FCC	Flussstromregelung	Flux Current Control
F-DI	Fehlersicherer Digitaleingang	Failsafe Digital Input

Abbreviation	German meaning	English meaning
F-DO	Fehlersicherer Digitalausgang	Failsafe Digital Output
FEM	Fremderregter Synchronmotor	Separately excited synchronous motor
FEPROM	Schreib- und Lesespeicher nichtflüchtig	Flash-EPROM
FG	Funktionsgenerator	Function Generator
FI	Fehlerstrom-Schutzschalter	Earth Leakage Circuit-Breaker (ELCB)
FP	Funktionsplan	Function diagram
FPGA	Field Programmable Gate Array	Field Programmable Gate Array
FW	Firmware	Firmware
G		
GB	Gigabyte	Gigabyte
GC	Global-Control-Telegramm (Broadcast-Telegramm)	Global Control Telegram (Broadcast Telegram)
GSD	Gerätestammdatei: beschreibt die Merkmale eines PROFIBUS-Slaves	Device master file: describes the features of a PROFIBUS slave
GSV	Gate Supply Voltage	Gate Supply Voltage
GUID	Globally Unique Identifier	Globally Unique Identifier
H		
HF	Hochfrequenz	High Frequency
HFD	Hochfrequenzdrossel	High frequency reactor
HLG	Hochlaufgeber	Ramp-function generator
HMI	Mensch-Maschine-Schnittstelle	Human Machine Interface
HTL	Logik mit hoher Störschwelle	High-Threshold Logic
HW	Hardware	Hardware
I		
i. V.	In Vorbereitung: diese Eigenschaft steht zur Zeit nicht zur Verfügung	In preparation: this feature is currently not available
I/O	Eingang/Ausgang	Input/Output
IASC	Interner Ankerkurzschluss	Internal Armature Short-Circuit
IBN	Inbetriebnahme	Commissioning
ID	Identifizierung	Identifier
IEC	Internationale Norm in der Elektrotechnik	International Electrotechnical Commission
IF	Interface	Interface
IGBT	Bipolartransistor mit isolierter Steuerelektrode	Insulated Gate Bipolar Transistor
IL	Impulslöschung	Pulse suppression
IPO	Interpolatortakt	Interpolator clock
IT	Drehstromversorgungsnetz ungeerdet	Insulated three-phase supply network
IVP	Interner Spannungsschutz	Internal Voltage Protection
J		
JOG	Tippen	Jogging
K		
KDV	Kreuzweiser Datenvergleich	Data cross-checking
KIP	Kinetische Pufferung	Kinetic buffering
Kp	Proportionalverstärkung	Proportional gain
KTY	Spezieller Temperatursensor	Special temperature sensor

Abbreviation	German meaning	English meaning
L		
L	Induktivität	Inductance
LED	Leuchtdiode	Light Emitting Diode
LIN	Linearmotor	Linear motor
LR	Lageregler	Position controller
LSB	Niederstwertiges Bit	Least Significant Bit
LSS	Netzschalter	Line Side Switch
LU	Längeneinheit	Length Unit
LWL	Lichtwellenleiter	Fiber-optic cable
M		
M	Masse	Reference potential, zero potential
MB	Megabyte	Megabyte
MCC	Motion Control Chart	Motion Control Chart
MDS	Motordatensatz	Motor Data Set
MLFB	Maschinenlesbare Fabrikatebezeichnung	Machine-readable product designation
MMC	Mensch-Maschine-Kommunikation	Man-Machine Communication
MSB	Höchstwertiges Bit	Most Significant Bit
MSCY_C1	Zyklische Kommunikation zwischen Master (Klasse 1) und Slave	Master Slave Cycle Class 1
MSC	Motorstromrichter	Motor power converter
MT	Messtaster	Measuring probe
N		
N. C.	Nicht angeschlossen	Not Connected
N...	Keine Meldung oder Interne Meldung	No Report
NAMUR	Normenarbeitsgemeinschaft für Mess- und Regeltechnik in der chemischen Industrie	Standardization association for instrumentation and control in the chemical industry
NC	Öffner	Normally Closed (contact)
NC	Numerische Steuerung	Numerical Control
NEMA	Normengremium in USA (United States of America)	National Electrical Manufacturers Association
NM	Nullmarke	Zero Mark
NO	Schließer	Normally Open (contact)
NSR	Netzstromrichter	Line power converter
O		
OA	Open Architecture	Open Architecture
OEM	Original Equipment Manufacturer	Original Equipment Manufacturer
OLP	Busstecker für Lichtleiter	Optical Link Plug
OMI	Option Module Interface	Option Module Interface
P		
p...	Einstellparameter	Adjustable parameter
PB	PROFIBUS	PROFIBUS
PcCtrl	Steuerungshoheit	Master Control
PD	PROFIdrive	PROFIdrive
PDS	Leistungsteildatensatz	Power Unit Data Set

Abbreviation	German meaning	English meaning
PE	Schutzerde	Protective Earth
PELV	Schutzkleinspannung	Protective Extra Low Voltage
PEM	Permanenterregter Synchronmotor	Permanent-magnet synchronous motor
PG	Programmiergerät	Programming terminal
PI	Proportional Integral	Proportional Integral
PID	Proportional Integral Differential	Proportional Integral Differential
PLC	Speicherprogrammierbare Steuerung (SPS)	Programmable Logic Controller (PLC)
PLL	Phase Locked Loop	Phase Locked Loop
PNO	PROFIBUS Nutzerorganisation	PROFIBUS user organization
PPI	Punkt zu Punkt Schnittstelle	Point to Point Interface
PRBS	Weißes Rauschen	Pseudo Random Binary Signal
PROFIBUS	Serieller Datenbus	Process Field Bus
PS	Stromversorgung	Power Supply
PSA	Power Stack Adapter	Power Stack Adapter
PTC	Positiver Temperaturkoeffizient	Positive Temperature Coefficient
PTP	Punkt zu Punkt	Point-To-Point
PWM	Pulsweitenmodulation	Pulse Width Modulation
PZD	PROFIBUS Prozessdaten	PROFIBUS process data
R		
r...	Beobachtungsparameter (nur lesbar)	Display parameter (read only)
RAM	Speicher zum Lesen und Schreiben	Random Access Memory
RCCB	Fehlerstrom-Schutzschalter	Residual Current Circuit Breaker
RCD	Fehlerstrom-Schutzschalter	Residual Current Device
RJ45	Norm. Beschreibt eine 8-polige Steckverbindung mit Twisted-Pair Ethernet.	Standard. Describes an 8-pole plug connector with twisted pair Ethernet.
RKA	Rückkühlanlage	Cooling unit
RO	Nur lesbar	Read Only
RPDO	Receive Process Data Object	Receive Process Data Object
RS232	Serielle Schnittstelle	Serial Interface
RS485	Norm. Beschreibt die Physik einer digitalen seriellen Schnittstelle.	Standard. Describes the physical characteristics of a digital serial interface.
RTC	Echtzeituhr	Real Time Clock
RZA	Raumzeigerapproximation	Space vector approximation (SVA)
S		
S1	Dauerbetrieb	Continuous operation
S3	Aussetzbetrieb	Periodic duty
SBC	Sichere Bremsenansteuerung	Safe Brake Control
SBH	Sicherer Betriebshalt	Safe operating stop
SBR	Sichere Bremsrampe	Safe braking ramp
SBT	Sicherer Bremsentest	Safe Brake Test
SCA	Sichere Nocke	Safe Cam
SDI	Sichere Richtung	Safe Direction
SE	Sicherer Software-Endschalter	Safe software limit switch

Abbreviation	German meaning	English meaning
SG	Sicher reduzierte Geschwindigkeit	Safely reduced speed
SGA	Sicherheitsgerichteter Ausgang	Safety-related output
SGE	Sicherheitsgerichteter Eingang	Safety-related input
SH	Sicherer Halt	Safety standstill-
SI	Safety Integrated	Safety Integrated
SIL	Sicherheitsintegritätsgrad	Safety Integrity Level
SLI	Sicheres Schrittmaß	Safely Limited Increment
SLM	Smart Line Module	Smart Line Module
SLP	Sicher begrenzte Position	Safely Limited Position
SLS	Sicher begrenzte Geschwindigkeit	Safely Limited Speed
SLVC	Geberlose Vektorregelung	Sensorless Vector Control
SM	Sensor Module	Sensor Module
SMC	Sensor Module Cabinet	Sensor Module Cabinet
SME	Sensor Module External	Sensor Module External
SN	Sicherer Software-Nocken	Safe software cam
SOS	Sicherer Betriebshalt	Safe Operational Stop
SPC	Sollwertkanal	Setpoint Channel
SPS	Speicherprogrammierbare Steuerung	Programmable Logic Controller (PLC)
SS1	Sicherer Stop 1	Safe Stop 1
SS2	Sicherer Stop 2	Safe Stop 2
SSI	Synchron Serielle Schnittstelle	Synchronous Serial Interface
SSM	Sichere Rückmeldung der Geschwindigkeitsüberwachung (n < nx)	Safe Speed Monitoring
SSR	Sichere Bremsrampe	Safe Stop Ramp
STO	Sicher abgeschaltetes Moment	Safe Torque Off
STW	PROFIBUS Steuerwort	PROFIBUS control word
T		
TB	Terminal Board	Terminal Board
TIA	Totally Integrated Automation	Totally Integrated Automation
TM	Terminal Module	Terminal Module
TN	Drehstromversorgungsnetz geerdet	Grounded three-phase supply network
Tn	Nachstellzeit	Integral time
TPDO	Transmit Process Data Object	Transmit Process Data Object
TT	Drehstromversorgungsnetz geerdet	Grounded three-phase supply network
TTL	Transistor-Transistor-Logik	Transistor-Transistor Logic
Tv	Vorhaltezeit	Derivative-action time
U		
UL	Underwriters Laboratories Inc.	Underwriters Laboratories Inc.
USV	Unterbrechungsfreie Stromversorgung	Uninterruptible Power Supply (UPS)
V		
VC	Vektorregelung	Vector Control
Vdc	Zwischenkreisspannung	DC link voltage

Abbreviation	German meaning	English meaning
VdcN	Teilzwischenkreisspannung negativ	Partial DC link voltage negative
VdcP	Teilzwischenkreisspannung positiv	Partial DC link voltage positive
VDE	Verband Deutscher Elektrotechniker	Association of German Electrical Engineers
VDI	Verein Deutscher Ingenieure	Association of German Engineers
Vpp	Volt Spitze zu Spitze	Volt peak to peak
VSM	Voltage Sensing Module	Voltage Sensing Module
W		
WEA	Wiedereinschaltautomatik	Automatic restart
WZM	Werkzeugmaschine	Machine tool
X		
XML	Erweiterbare Auszeichnungssprache (Standardsprache für Web-Publishing und Dokumentenmanagement)	Extensible Markup Language
Z		
ZK	Zwischenkreis	DC Link
ZSW	PROFIBUS Zustandswort	PROFIBUS status word

Overview of SINAMICS Documentation (07/2007)

General Documentation/Catalogs

SINAMICS G110 G120 G120D
D11.1
G110/G120
Inverter chassis units
G120D
Distributed frequency inverters

SINAMICS G130 G150
D11
Drive Converter
Chassis Units
Drive Converter
Cabinet Units

SINAMICS S120
D21.1
Drive System
0.12 kW to 1200 kW

SINAMICS S150
D21.3
Drive Converter
Cabinet Units
75 kW to 1200 kW

Manufacturer/Service Documentation

SINAMICS G110
– Getting Started
– Operating Instructions
– List Manual

SINAMICS G120
– Getting Started
– Operating Instructions
– Function Manual
– List Manual

SINAMICS G130
– Operating Instructions
– List Manual

SINAMICS G150
– Operating Instructions
– List Manual

SINAMICS GM150 SM150 GL150
– Operating Instructions
– List Manual

Manufacturer/Service Documentation

SINAMICS S120
– Equipment Manual for Control Units and Additional System Components
– Equipment Manual for Booksize Power Units
– Equipment Manual Chassis Power Units
– Equipment Manual Booksize Cold–Plate Power Units
– Equipment Manual Cabinet Modules
– Equipment Manual AC Drive
– Equipment Manual Chassis Liquid Cooled Power Units

SINAMICS S120
– Getting Started
– Commissioning Manual
– Commissioning Manual CANopen
– Function Manual Drive Functions
– Function Manual Safety Integrated
– Function Manual DCC Standard Blocks
– Programming and Operating Manual DCC Editor Description
– List Manual

SINAMICS S150
– Operating Instructions
– List Manual

Manufacturer/Service Documentation

SINAMICS G110/G120/ S120 Motors
DOCONCD

Configuration Manual
Motors

EMC
Installation Guideline

If you come across any misprints in this document, please let us know using this form. We would also be grateful for any suggestions and recommendations for improvement.

To SIEMENS AG A&D MC MS1 P.O. Box 3180 D-91050 Erlangen, Germany Fax: +49 (0) 9131 / 98 - 63315 (documentation) mailto:docu.motioncontrol@siemens.com http://www.siemens.com/automation/service&support	From Name:
	Address of your company/Dept.
	Street:
	Postal code: City:
	Phone: /
	Fax: /

Suggestions and/or corrections

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S

W

6SL3097-2AB00-0BP4

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