SINAMICS S120

Function Manual · 01/2011

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S120
Drive functions

Function Manual

Applies to: Firmware version 4.4

(FH1), 01/2011

6SL3097-4AB00-0BP1

Legal information

Warning notice system

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

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

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

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

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

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

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

Qualified Personnel

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

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

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Ⓟ 01/2011

Foreword

SINAMICS documentation

The SINAMICS documentation is organized in the following categories:

- General documentation/catalogs
- User documentation
- Manufacturer/service documentation

More information

The following link provides information on the topics:

- Ordering documentation/overview of documentation
- Additional links to download documents
- Using documentation online (find and search in manuals/information)

http://www.siemens.com/motioncontrol/docu

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http://www.siemens.com/mdm

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The following link provides information on SITRAIN - training from Siemens for products, systems and automation engineering solutions:

http://www.siemens.com/sitrain

FAQs

You can find Frequently Asked Questions in the Service&Support pages under **Product Support**.

http://support.automation.siemens.com

SINAMICS

You can find information on SINAMICS at:

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

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
Deciding/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
Commissioning	• STARTER commissioning tool • SINAMICS S120 Getting Started • SINAMICS S120 Commissioning Manual • SINAMICS S120 CANopen Commissioning Manual • SINAMICS S120 Function Manual • SINAMICS S120/S150 List Manual
Usage/operation	• SINAMICS S120 Commissioning Manual • SINAMICS S120/S150 List Manual
Maintenance/servicing	• SINAMICS S120 Commissioning Manual • SINAMICS S120/S150 List Manual
References	• SINAMICS S120/S150 List Manual

Target group

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

Benefits

This Manual describes all the information, procedures and operational instructions required for commissioning and servicing SINAMICS S120.

Standard scope

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

- It may be possible for other functions not described in this documentation 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 that are not available in a particular product version of the drive system may be described in the documentation. 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

Country-specific telephone numbers for technical support are provided in the Internet under **Contact**:

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

EC Declaration of Conformity

The EC Declaration of Conformity for the EMC Directive can be found on the Internet at:

http://support.automation.siemens.com

There – as a search term – enter the number **15257461** or contact your local Siemens office.

Structure

The Function Manual is structured as follows:

Advice for beginners:
First read Chapter Basic information about the drive system (Page 691), followed by the appropriate chapter depending on the particular requirement.

Search guides

The following help is available for better orientation:

- Contents
- List of abbreviations
- Index

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 must only be taken on boards when the measuring instrument is grounded (via protective conductors, for example) or the measuring probe is briefly discharged before measurements are taken with an isolated measuring device (for example, touching a bare metal housing).

Safety instructions

⚠ DANGER

- Commissioning is absolutely prohibited until it has been completely ensured that the machine, in which the components described here are to be installed, is in full compliance with the provisions of the EC Machinery Directive.
- 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 three-phase 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 IEC 61800-5-1.

⚠ 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 (PELVs) that comply with EN 60204-1 may be connected to any 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 three-phase motors are subject to a voltage test in accordance with EN 61800-5-1. Before the voltage test is performed on the electrical equipment of industrial machines to EN 60204-1, Section 18.4, 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 areas, SINAMICS equipment with three-phase motors conforms to Low-Voltage Directive 2006/95/EC.

Contents

1 Infeed

1.1 Active Infeed

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 (cos φ = 1)
- Several Active Line Modules connected in parallel
- Master/Slave operation for several Active Line Modules

Description

The Active Infeed closed-loop control works in conjunction with the line reactor or an Active Interface Module and the Active Line Module as step-up controller. 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 of the Active Line Module runs on the Control Unit assigned to it. The Active Line Module and Control Unit communicate via DRIVE-CLiQ.

The operating modes "Parallel connection" and "Master/slave circuit" of power units - including the use of "Voltage Sensing Module" (VSM) - are described in this Manual in Chapter Function modules (Page 295).

1.1.1 Active Infeed closed-loop control booksize

Schematic structure

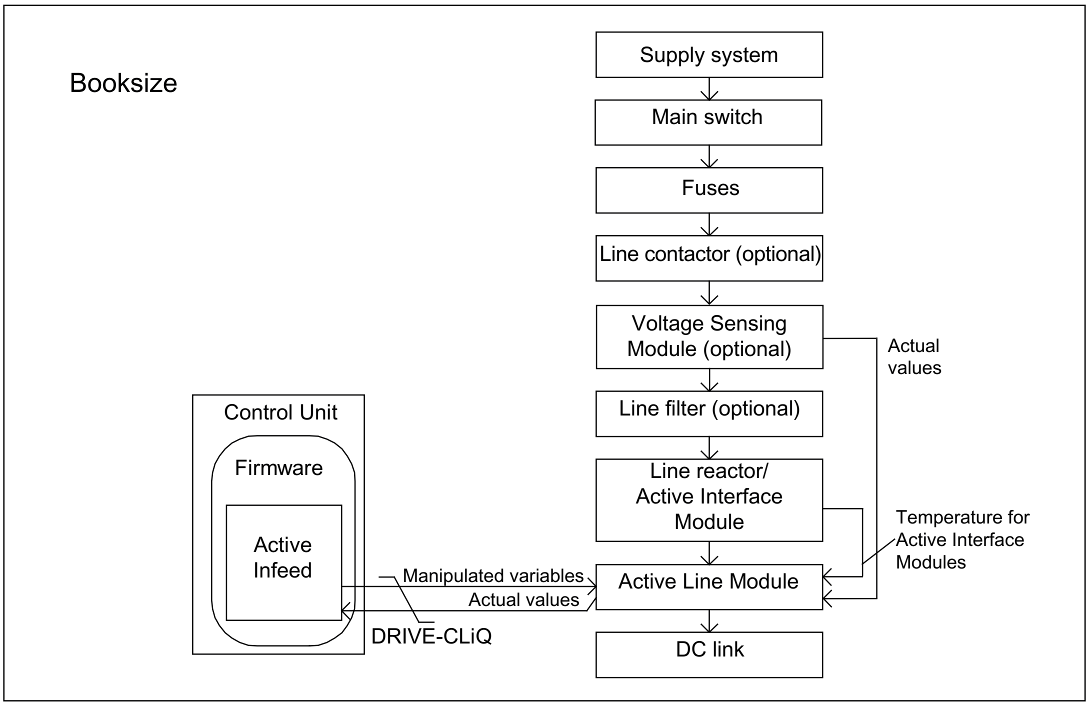


Figure 1-1 Schematic structure of Active Infeed booksize

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 the Active Mode, the DC link voltage is regulated to a variable setpoint (p3510), which results in a sinusoidal line current (cos φ = 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_setp p3510 [V]	600	625	562-594 1)	621 1)	648 1)
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 significant frequency fluctuations beyond the range defined in IEC 61000-2-4 if certain supplementary conditions are met. Significant 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 Voltage Sensing Module is urgently recommended.

The Voltage Sensing Modules help 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.

Following automatic commissioning, the appropriate filter for the matching Active Interface Module 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 a Wideband Line Filter is connected, it must be parameterized with p0220 = 1...5. The temperature sensor must be connected to terminal 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

1.1.2 Active Infeed closed-loop control chassis

Schematic structure

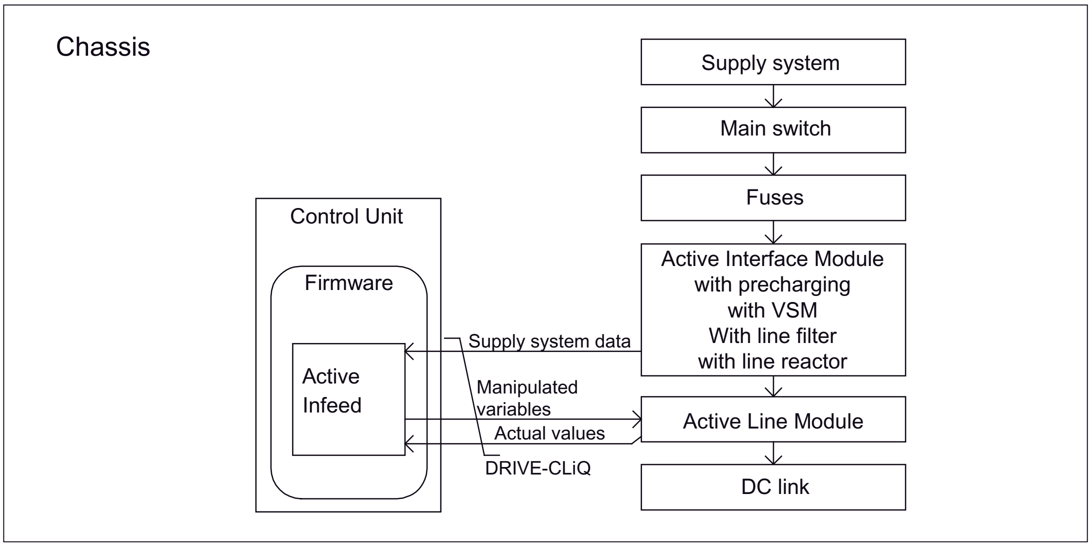


Figure 1-2 Schematic structure of Active Infeed chassis

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

Active Line Modules chassis only function in Active Mode.

In the Active Mode, the DC link voltage is regulated to a variable setpoint (p3510), which results in a sinusoidal line current (cos φ = 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 the supply voltage (p0210) and step-up factor (max. p3508 = 2.00)
- Lower limit: Supply voltage (p0210) multiplied by 1.42

⚠ CAUTION
Step-up factor for Active Line Modules, chassis format
For thermal reasons, the step-up factor may be set to a maximum of 2.00.

1.1.3 Integration

Function diagrams (see SINAMICS S120/S150 List Manual)

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

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0002 Infeed operating display
- r0046 CO/BO: 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
- r0898 CO/BO: Control word sequence 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
- p3400 Infeed configuration word
- r3405 CO/BO: Status word infeed
- p3410 Infeed identification method
- 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

1.1.4 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 DC link (e.g. after installation of the equipment at the customer's site or after expanding the drive line-up), 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 S120/S150 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 infeed parameters are then automatically stored in non-volatile memory.
  The infeed continues to operate without interruption on 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 when one of the two identification routines (p3410 = 4 or p3510 = 5) completes successfully.

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 important parameters (see SINAMICS S120/S150 List Manual)

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

1.1.5 Active Infeed open-loop control

Description

The Active Line Module can be controlled via the BICO interconnection using terminals or the fieldbus. 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 Manual of the corresponding power units. The drive unit must have been commissioned for the first time.

Acknowledge fault

Fault messages 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 fault" signal (p2103).

Switching on the Active Line Module

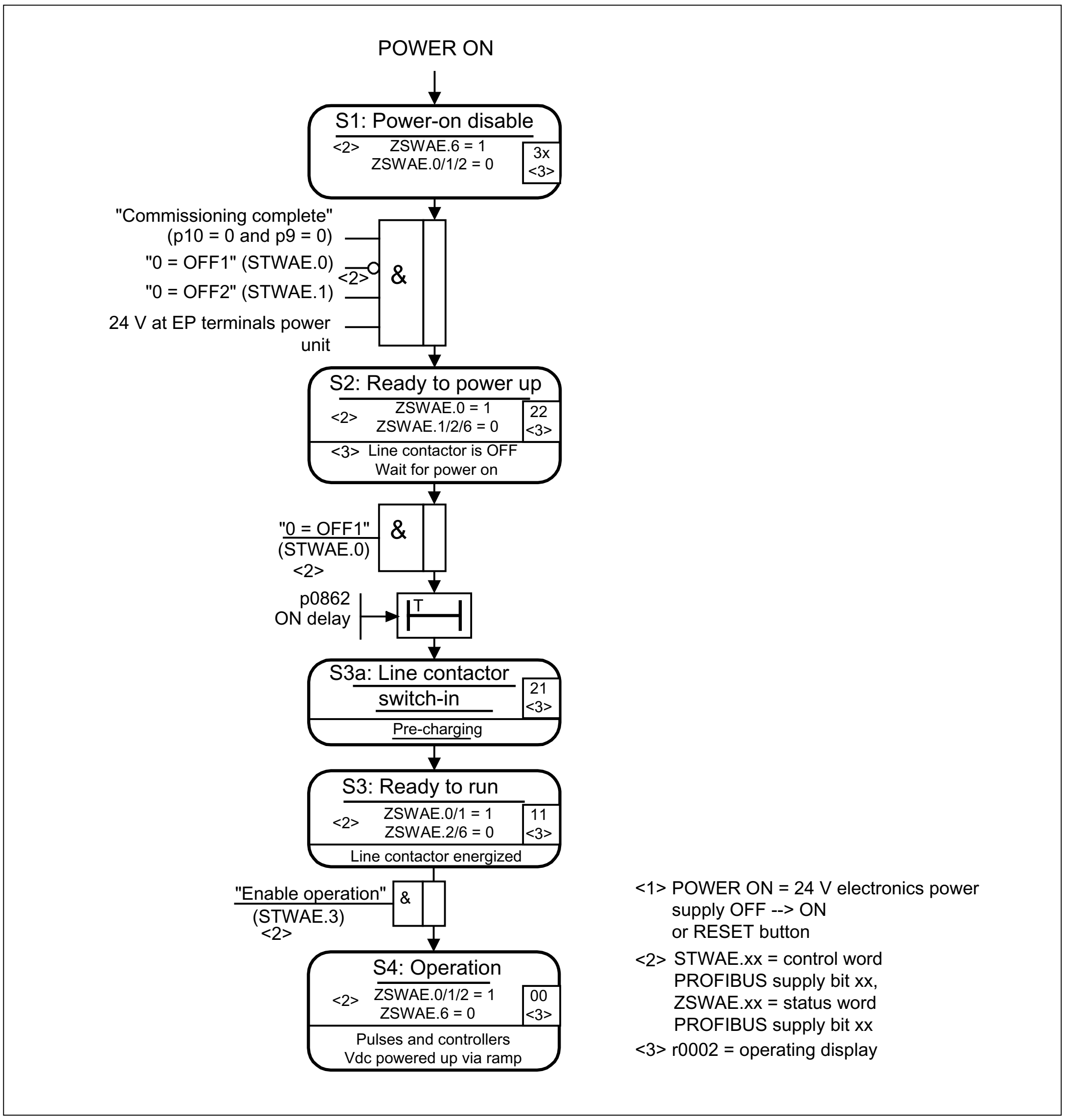


Figure 1-3 Active Infeed power-up

Note

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

Switching off the Active Line Module

The Active Line Module is switched off by the same procedure used to switch it on, but in the reverse order. However, there is no pre-charging at switch off.

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 fault	STWAE.7	p2103 1 Acknowledge or p2104 2 Acknowledge or p2105 3 Acknowledge	r2138.7	A_STW1.7
Master control by PLC	STWAE.10	p0854 Master control by PLC	r0898.10	A_STW1.10

Table 1- 3 Active Infeed status message

Signal name	Internal status word	Parameter	PROFIdrive telegram 370
Ready for switching on	ZSWAE.0	r0899.0	A_ZSW1.0
Ready for operation	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
Switching on inhibited	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm active	ZSWAE.7	r2139.7	A_ZSW1.7
Master control 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

1.1.6 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 line supply can be derived by multiplying the parameterized total reactive current setpoint by 1.73 · rated line voltage.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 1774 Overviews - Active Infeed
- 8946 Current pre-control / current controller / gating unit (p3400.0 = 0)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p3610 Infeed reactive current fixed setpoint
- p3611 CI: Infeed reactive current supplementary setpoint

1.1.7 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	p3625
[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 of important parameters (see the SINAMICS S120/150 List Manual)

- p3624[0...1] Infeed harmonics controller order
- p3625[0...1] Infeed harmonics controller scaling
- r3626[0...1] Infeed harmonics controller output
- r0069[0..6] Phase current, actual value

1.2 Smart Infeed

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.

Smart Line Module Booksize

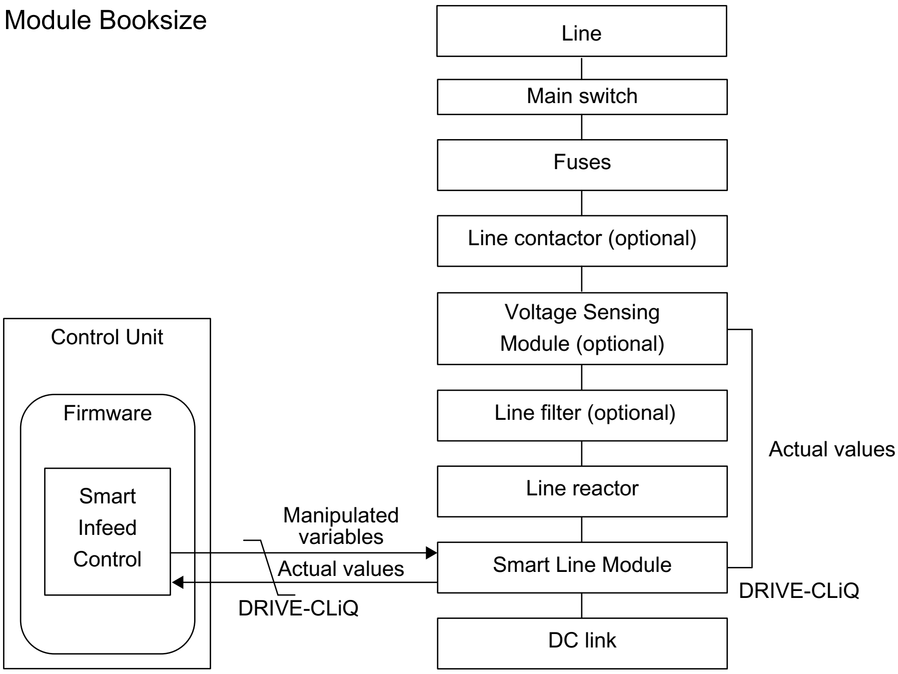


Figure 1-4 Schematic structure of Smart Infeed booksize

Smart Line Module Chassis

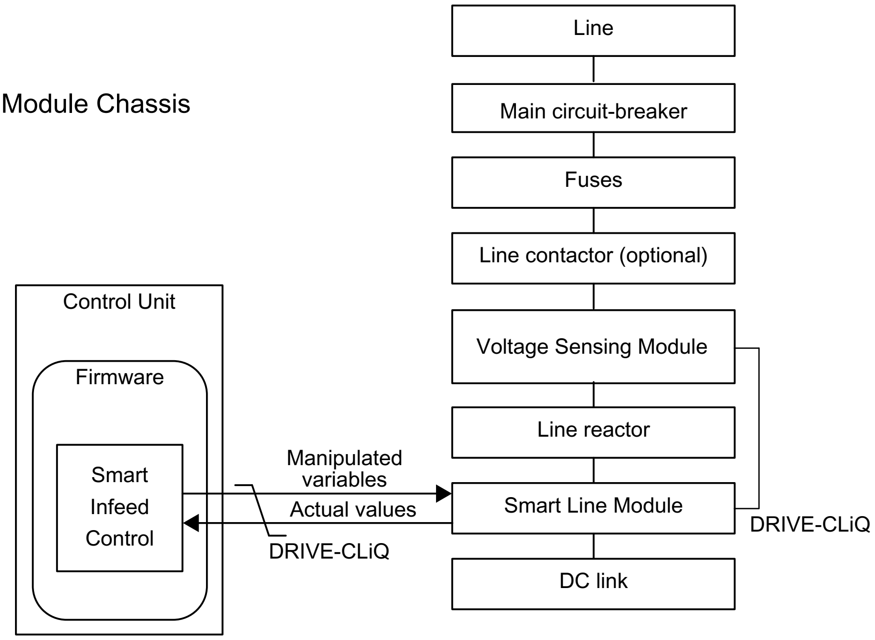


Figure 1-5 Schematic structure of Smart Infeed chassis

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.

Smart Line Modules do not support kinetic buffering in generator mode.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 1775 Overviews - Smart Infeed
- 8820 Control word sequence control infeed
- 8826 Status word sequence 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 important parameters (see SINAMICS S120/S150 List Manual)

- r0002 Infeed operating display
- r0046 CO/BO: Missing enable signals
- p0210 Device supply voltage
- p0840 BI: ON/OFF1
- p0844 BI: 1. OFF2
- p0852 BI: Enable operation
- r0898 CO/BO: Control word sequence 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

1.2.1 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 DC link (e.g. after installation of the equipment at the customer's site or after expanding the drive line-up), 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 S120/S150 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 infeed parameters are then automatically stored in non-volatile memory.
  The infeed continues to operate without interruption on 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 when one of the two identification routines (p3410 = 4 or p3510 = 5) completes successfully.

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 important parameters (see SINAMICS S120/S150 List Manual)

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

1.2.2 Smart Infeed open-loop control

Description

The Smart Line Module can be controlled via the BICO interconnection, e.g. using terminals or the fieldbus. 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 Manual of the corresponding power units. The drive unit must have been commissioned for the first time.

Acknowledge fault

Fault messages that are still present but the causes of which have been rectified can be acknowledged using a 0/1 edge at the "1. Acknowledge faults" signal (p2103).

Switching on the Smart Line Module

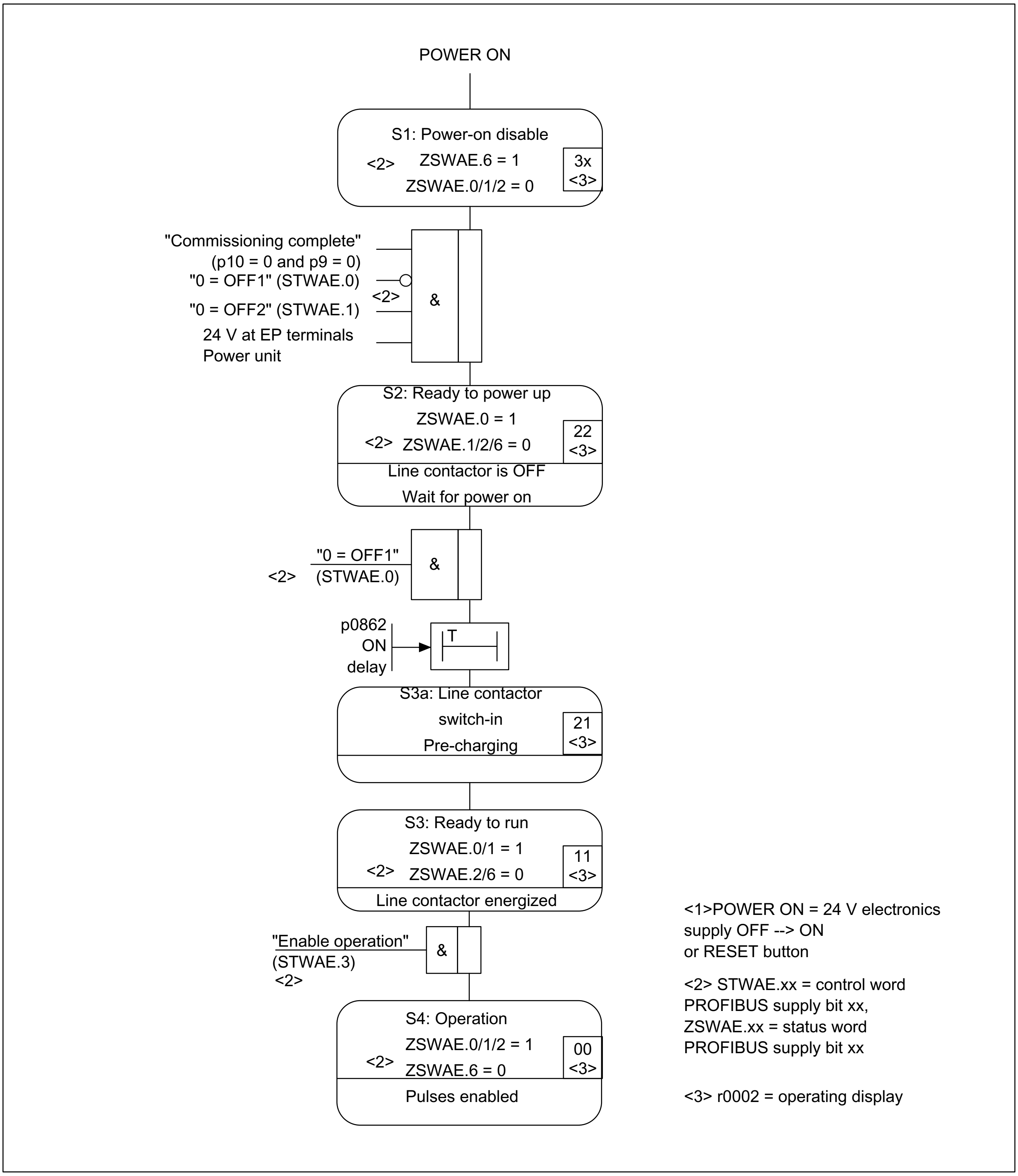


Figure 1-6 Smart Infeed power-up

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

The Smart Line Module is switched off by the same procedure used to switch it on, but in the reverse order.
However, there is no precharging at switch off.

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 BI: ON/OFF1	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 BI: 1. OFF2 and p0845 BI: 2. OFF2	r0898.1	A_STW1.1
Enable operation	STWAE.3	p0852 BI: Enable operation	r0898.3	A_STW1.3
Inhibit regenerating	STWAE.6	p3533 BI: Infeed, inhibit regenerative operation	r0898.6	A_STW1.6
Acknowledge fault	STWAE.7	p2103 BI: 1. Acknowledge faults or p2104 BI: 2. Acknowledge faults or p2105 BI: 3. Acknowledge faults	r2138.7	A_STW1.7
Master control by PLC	STWAE.10	p0854 BI: Master control by PLC	r0898.10	A_STW1.10

Table 1- 6 Smart Infeed status message

Signal name	Internal status word	Parameter	PROFIdrive telegram 370
Ready for switching on	ZSWAE.0	r0899.0	A_ZSW1.0
Ready for operation	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
Switching on inhibited	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm active	ZSWAE.7	r2139.7	A_ZSW1.7
Master control 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

1.3 Basic Infeed

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

The 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.

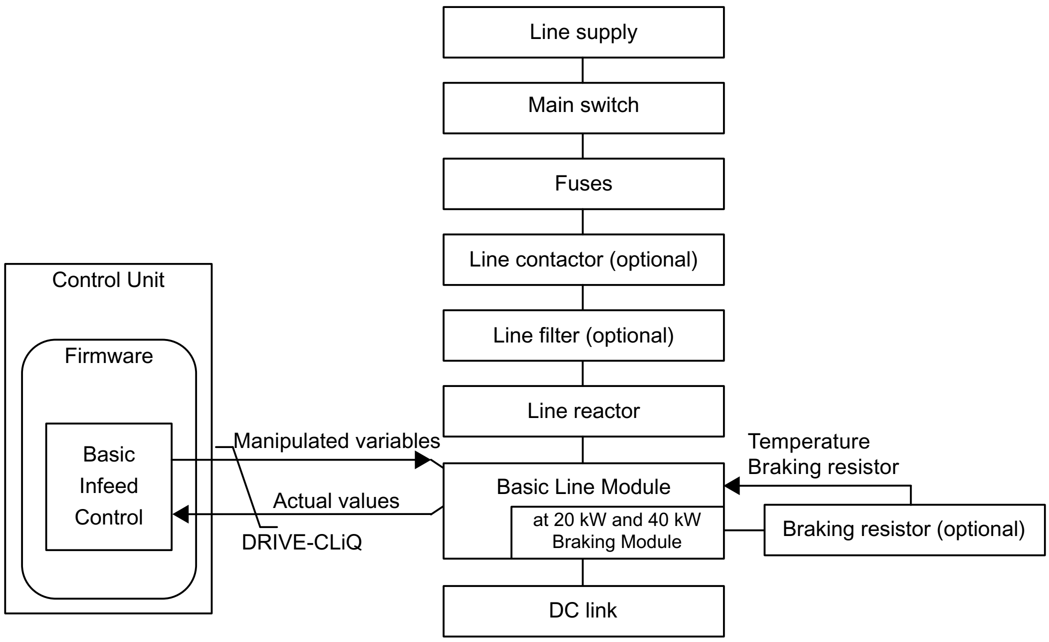


Figure 1-7 Schematic structure of Basic Infeed booksize

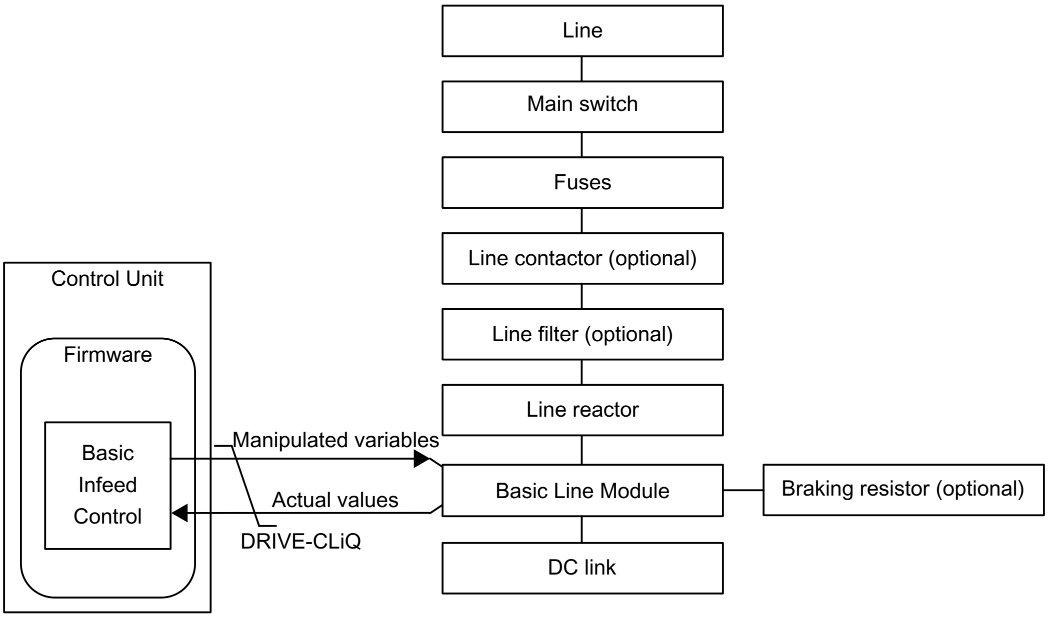


Figure 1-8 Schematic structure of Basic Infeed chassis

Commissioning

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

For the 20 kW and 40 kW Basic Line Modules booksize, 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.

An optional braking chopper can be externally mounted on the Basic Line Module chassis. A braking resistor must then be connected to the braking chopper.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8720 Control word sequence control infeed
- 8726 Status word sequence control infeed
- 8732 Sequencer
- 8734 Missing enable signals, line contactor control
- 8750 Interface to the Basic Infeed power unit (control signals, actual values)
- 8760 Signals and monitoring functions (p3400.0 = 0)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0002 Infeed operating display
- r0046 CO/BO: Missing enable signals
- p0210 Device supply voltage
- p0840 BI: ON/OFF1
- p0844 BI: 1. OFF2
- r0898 CO/BO: Control word sequence 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 BI: Inhibit Braking Module internally

1.3.1 Basic Infeed open-loop control

Description

The Basic Line Module can be controlled via a BICO interconnection, e.g. using terminals or fieldbus. 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 Manual of the corresponding power units.

Acknowledge fault

Fault messages 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 fault" signal (p2103).

Switching on the Basic Line Module

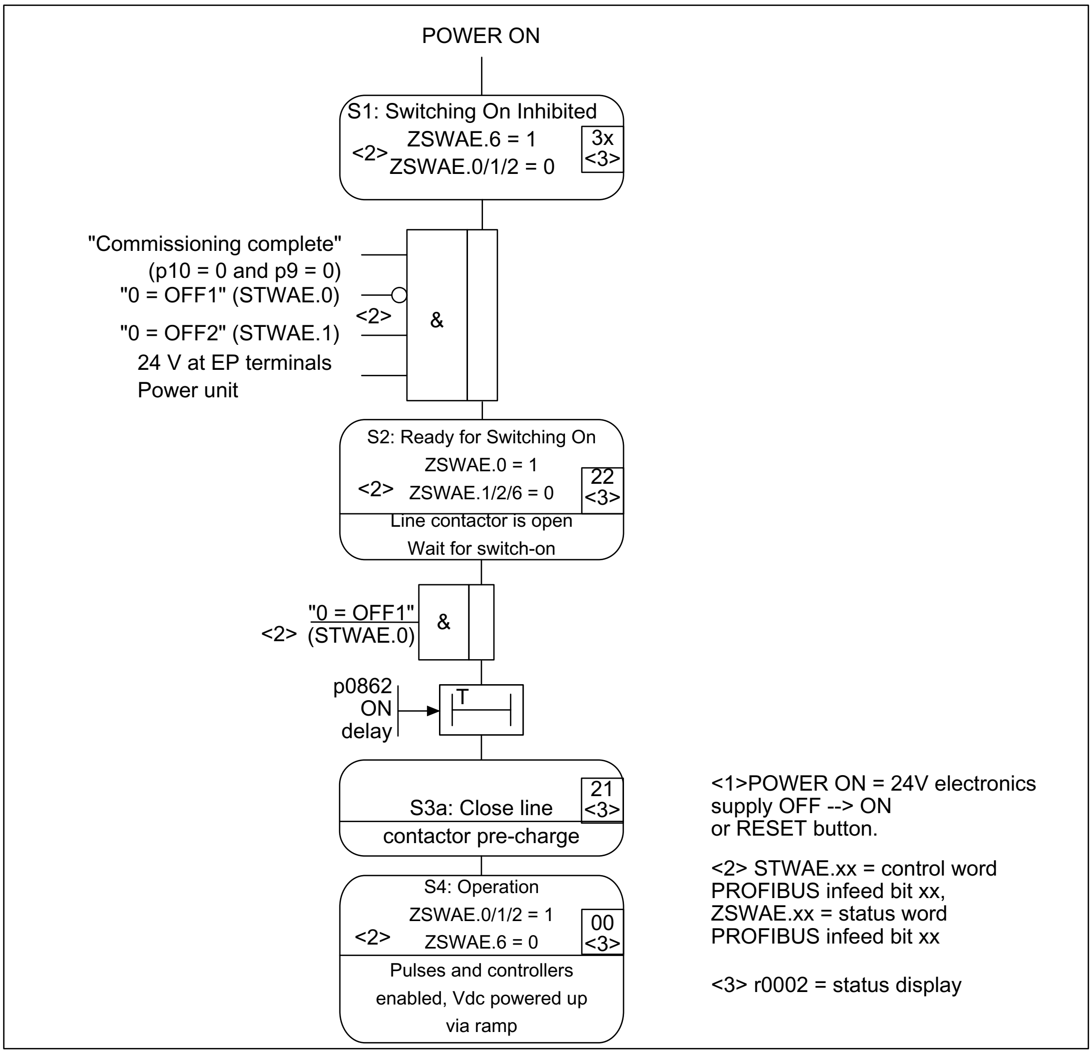


Figure 1-9 Basic Infeed power-up

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

For switching off, carry out the steps for switching on in the reverse order. However, there is no pre-charging at switch off.

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 BI: ON/OFF1	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 BI: 1. OFF2 and p0845 BI: 2. OFF2	r0898.1	A_STW1.1
Acknowledge fault	STWAE.7	p2103 BI: 1. Acknowledge faults or p2104 BI: 2. Acknowledge faults or p2105 BI: 3. Acknowledge faults	r2138.7	A_STW1.7
Master control by PLC	STWAE.10	p0854 BI: Master control by PLC	r0898.10	A_STW1.10

Table 1- 8 Basic Infeed status message

Signal name	Internal status word	Parameter	PROFIdrive telegram 370
Ready for switching on	ZSWAE.0	r0899.0	A_ZSW1.0
Ready for operation	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
Switching on inhibited	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm active	ZSWAE.7	r2139.7	A_ZSW1.7
Master control 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 can be controlled using the following drive objects:

- Via bit r0863.1 of drive object INFEED
- Via bit r0863.1 of drive objects SERVO and 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

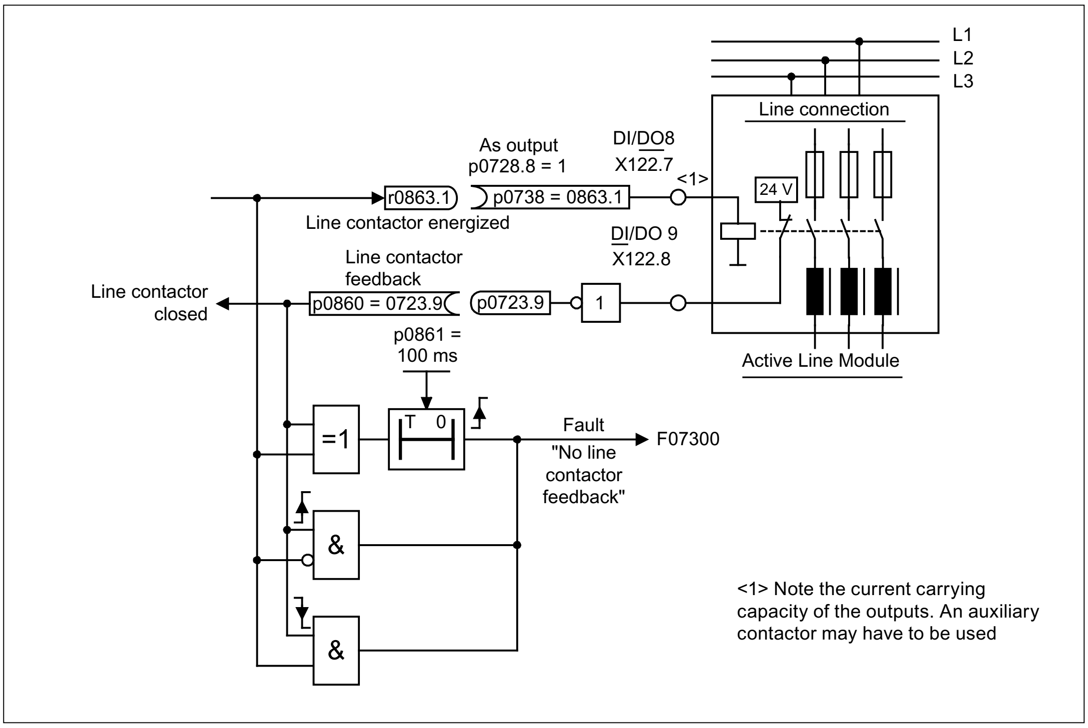


Figure 1-10 Line contactor control

Commissioning steps:

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

Note

Note the current carrying capacity of the digital output (see the Manual of the Control Units and supplementary system components). A line contactor may have to be used.

- Parameterize DI/DO 8 as output (p0728.8 = 1).
- Assign parameter p0738 the control signal for the line contactor r0863.1.
- Connect the line contactor feedback contact to DI/DO 9.
- Assign parameter p0860 an inverted input signal r0723.9.
- Enter the monitoring time for the line contactor (100 ms) in p0861.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8934 Missing enables, line contactor control

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

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 Manual for chassis power units

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 for operation. If pre-charging could not be completed, fault F06000 is output.

Power OFF:

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

Extended setpoint channel 2

Description

In the servo control mode, the extended setpoint channel is deactivated by default. If an extended setpoint channel is required, it has to be activated. The extended setpoint channel is always activated in the vector control mode.

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)
- 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 deactivated.
- Deceleration ramp OFF1 via p1121[D]
- Deceleration ramp OFF3 via p1135[D]
- For PROFIdrive telegrams 2 to 103 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 the servo control mode

In the servo control mode, the "extended setpoint channel" function module can be activated via the commissioning wizard or the drive configuration (configuring 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 the motor control can also originate from the technology controller, see Chapter Technology controller (Page 296)

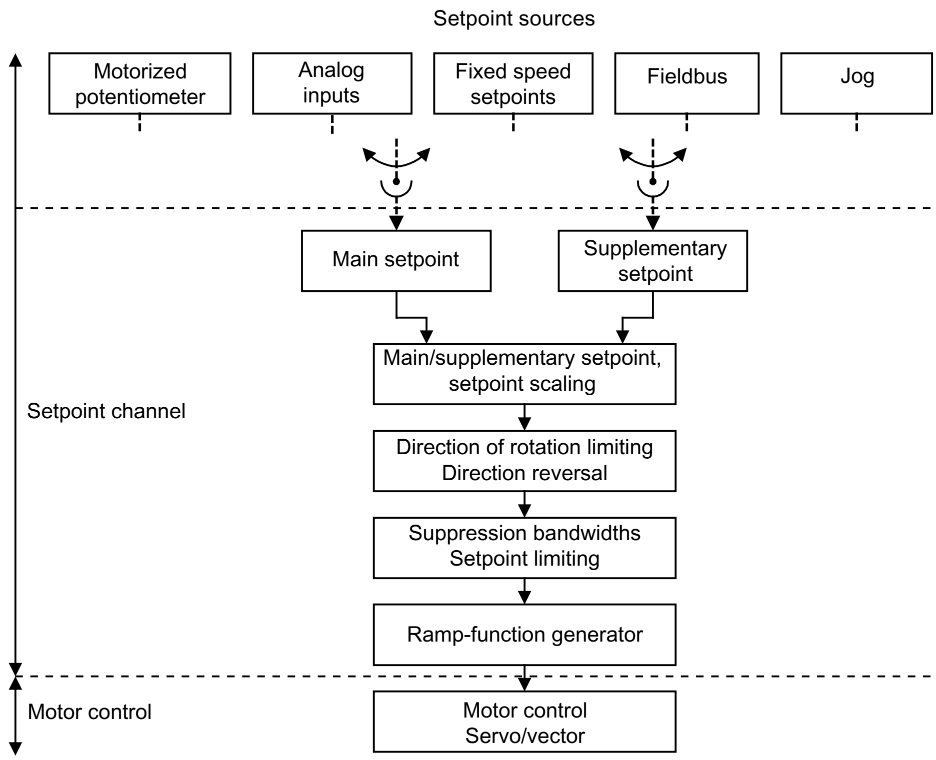


Figure 2-1 Extended setpoint channel

Properties of the extended setpoint channel

- Main/supplementary setpoint, setpoint scaling
- Direction of rotation limiting and direction reversal
- 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. at 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
- 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-compliant!

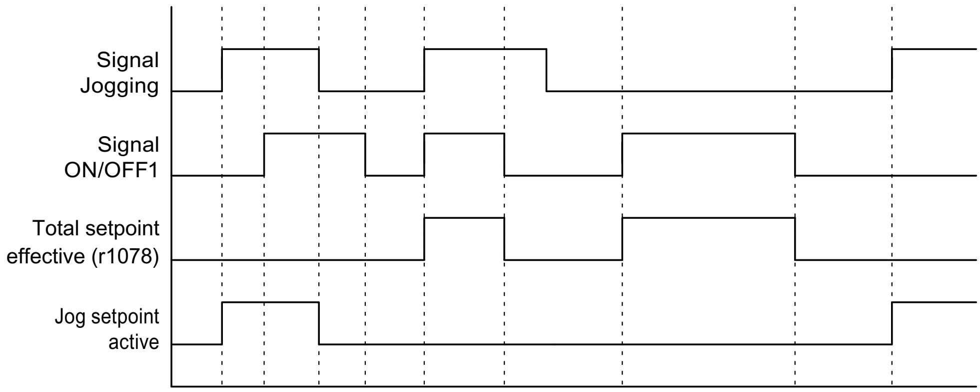


Figure 2-2 Function chart: jog and OFF1

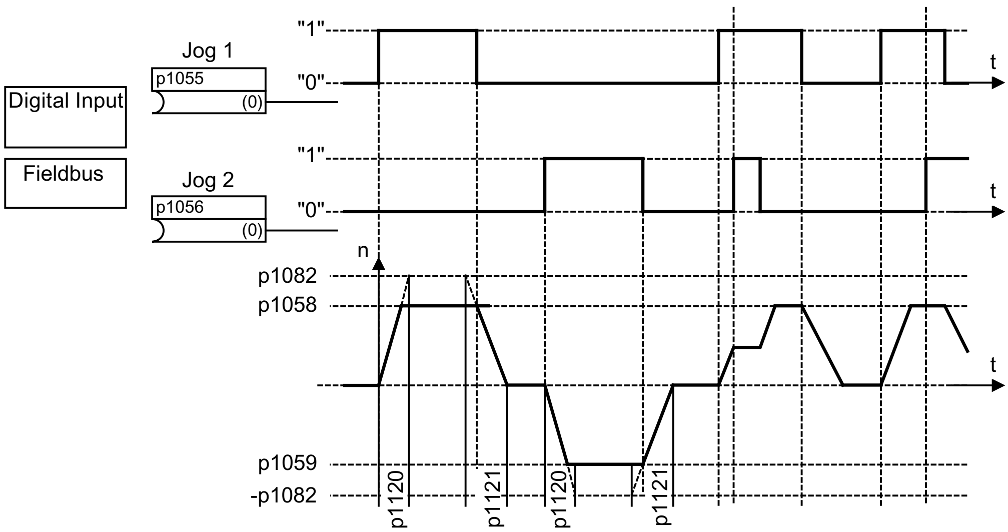


Figure 2-3 Function chart: jog 1 and jog 2

Jog properties

- If both jog signals are issued at the same time, the current speed is maintained (constant speed phase).
- Jog setpoints are approached and exited via the ramp-function generator.
- The jog function can be activated from the "ready for switching on" 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 jog.
- In "jog mode":
  - The main speed setpoints (r1078) and
  - the additional setpoint 1 (p1155) are blocked.
  - The additional setpoint 2 (p1160) is forwarded and added to the current speed.
- The suppression bandwidths (p1091 ... p1094) and the minimum limit (p1080) in the setpoint channel are also active in jog mode.
- The ramp-function generator cannot be frozen (via p1141) in jog mode (r0046.31 = 1).

Jog sequence

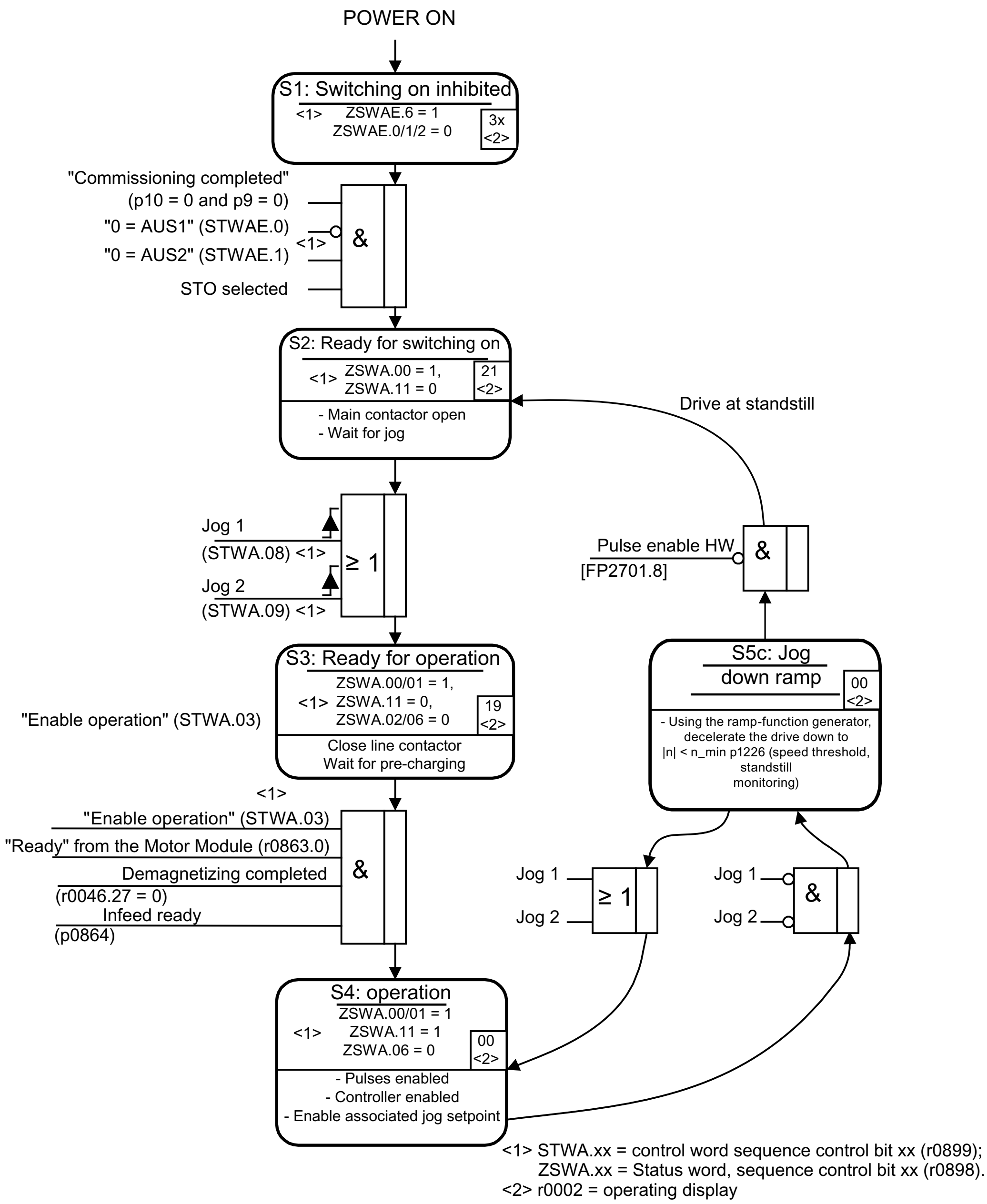


Figure 2-4 Jog sequence

Control and status messages

Table 2- 1 Jog control

Signal name	Internal control word	Binector input	PROFIdrive/Siemens telegram 1 ... 352
0 = OFF1	STWA.0	p0840 BI: ON/OFF1	STW1.0
0 = OFF2	STWA.1	p0844 BI: 1. OFF2 p0845 BI: 2. OFF2	STW1.1
0 = OFF3	STWA.2	p0848 BI: 1. OFF3 p0849 BI: 2. OFF3	STW1.2
Enable operation	STWA.3	p0852 BI: Enable operation	STW1.3
Jog 1	STWA.8	p1055 BI: Jog bit 0	STW1.8 [1)]
Jog 2	STWA.9	p1056 BI: Jog bit 1	STW1.9 [1)]

[1)] Interconnected automatically in telegrams 7, 9, 110, and 111 only.

Table 2- 2 Jog status message

Signal name	Internal status word	Parameter	PROFIdrive/Siemens telegram 1 ... 352
Ready for switching on	ZSWA.0	r0899.0	ZSW1.0
Ready for operation	ZSWA.1	r0899.1	ZSW1.1
Operation enabled	ZSWA.2	r0899.2	ZSW1.2
Switching on inhibited	ZSWA.6	r0899.6	ZSW1.6
Pulses enabled	ZSWA.11	r0899.11	ZSW2.10 [2)]

[2)] Only available in Interface Mode p2038 = 0.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2610 Execution control - processor
- 3030 Setpoint addition, setpoint scaling, jog

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

Parameterization with STARTER

The "speed setpoint jog" parameter screen is selected via the following symbol in the toolbar of the STARTER commissioning tool:

Figure 2-5 STARTER symbol for "speed setpoint jog"

2.4 Fixed speed setpoints

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 S120/S150 List Manual)

- 1550 Overviews - setpoint channel
- 3010 Fixed speed setpoints

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- 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
- 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 called by double-clicking on **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, setpoint, lower
- 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 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 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 S120/S150 List Manual)

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

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

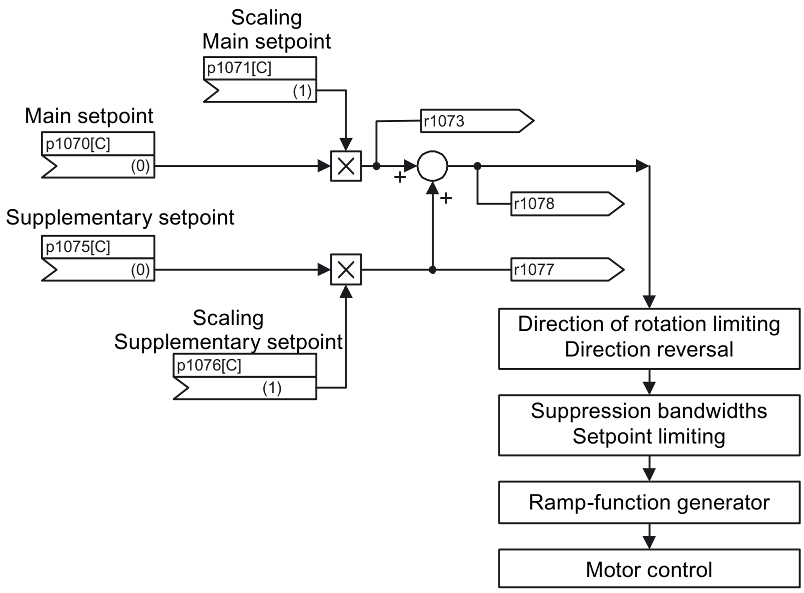


Figure 2-6 Setpoint addition, setpoint scaling

Function diagrams (see SINAMICS S120/S150 List Manual)

- 1550 Setpoint channel
- 3030 Main/supplementary setpoint, setpoint scaling, jog

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1070[C] CI: Main setpoint
- p1071[C] CI: Main setpoint scaling
- r1073[C] CO: Main setpoint effective
- p1075[C] CI: Supplementary setpoint
- p1076[C] CI: Supplementary setpoint scaling
- r1077[C] CO: Supplementary setpoint effective
- r1078[C] CO: Total setpoint effective

Parameterization with STARTER

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

Figure 2-7 STARTER symbol for "speed setpoint"

2.7 Direction of rotation limiting and direction of rotation changeover

Description

A reverse operation involves a direction reversal. Selecting setpoint inversion p1113[C] can reverse the direction in the setpoint channel.

Parameter p1110[C] or p1111[C] can be set respectively to prevent input of a negative or positive setpoint via the setpoint channel. 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.

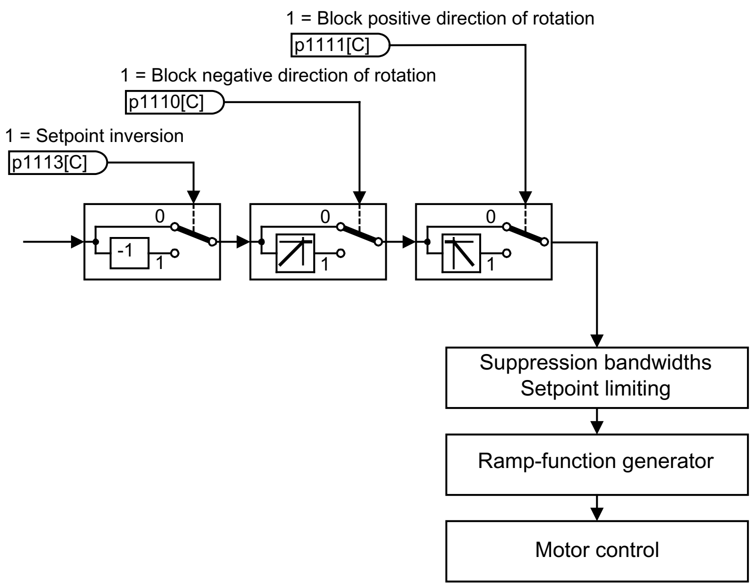


Figure 2-8 Direction of rotation limiting and direction reversal

Function diagrams (see SINAMICS S120/S150 List Manual)

- 1550 Setpoint channel
- 3040 Direction limitation and direction reversal

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1110[C] BI: Block negative direction
- p1111[C] BI: Block positive direction
- p1113[C] BI: Setpoint inversion

Parameterization with STARTER

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

Figure 2-9 STARTER symbol for "speed setpoint"

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[D] and p1082[D]. Further, using connectors p1085[C] and p1088[C] it is possible to influence these limits in operation.

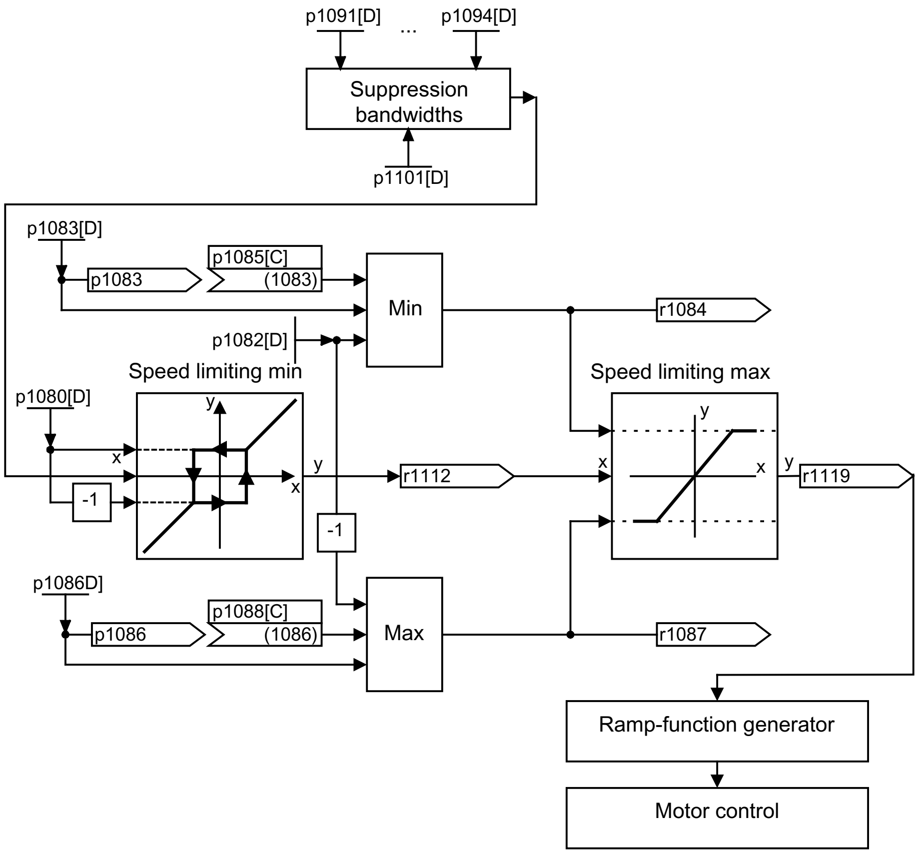


Figure 2-10 Suppression bandwidths, setpoint limitation

Function diagrams (see SINAMICS S120/S150 List Manual)

- 1550 Setpoint channel
- 3050 Suppression bandwidth and speed limiting

Overview of important parameters (see SINAMICS S120/S150 List Manual)

Setpoint limitation

- p1080[D] Minimum speed
- p1082[D] Maximum speed
- p1083[D] CO: Speed limit in positive direction of rotation
- r1084 CO: Speed limit positive effective
- p1085[C] CI: Speed limit in positive direction of rotation
- p1086[D] CO: Speed limit negative direction of rotation
- r1087 CO: Speed limit negative effective
- p1088[C] CI: Speed limit negative direction of rotation
- r1119 CO: 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 2-11 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 complete drive train. The ramp-up time p1120[D] and ramp-down time p1121[D] can be used to set mutually independent acceleration and deceleration ramps. This allows a controlled transition to be made in the event of setpoint changes.

The maximum speed p1082[D] 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 quick stop (OFF3), e.g. for rapid controlled deceleration when an emergency OFF button is pressed.

There are two types of ramp-function generator:

- Basic ramp-function generator with
  - Acceleration and deceleration ramps
  - Ramp for quick stop (OFF3)
  - Tracking configurable via parameter p1145
  - Setting values for the ramp-function generator
- The 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 basic ramp-function generator

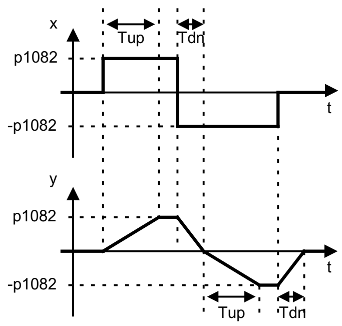


Figure 2-12 Ramp-up and ramp-down with the basic ramp-function generator

- RFG ramp-up time Tup p1120[D]
- RFG ramp-down time Tdn p1121[D]
- OFF3 deceleration ramp
  - OFF3 ramp-down time p1135[D]
- Set ramp-function generator
  - Ramp-function generator setting value p1144[C]
  - Set ramp-function generator signal p1143[C]
- Freezing of the ramp-function generator using p1141 (not in jog mode r0046.31 = 1)

Properties of the extended ramp-function generator

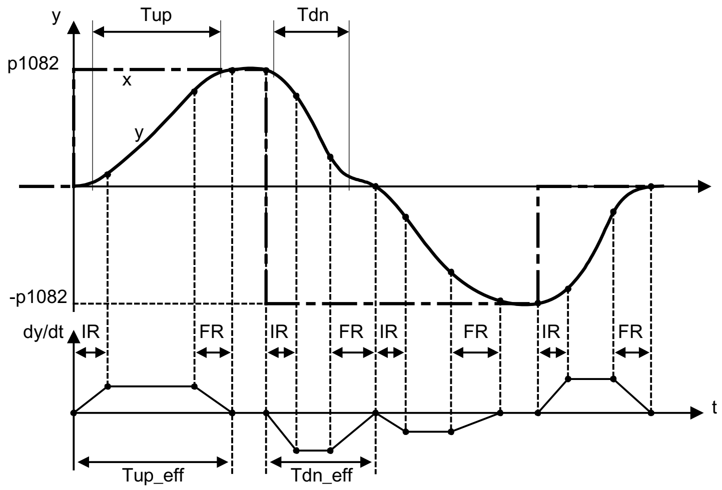


Figure 2-13 Extended ramp-function generator

- RFG ramp-up time Tup p1120[D]
- RFG ramp-down time Tdn p1121[D]
- Initial rounding IR p1130[D]
- Final rounding FR p1131[D]
- 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[D]
  OFF3 initial rounding p1136[D]
  OFF3 final rounding p1137[D]
- Set ramp-function generator
  - Ramp-function generator setting value p1144[C]
  - Set ramp-function generator signal p1143[C]
- Select ramp-function generator rounding type p1134[D]
  - 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": discontinuous smoothing; for a setpoint change, the change is immediately made to the direction of the new setpoint.
- Configure ramp-function generator, deactivate rounding at zero crossing p1151[D]
- Freezing of the ramp-function generator using p1141 (not in jog mode r0046.31 = 1)

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 basic and the extended ramp-function generators.

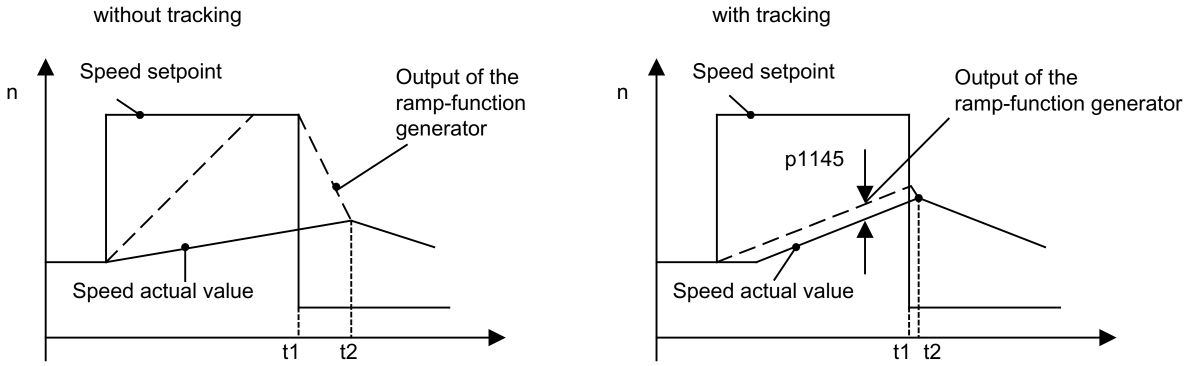


Figure 2-14 Ramp-function generator tracking

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 S120/S150 List Manual)

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

Signal overview (see SINAMICS S120/S150 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

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1115 Ramp-function generator selection
- r1119 CO: Ramp-function generator setpoint at the input
- p1120[D] Ramp-function generator ramp-up time
- p1121[D] Ramp-function generator ramp-down time
- p1122[C] BI: Bypass ramp-function generator
- p1130[D] Ramp-function generator initial rounding time
- p1131[D] Ramp-function generator final rounding time
- p1134[D] Ramp-function generator rounding type
- p1135[D] OFF3 ramp-down time
- p1136[D] OFF3 initial rounding time
- p1137[D] OFF3 final rounding time
- p1140[C] BI: Enable ramp-function generator
- p1141[C] BI: Continue ramp-function generator
- p1143[C] BI: Ramp-function generator, accept setting value
- p1144[C] CI: Ramp-function generator setting value
- p1145[D] Ramp-function generator tracking, intensity
- p1148 [D] Ramp-function generator tolerance for ramp-up and ramp-down active
- r1149 CO: Ramp-function generator acceleration
- r1150 CO: Ramp-function generator speed setpoint at the output
- p1151 [D] Ramp-function generator configuration

Parameterization with STARTER

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

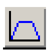


Figure 2-15 STARTER icon for "ramp-function generator"

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.

Comparison of servo control and vector control

The table below shows a comparison between the characteristic features of servo and vector controls.

Table 3- 1 Comparison of servo control and vector control

Subject	Servo control	Vector control
Typical applications	• Drives with highly dynamic motion control • Drives with high speed and torque accuracy (servo synchronous motors) • Angular-locked synchronism with isochronous PROFIdrive. • For use in machine tools and clocked production machines	• Speed and torque-controlled drives with high speed and torque accuracy, particularly in operation without an encoder (sensorless operation).
Maximum number of drives that can be controlled by one Control Unit. To be taken into account: Chapter "Rules for wiring with DRIVE-CLiQ" in this document below	• 1 infeed + 6 drives (for current controller sampling rates 125 µs or speed controller 125 µs) • 1 infeed + 3 drives (for current controller sampling rates 62.5 µs or speed controller 62.5 µs) • 1 infeed + 1 drive (for current controller sampling rates 31.25 µs or speed controller 62.5 µs)	• 1 infeed + 3 drives (for current controller sampling times 250 µs or speed controller 1 ms) • 1 infeed + 6 drives (with current controller sampling times 400 µs/500 µs or speed controller 1.6 ms/2 ms) • V/f control: 1 infeed + 12 drives (with current controller sampling times 500 µs or speed controller 2000 µs)
Dynamic response	High	Medium

<table>
<tr><th>Subject</th><th>Servo control</th><th>Vector control</th></tr>
<tr><td>Sampling time, current controller / sampling time, speed controller / pulse frequency</td><td>Booksize:
31.25 µs / 31.25 µs / ≥ 8 kHz (factory setting, 8 kHz)
Blocksize:
31.25 µs / 31.25 µs / ≥ 8 kHz
(factory setting, 8 kHz)
Chassis:
Frame size Fx :
250 µs / 250 µs / ≥ 2 kHz
(factory setting, 2 kHz)
Frame size Gx:
125 µs / 125 µs / ≥ 4 kHz</td><td>Booksize:
250 µs / 1000 µs / ≥ 2 kHz
(factory setting 4 kHz)
500 µs / 2000 µs / ≥ 2 kHz
(factory setting, 4 kHz)
Blocksize:
250 µs / 1000 µs / ≥ 2 kHz
(factory setting 4 kHz)
500 µs / 2000 µs / ≥ 2 kHz
(factory setting, 4 kHz)
Chassis:
≤ 250 kW:
250 µs / 1000 µs / ≥ 2 kHz
> 250 kW:
400 µs / 1600 µs / ≥ 1.25 kHz
690 V:
400 µs / 1600 µs / ≥ 1.25 kHz</td></tr>
<tr><td colspan="3">Note:
Further information about the sampling conditions is contained in the "Rules for setting the sampling time" subsection later in this manual.</td></tr>
<tr><td>Connectable motors</td><td>Synchronous servomotors
Induction motors
Torque motors</td><td>Induction motors
Synchronous motors (including torque motors)
Reluctance motors (only for V/f control)
Separately-excited synchronous motors
Note:
Synchronous motors of the 1FT6, 1FK6 and 1FK7 series cannot be connected.</td></tr>
<tr><td>Position interface via PROFIdrive for higher-level motion control</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Encoderless speed control</td><td>Yes (from 10 % rated motor speed)</td><td>Yes (from standstill or 2% rated motor speed)</td></tr>
<tr><td>Motor identification
(third-party motors)</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Speed controller optimization</td><td>Yes</td><td>No, only parameter pre-assignment</td></tr>
<tr><td>V/f control</td><td>Yes</td><td>Yes (various characteristics)</td></tr>
<tr><td>Encoderless
closed-loop torque control</td><td>No</td><td>Yes (open-loop control at low speeds)</td></tr>
<tr><td>Field-weakening range for induction motors</td><td>≤ 16 field-weakening threshold speed (with encoder)
≤ 5 field-weakening threshold speed (without encoder)</td><td>≤ 5 · rated motor speed</td></tr>
</table>

Subject	Servo control	Vector control
Maximum output frequency with closed-loop control	• 1300 Hz with 62.5 µs / 8 kHz • 650 Hz with 125 µs / 4 kHz • 300 Hz with 250 µs / 2 kHz Note: The specified values have been dimensioned so that they can be achieved by SINAMICS S without optimization. Higher frequencies can be set under the following secondary conditions and additional optimization runs: • Up to 1500 Hz – Operation without an encoder – In conjunction with controlled infeeds • Up to 1600 Hz – Operation with encoder – In conjunction with controlled infeeds • Absolute upper limit 1600 Hz	• 300 Hz with 250 µs / 4 kHz or with 400 µs / 5 kHz • 240 Hz with 500 µs / 4 kHz
Note: The derating characteristics in the various Manuals must be carefully observed! Max. output frequency when using dv/dt and sine-wave filters: 150 Hz		
Response when operating at the thermal limit of the motor	Reduction of the current setpoint or shutdown	Reduction in the pulse frequency and / or the current setpoint or shutdown (not applicable with parallel connection / sine-wave filter)
Speed setpoint channel (ramp-function generator)	Optional (reduces the number of drives from 6 to 5 Motor Modules for current controller sampling times of 125 µs - or speed controller sampling times of 125 µs)	Standard
Parallel connection of power units	No	• Booksize: No • Chassis: Yes

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.

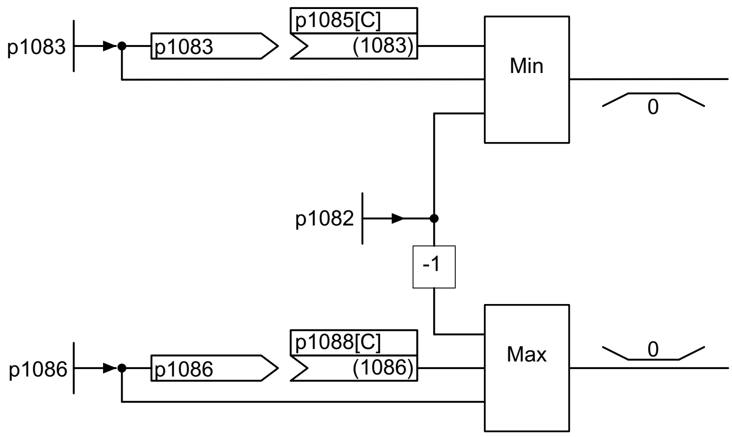


Figure 3-1 Speed controller limitations

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.

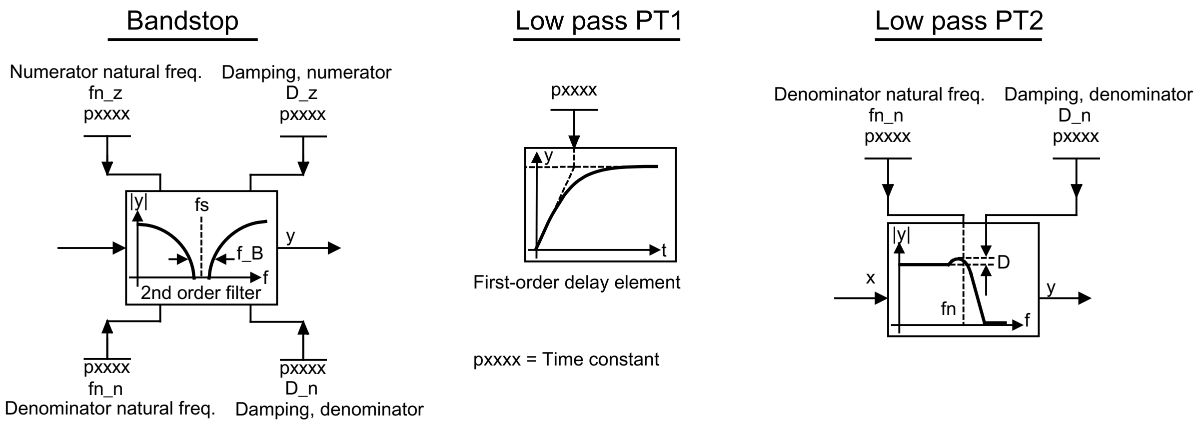


Figure 3-2 Filter overview for speed setpoint filters

Function diagrams (see SINAMICS S120/S150 List Manual)

- 5020 Speed setpoint filter and speed pre-control

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1414[D] Speed setpoint filter activation
- p1415[D] Speed setpoint filter 1 type
- p1416[D] Speed setpoint filter 1 time constant
- p1417[D] Speed setpoint filter 1 denominator natural frequency
- p1418[D] Speed setpoint filter 1 denominator damping
- p1419[D] Speed setpoint filter 1 numerator natural frequency
- p1420[D] Speed setpoint filter 1 numerator damping
- p1421[D] Speed setpoint filter 2 type
- p1422[D] Speed setpoint filter 2 time constant
- p1423[D] Speed setpoint filter 2 denominator natural frequency
- p1424[D] Speed setpoint filter 2 denominator damping
- p1425[D] Speed setpoint filter 2 numerator natural frequency
- p1426[D] Speed setpoint filter 2 numerator damping

Parameterization with STARTER

The "speed setpoint filter" parameterization screen form is selected via the following symbol in the toolbar of the STARTER commissioning tool:

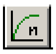


Figure 3-3 STARTER symbol for "speed setpoint filter"

3.3 Speed controller adaptation

Description

There are two types of adaptation available: The free Kp_n adaptation and the 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.

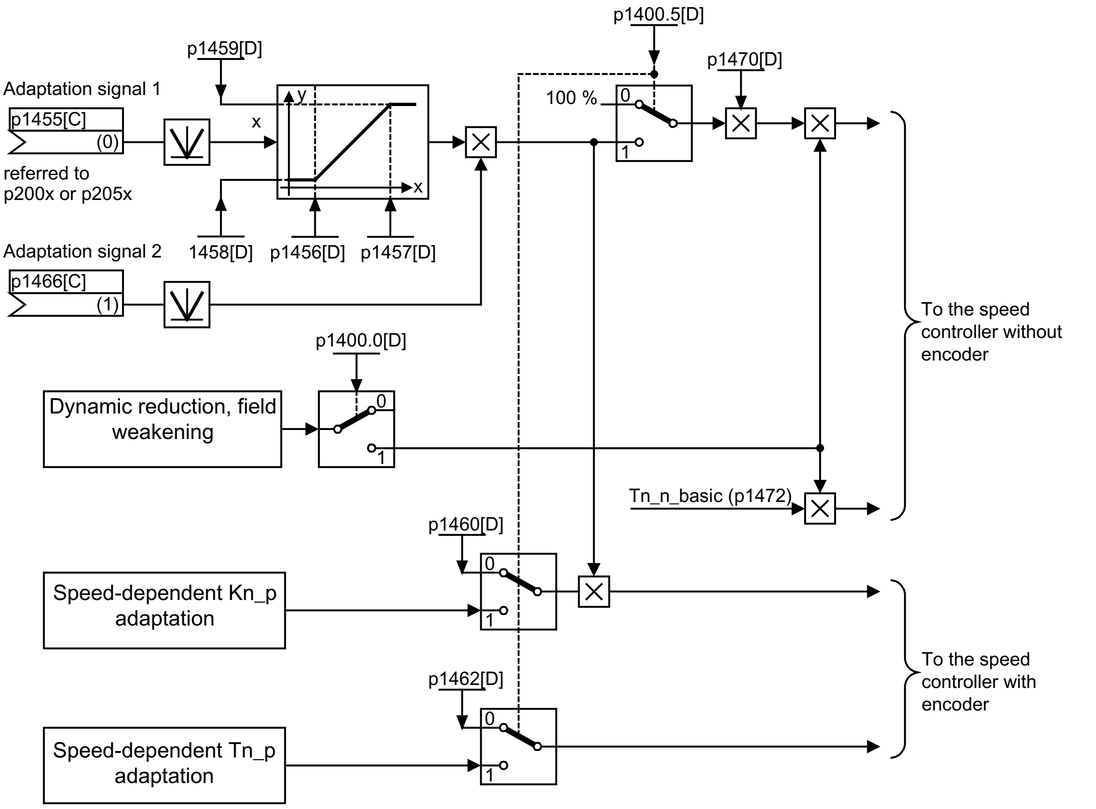


Figure 3-4 Free Kp_n adaptation

Example of speed-dependent adaptation

Note

This type of adaptation is only active when the drive is operated with an encoder!

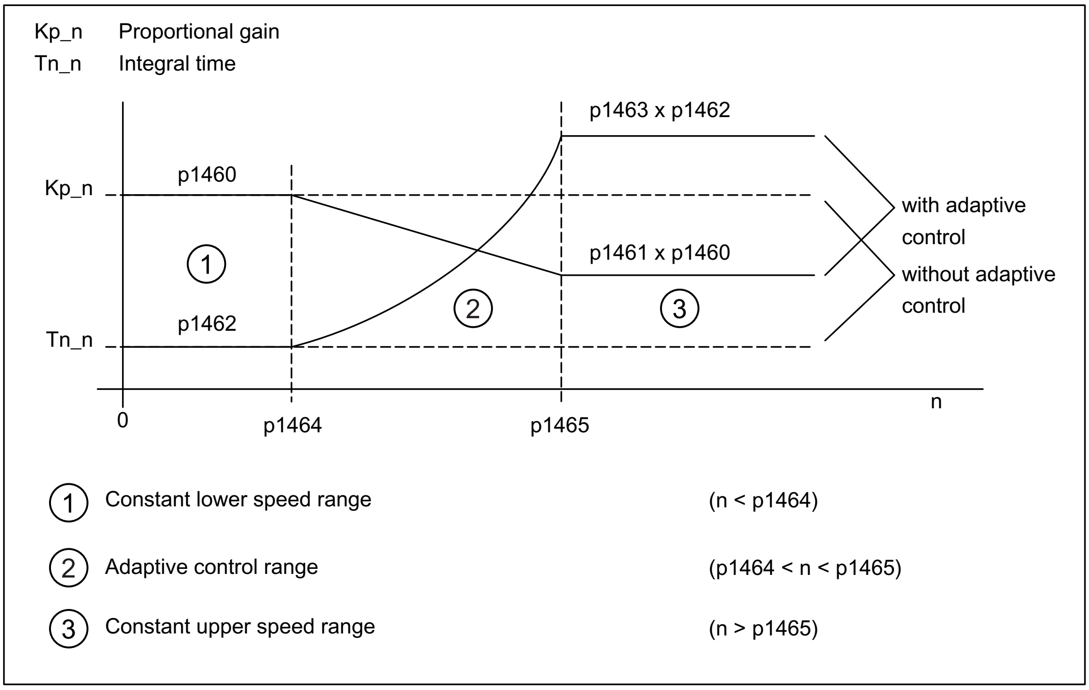


Figure 3-5 Speed controller Kp_n/Tn_n adaptation

Function diagrams (see SINAMICS S120/S150 List Manual)

- 5050 Kp_n and Tn_n adaptation

Overview of important parameters (see SINAMICS S120/S150 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] Speed controller P gain adaptation upper starting point
- 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

Parameterization with STARTER

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

Figure 3-6 STARTER icon for "speed controller"

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)

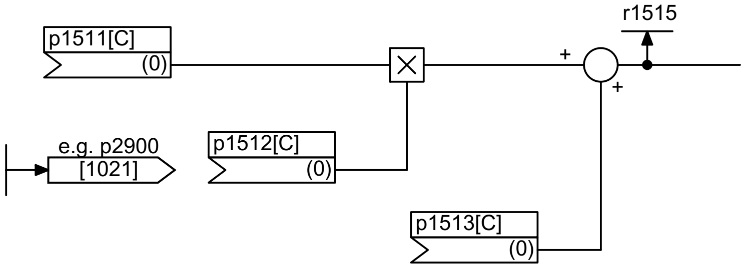


Figure 3-7 Torque setpoint

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.
  - Switching on inhibited is activated.
- OFF2
  - Immediate pulse suppression, the drive coasts to standstill.
  - The motor brake (if parameterized) is closed immediately.
  - Switching on inhibited 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.
  - Switching on inhibited is activated.

Function diagrams (see SINAMICS S120/S150 List Manual)

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

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1300 Open-loop/closed-loop control operating mode
- r1406.12 Torque control active
- p1501[C] BI: Change over between closed-loop speed/torque control
- p1511[C] CI: Supplementary torque 1
- p1512[C] CI: Supplementary torque 1 scaling
- p1513[C] CI: Supplementary torque 2
- r1515 Supplementary torque total

Parameterization with STARTER

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

Figure 3-8 STARTER icon for "torque setpoint"

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.

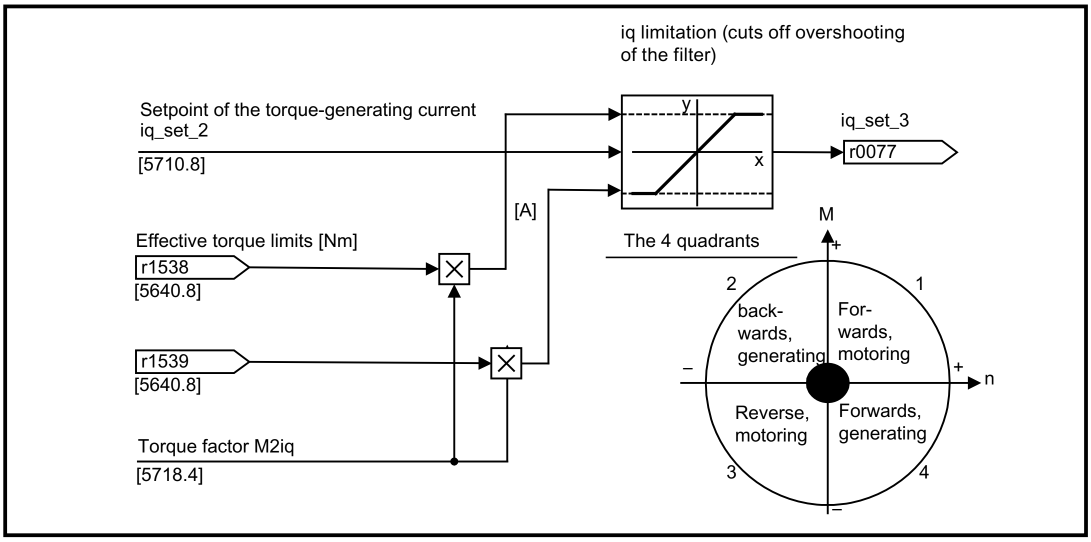


Figure 3-9 Current/torque setpoint limiting

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- 2 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:

- No settings entered:

  The application does not require any additional restrictions to the torque limits.
- 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.
- 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.
- A torque offset can be parameterized.
- 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 counteractive load torque is generated (see function diagram 5630 in the SINAMICS S120/S150 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.

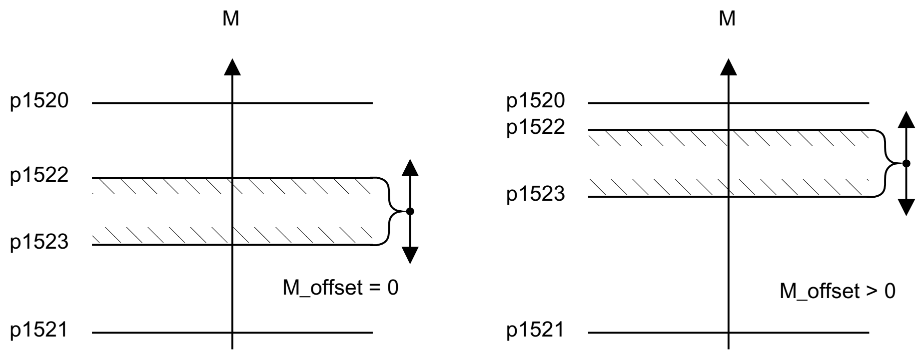


Figure 3-10 Example: Torque limits with or without offset

Activating the torque limits

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

Examples

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

Function diagrams (see SINAMICS S120/S150 List Manual)

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

Overview of important parameters (see SINAMICS S120/S150 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[C] CI: Torque limit, upper/motoring
- p1523[C] 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] CO: Torque limit, offset
- r1533 Current limit torque-generating, total
- r1534 CO: Torque limit, upper total
- r1535 CO: Torque limit, lower total
- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit

Parameterization with STARTER

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

Figure 3-11 STARTER icon for "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.

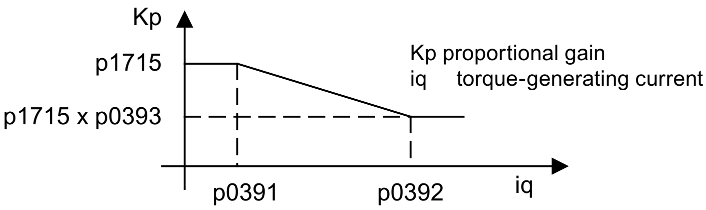


Figure 3-12 Current controller adaptation

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.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 5710 Current setpoint filters
- 5714 Iq and Id controller
- 5722 Specified field current, flux reduction, flux controller

Overview of important parameters (see SINAMICS S120/S150 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] Motor 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
- r1526 CO: Torque limit, upper/motoring without offset
- r1527 CO: Torque limit, lower/regenerative without offset
- 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
- r1533 Current limit torque-generating, total
- r1534 CO: Torque limit, upper total
- r1535 CO: Torque limit, lower total
- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit

Current controller adaptation

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

Commissioning with STARTER

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

Figure 3-13 STARTER icon for "current controller"

3.7 Current setpoint filters

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 low-pass with reduction are converted into the parameters of the general 2nd order filter 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.

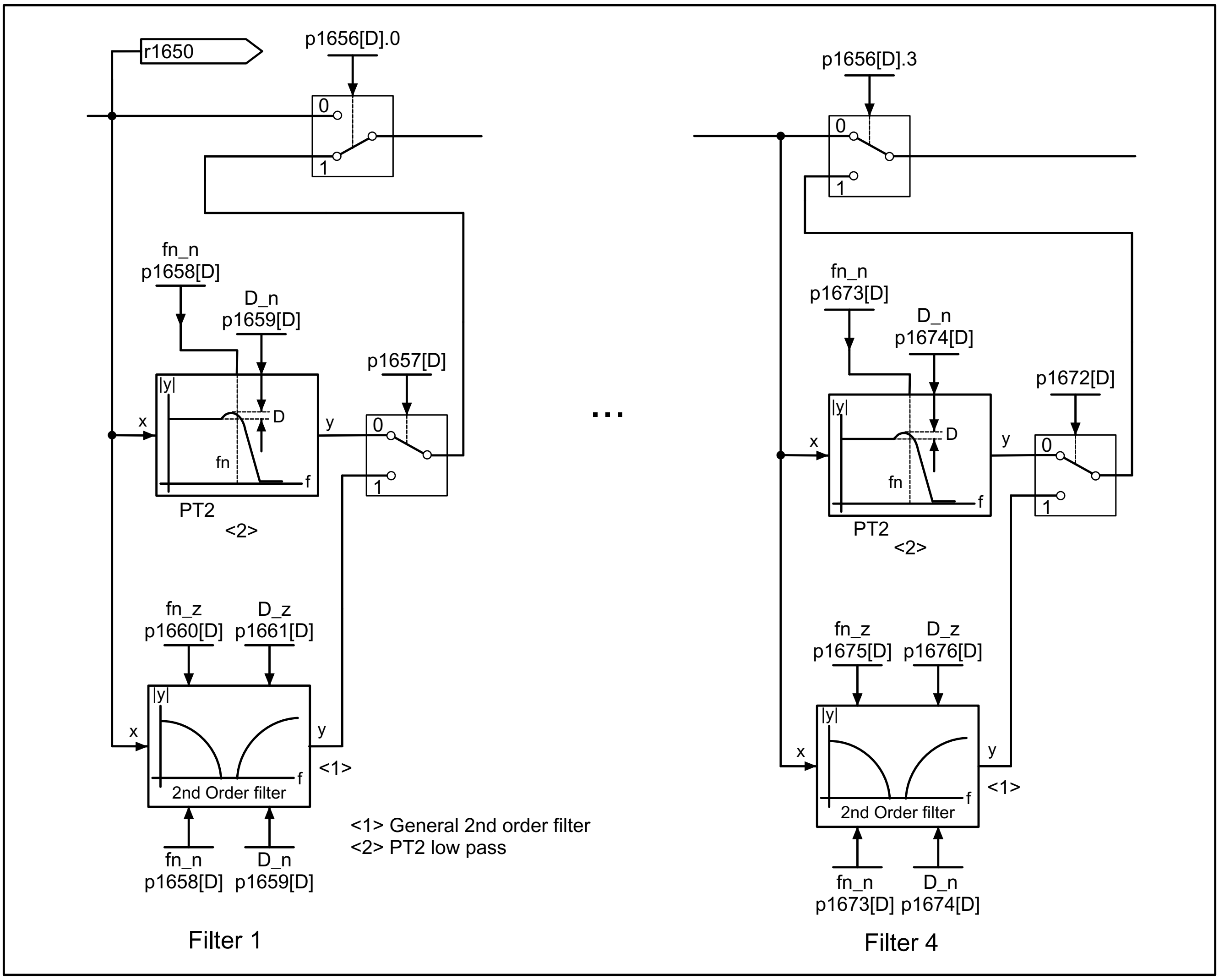


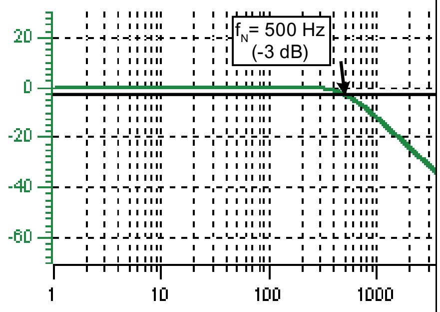
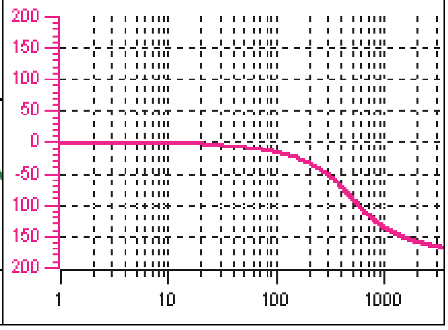
Figure 3-14 Current setpoint filter

Transfer function:

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

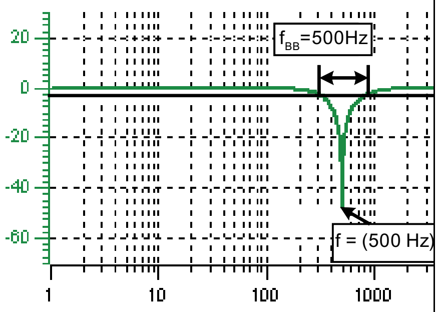
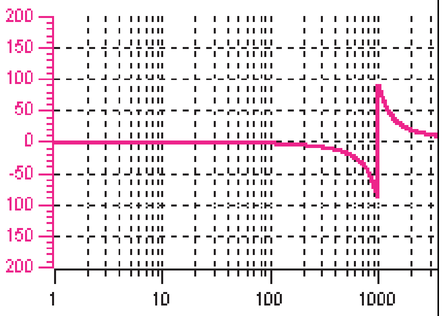
Denominator natural frequency f_N
Denominator damping D_N

Table 3- 3 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- 4 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		

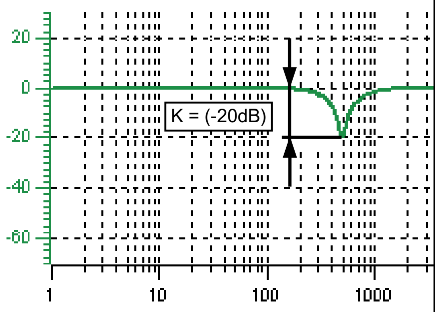
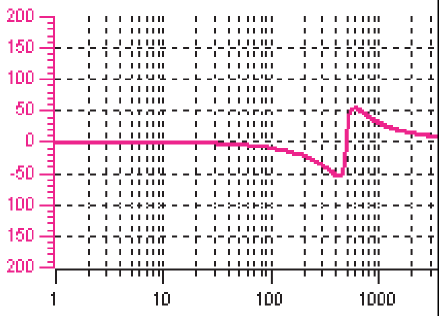
Simplified conversion to parameters for general order filters:

- Reduction or increase after the blocking frequency (Abs)
- Infinite notch depth at the blocking frequency
- Numerator natural 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- 5 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 natural frequency $f_Z = f_{Sp}$
- Numerator damping:

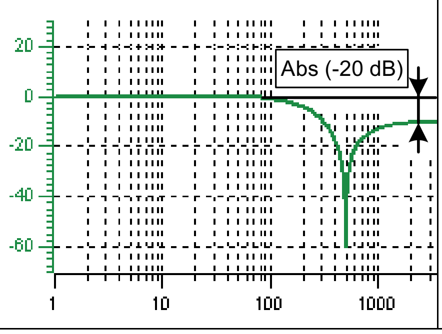
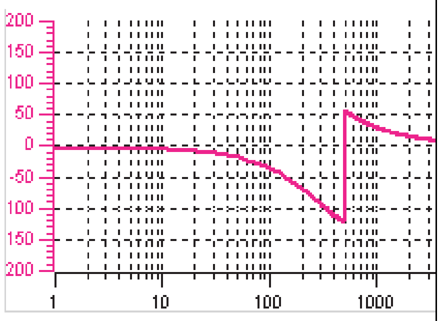
$$D_Z = \frac{f_{BB}}{2 \bullet f_{Sp} \bullet 10^{\frac{K}{20}}}$$

- 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- 6 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:

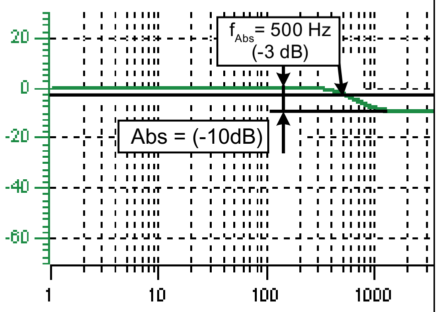
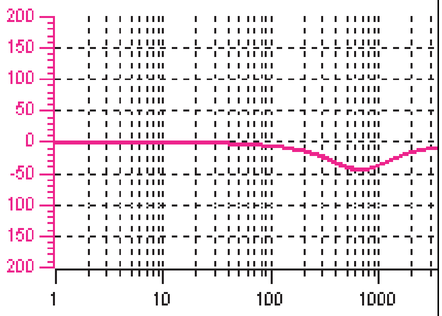
$$f_N = \frac{\omega_N}{2\pi} = f_{Sp} \bullet 10^{\frac{Abs}{40}}$$

- Denominator damping:

$$D_N = \frac{f_{BB}}{2 \bullet f_{Sp} \bullet 10^{\frac{Abs}{40}}}$$

General low-pass with reduction

Table 3- 7 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

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

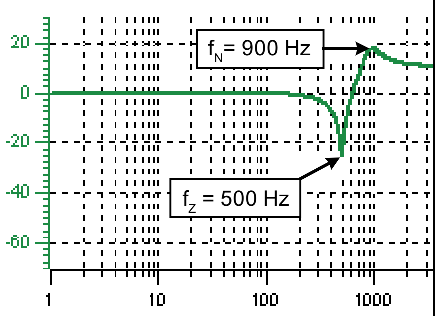
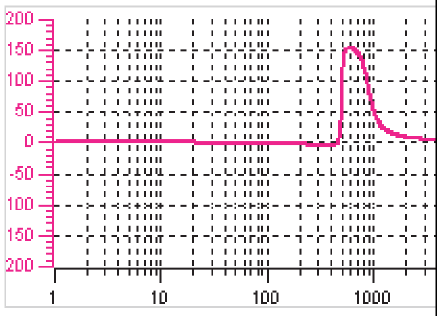
Numerator natural frequency f_Z

Numerator damping D_Z

Denominator natural frequency f_N

Denominator damping D_N

Table 3- 8 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		

Function diagrams (see SINAMICS S120/S150 List Manual)

- 5710 Current setpoint filters

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1656[0...n] Current setpoint filter activation
- p1657[0...n] Current setpoint filter 1 type
- p1658[0...n] Current setpoint filter 1 denominator natural frequency
- p1659[0...n] Current setpoint filter 1 denominator damping
- p1660[0...n] Current setpoint filter 1 numerator natural frequency
- p1661[0...n] Current setpoint filter 1 numerator damping
- ...
- p1676[0...n] Current setpoint filter 4 numerator damping
- p1699 Filter data transfer

Parameterization with STARTER

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

Figure 3-15 STARTER icon for "current setpoint filter"

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

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 the Motor Module and motor
- Motor
- DRIVE-CLiQ cable between the Motor Module and motor
- Encoder and actual encoder value

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

- Induction motors
- Synchronous motors

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

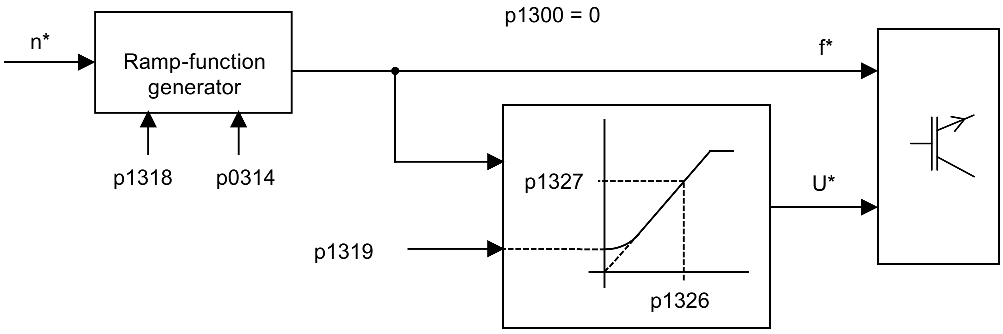


Figure 3-16 Structure of V/f control

Prerequisites for V/f control

- First commissioning has been carried out:
  The parameters for V/f control have been initialized with appropriate values.
- First 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
  - p1338[0...n] V/f mode resonance damping gain
  - p1339[0...n] V/f mode resonance damping filter time constant
  - p1349[0...n] V/f mode resonance damping maximum frequency

---

Note

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

Oscillation damping is activated on the basis of suitable default parameter values and does not require further parameterization in most applications. If you become aware of interference caused by a transient response, you have the option of gradually increasing the value of p1338 and evaluating how this affects your system.

Note

The drive can be ramped up to the current limit (p0640) relatively quickly without the need for extensive parameterization (when operating the drive with a variable moment of inertia, for example).

Note the following: Only the ramp-function generator stops when the current limit (p0640) is reached. This does not prevent the current from increasing even further. In view of this, the parameters you set must include a safety margin relative to the current limits for the monitoring functions to prevent the drive from switching off with an overcurrent fault.

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.

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).

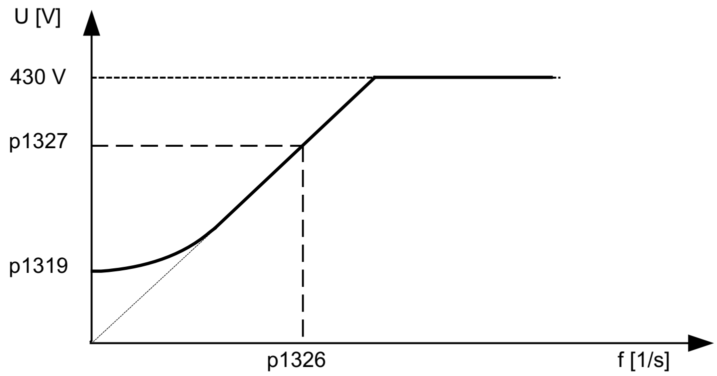


Figure 3-17 V/f characteristic

Function diagrams (see SINAMICS S120/S150 List Manual)

- 5300 V/f control
- 5650 Vdc_max controller and Vdc_min controller

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0304[0...n] Rated motor voltage
- p0310[0...n] Rated motor frequency
- p0311[0...n] Rated motor speed
- r0313[0...n] Motor pole pair number, actual (or calculated)
- p0314[0...n] Motor pole pair number
- p0317[0...n] Motor voltage constant
- p0322[0...n] Maximum motor speed
- p0323[0...n] Maximum motor current
- p0640[0...n] Current limit
- p1082[0...n] Maximum speed
- p1317[0...n] V/f control activation
- p1318[0...n] V/f control ramp-up/ramp-down time
- p1319[0...n] V/f control voltage at zero frequency
- p1326[0...n] V/f control programmable characteristic frequency 4
- p1327[0...n] 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
- Measuring sockets on the Control Unit

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 (gain factor Kp, integral time Tn)
- The automatic controller settings can be verified with the measuring functions.

The "automatic controller setting" parameterization screen form is selected using the following symbol in the toolbar of the STARTER commissioning tool:

Figure 3-18 STARTER symbol for "automatic controller setting"

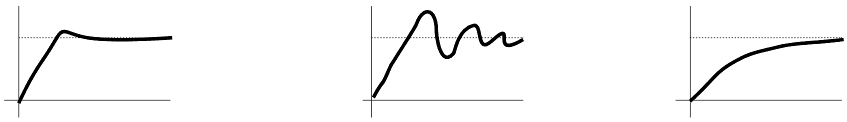
Example of measuring the speed controller frequency response

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.



Kp_n is optimum	Kp_n is too high, overshoots.	Kp_n is too low, dampened transient response.
→ OK	→ Not OK	→ OK, not optimum

Figure 3-19 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 also mixed operation (with/without encoder). Encoderless operation with the motor model allows a higher dynamic response and greater stability than a standard drive with U/f control. Compared with drives with an encoder, however, speed accuracy is lower and the dynamic response and smooth running features 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 ≠ 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 motor rated current (p0305). When parameterizing the motor current (p1612), you must take into account the thermal motor load.

Note

Encoderless operation is not permitted for vertical axes or similar. Encoderless 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 no longer provide any useful information.

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.

To prevent encoder evaluation alarms in encoderless operation, set p1402.1 = 1 to park the encoder evaluation. Reading in the motor temperature via the encoder evaluation remains active.

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

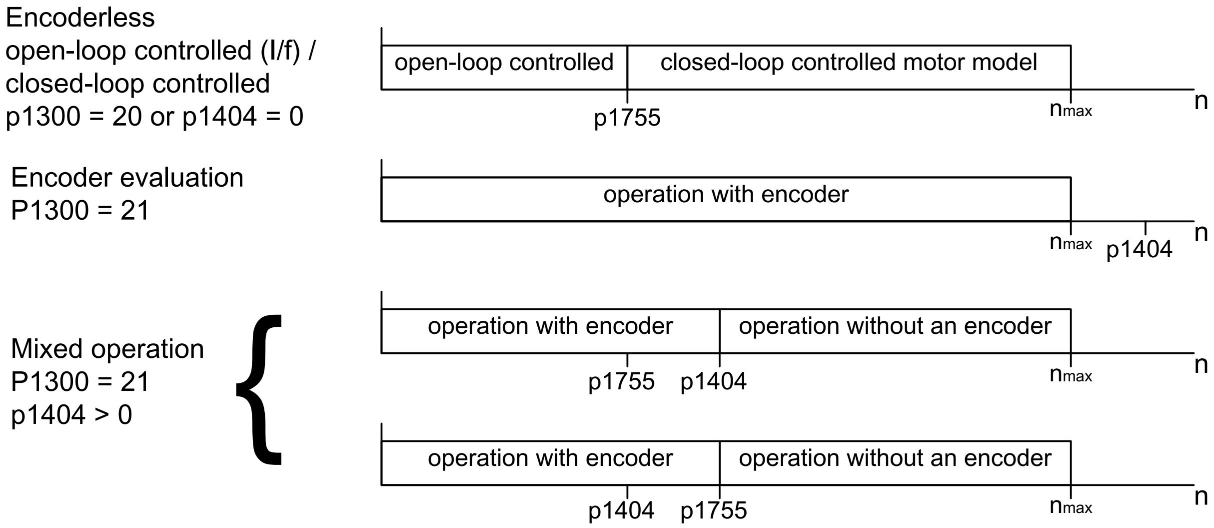


Figure 3-20 Area switchover

Note

In closed-loop control operating mode "Speed controller without encoder", a rotor position encoder is not required. Temperature evaluation remains active, even when the encoder is parked. This state can be identified at parameter r0458.26 = 1. When parameter r0458.26 = 0, temperature sensing is also deactivated.

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 S120/S150 List Manual)

- 5050 Kp_n-/Tn_n adaptation
- 5060 Torque setpoint, control type switchover
- 5210 Speed controller without encoder

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0341[0...n] Motor moment of inertia
- p0342[0...n] Ratio between the total moment of inertia and that of the motor
- p0353[0...n] Motor series inductance
- p0600[0...n] Motor temperature sensor for monitoring
- p0640[0...n] Current limit
- p0642[0...n] Encoderless operation current reduction
- p1300[0...n] Open-loop/closed-loop control operating mode
- p1400.11 Speed control configuration; encoderless operation actual velocity start value
- p1404[0...n] Encoderless operation changeover speed
- r1407.1 CO/BO: Status word speed controller; encoderless operation active
- p1470[0...n] Speed controller encoderless operation P gain
- p1472[0...n] Speed controller encoderless operation integral time
- p1498[0...n] Load moment of inertia
- p1517[0...n] Accelerating torque smoothing time constant
- p1612[0...n] Current setpoint, open-loop control, encoderless
- p1755[0...n] Motor model changeover speed encoderless operation
- 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:

1. Enter the motor data or the rating plate data and the encoder data
2. 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)
3. Carry out a static measurement (p1910)
4. For synchronous motors: Carry out an angular commutation calibration (p1990) and if required, fine synchronization by passing the zero mark (refer to r1992). Absolute encoders do not have to be finely synchronized. For fine synchronization, see also Table 3-16.
5. 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 a direction of rotation limit is active, 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 Off 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- 9 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

Rating plate data

Input of the rating plate data requires the following parameters:

Table 3- 10 Rating plate 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 • p0322 Maximum motor speed • p0353 Motor series inductance • p0400ff Encoder data	• p0304 Rated motor voltage • p0305 Rated motor current • p0307 Rated motor power (alternative p0316) • p0311 Rated motor 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 rating 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- 11 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 Positive/negative direction 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.	

* The p1959 setting has the following effects on the rotational direction parameter p1821:
Positive direction permitted, with setting p1821= 0 means: Clockwise direction of rotation
Negative direction permitted, with setting p1821=1 means: Counter-clockwise direction of rotation

3.12.1 Motor data identification 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- 12 Data determined using p1910 for induction motors (stationary measurement)

Determined data (gamma)	Data that are accepted (p1910 = 1)
r1912 identified stator resistance	p0350 motor stator resistance, cold + p0352 cable resistance
r1913 rotor time constant identified	r0384 motor rotor time constant/damping time constant, d axis
r1915 stator inductance identified	-
r1925 threshold voltage identified	-
r1927 rotor resistance identified	r0374 motor resistance cold (gamma) p0354
r1932 d inductance	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
r1934 q inductance identified	-
r1936 magnetizing inductance identified	r0382 motor main inductance, transformed (gamma) p0360 motor main inductance p1590 flux controller P gain p1592 flux controller integral action time
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).	
-	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- 13 Data determined using p1960 for induction motors (rotating measurement)

Determined data (gamma)	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).	
r1936 magnetizing inductance identified	r0382 motor main inductance, transformed (gamma) p0360 motor main inductance p1590 flux controller P gain p1592 flux controller integral action time
r1948 magnetizing current identified	p0320 rated motor magnetizing current
r1962 saturation characteristic magnetizing current identified	-
r1963 saturation characteristic stator inductance identified	-
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

Table 3- 14 Data determined using p1910 for synchronous motors (stationary measurement)

<table>
<tr><th>Determined data</th><th>Data that are accepted (p1910 = 1)</th></tr>
<tr><td>r1912 stator resistance identified</td><td>p0350 motor stator resistance, cold
+ p0352 cable resistance</td></tr>
<tr><td>r1925 threshold voltage identified</td><td>-</td></tr>
<tr><td>r1932 d inductance</td><td>p0356 motor stator leakage inductance
+ p0353 motor series 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>r1950 Voltage emulation error
voltage values</td><td>p1952 Voltage emulation error, final value</td></tr>
<tr><td>r1951 Voltage emulation error, current values</td><td>p1953 Voltage emulation error, current offset</td></tr>
<tr><td colspan="2">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).</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>r1984 Pole position identification angular difference</td><td>p0431 Angular commutation offset</td></tr>
<tr><td colspan="2">Note:
r1984 indicates the difference of the angular commutation offset before being transferred into p0431.</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- 15 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 travel distances in one direction.

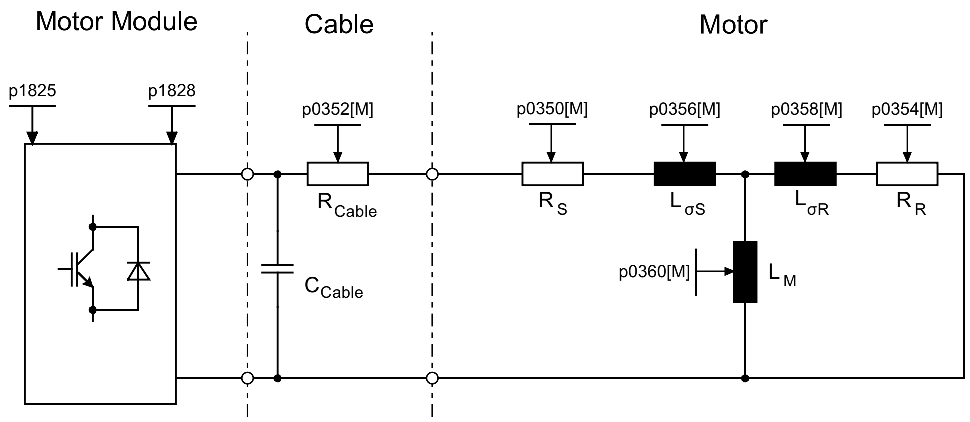


Figure 3-21 Equivalent circuit diagram for induction motor and cable

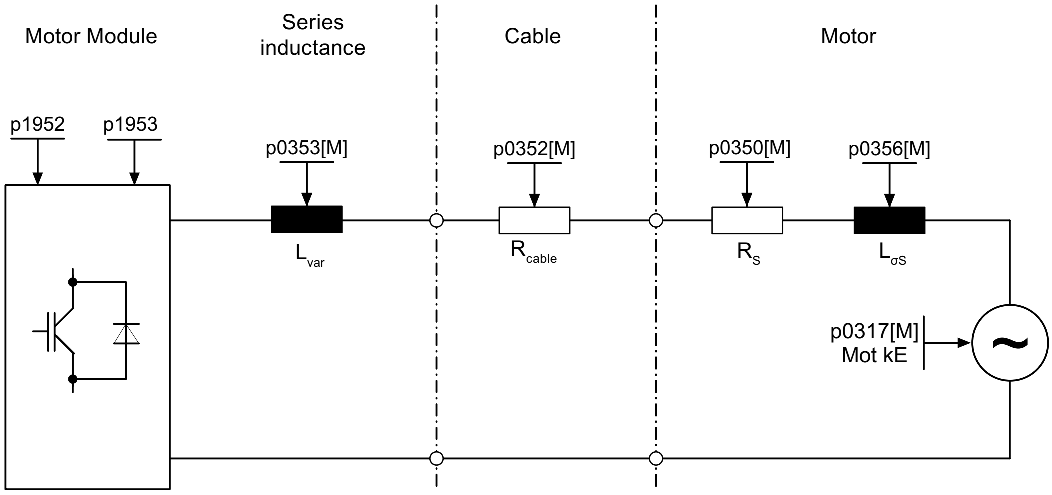


Figure 3-22 Equivalent circuit diagram for synchronous motor and cable

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0047 Status identification

Standstill measurement

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

Rotating measurement

- p1958[0...n] Rotating measurement ramp-up/ramp-down time
- p1959[0...n] Rotating measurement configuration
- p1960 Rotating measurement selection

3.13 Pole position identification

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.

A one-off pole position identification run is required for motors with encoders that are either not calibrated or have not been adjusted.

- Select a technique using p1980
- Start the one-off pole position identification by setting p1990=1,
  the value in p1982 is not taken into consideration.

For Siemens 1FN1, 1FN3 and 1FN6 linear motors, p1990 is automatically set to 1 after commissioning or after an encoder has been replaced.

For the following encoder properties, pole position identification is not required:

- Absolute encoder (e.g. EnDat, DRIVE-CLiQ encoder)
- 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.

Note

Siemens standard motors

When using standard Siemens motors, the automatically pre-selected setting should be kept.

Notes regarding pole position identification

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

- Saturation-based 1st + 2nd harmonics (p1980 = 0)
- Saturation-based 1st harmonic (p1980 = 1)
- Saturation-based, two-stage (p1980 = 4)
- Saturation-based (p1980 = 10)
- Elasticity-based (p1980 = 20)

The following supplementary conditions apply to 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, it is not permissible to traverse with the 2nd harmonic (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 supplementary conditions 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.

For the elasticity-based technique, the following supplementary conditions apply:

- A brake must be available and must also be closed during the pole position identification. Either the drive controls the brake (p1215 = 1 or 3) or the brake is externally closed well in advance of the start of the pole position identification and is re-opened after the operation has been completed.
- Parameters p3090 to p3096 must be correctly set for a successful pole position identification.
- The specified current magnitude (p3096) must deflect the motor by a sufficient amount.
- The ratio between the sign of the deflection and the force/torque must be taken into account in p3090.0.

⚠ WARNING
Before using the pole position identification routine, the control sense of the speed control loop must be corrected (p0410.0). For linear motors, see SINAMICS S120 Commissioning Manual (IH1). For rotating motors, in encoderless 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 p0404.15 = 0 or to determine the offset of the commutation angle using 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

Selecting the reference mark for fine synchronization for determining the pole position using zero marks

A precondition for determining the pole position using zero marks is that the zero mark distance of the encoder is a multiple integer of the pole pitch/pole pair width of the motor.

For example, for linear motors with measuring systems where this is not available, SINAMICS S permits the zero mark, which is used for the reference point approach, to be used for fine synchronization. With this zero mark, due to the mechanical arrangement, the commutation angle = 0 or is available as offset in p0431.

This technique is available for absolute encoders (with the exception of DRIVE-CLiQ encoders), incremental encoders with equidistant zero mark and resolvers.

The sequence is then as follows:

- Select the "fine synchronization with reference mark search" mode in p0437.
- Via the PROFIdrive encoder interface, SINAMICS S receives the request for a reference mark search.
- Together with the Sensor Module, SINAMICS S determines the reference mark as a result of the parameterization.
- SINAMICS S provides the reference mark position via the PROFIdrive encoder interface.
- SINAMICS S transfers the same position to the Sensor Module.
- The Sensor Module corrects the commutation angle (fine synchronization).

Determining the suitable technique for the pole position identification routine

Table 3- 16 Determining the suitable technique for the pole position identification routine

	Saturation-based	Motion-based	Elasticity-based
Brake available	Possible	Not possible	Required
Motor can freely move	Possible	Required	Not possible
Motor has no iron	Not possible	Possible	Possible

Important parameters depending on the pole position identification technique used

Table 3- 17 Important parameters depending on the pole position identification technique used

	Saturation-based	Motion-based	Elasticity-based
p0325	+	-	-
p0329	+	-	-
p1980	Value 0, 1 or 4	Value 10	Value 20
p1981	+	+	-
p1982	+	+	+
p1983	+	+	+
r1984	+	+	+
r1985	+	+	+
r1986	+	+	+
r1987	+	+	+
p1990	+	+	+
r1992	+	+	+
p1993	-	+	-
p1994	-	+	-
p1995	-	+	-
p1996	-	+	-
p1997	-	+	-
p3090	-	-	+
p3091	-	-	+
p3092	-	-	+
p3093	-	-	+
p3094	-	-	+
p3095	-	-	+
p3096	-	-	+
r3097	-	-	+

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- 18 Mode of operation of p0431

	Incremental without zero mark	Incremental with one zero mark	Incremental with distance-coded zero marks	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 absolute position

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Note

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

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0325[0...n] Motor pole position identification current 1st phase
- p0329[0...n] Motor pole position identification current
- p0404.15 Commutation with zero mark (not induction motor)
- p0430[0...n] Sensor Module configuration
- p0431[0...n] Commutation angle offset
- p0437[0...n] Sensor Module configuration extended
- r0458 Sensor Module properties
- r0459 Sensor Module properties extended
- p1215 Motor holding brake configuration
- p1980[0...n] PolID technique
- p1981[0...n] PolID distance max
- p1982[0...n] PolID selection
- p1983 PolID test
- r1984 PolID angular difference
- r1985 PolID saturation curve
- r1986 PolID saturation curve 2
- r1987 PolID trigger curve
- p1990 Determine encoder adjustment commutation angle offset
- p1991[0...n] Motor changeover commutation angle correction
- r1992 Pole ID diagnostics
- p1993[0...n] Pole ID current, motion based
- p1994[0...n] Pole ID rise time, motion based
- p1995[0...n] Pole ID gain, motion based
- p1996[0...n] Pole ID integral time, motion based
- p1997[0...n] Pole ID smoothing time, motion based
- p3090[0...n] Pole ID elasticity-based configuration
- p3091[0...n] Pole ID elasticity-based ramp time
- p3092[0...n] Pole ID elasticity-based wait time
- p3093[0...n] Pole ID elasticity-based measuring operation number
- p3094[0...n] Pole ID elasticity-based deflection expected
- p3095[0...n] Pole ID elasticity-based deflection permissible
- p3096[0...n] Pole ID elasticity-based current
- r3097.0...31 BO: Pole ID elasticity-based status

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.

Generally, a maximum motoring power drawn p_{mot} of the motor inverter from the DC link of

$P_{mot} = V_{DClink, actual value}$ x ($V_{DClink, actual value}$ - p1248) x p1250 is obtained

Correspondingly, a maximum regenerative feedback power P_{gen} of the motor inverter into the DC link of

$P_{gen} = V_{DClink, actual value}$ x (p1244 - $V_{DClink, actual value}$) x p1250 is obtained

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 x 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.

The voltage limit values for Vdc control also have an impact on V/f control, although the dynamic response of Vdc control is slower in this case.

Description of Vdc_min control (p1240 = 2, 3)

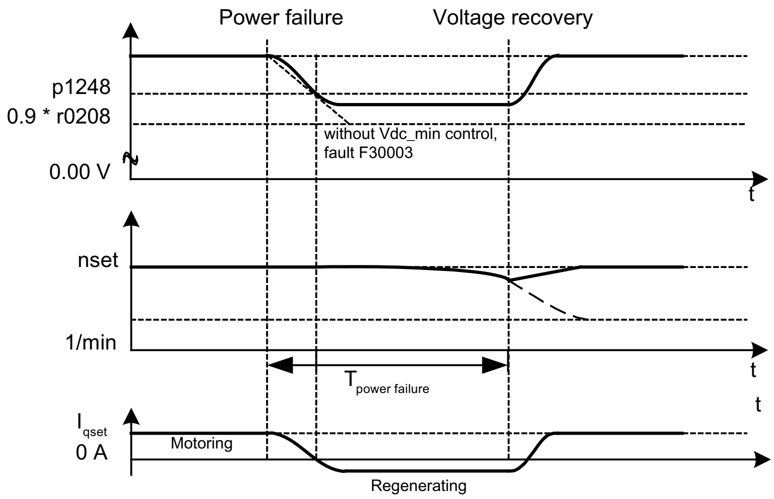

Figure 3-23 Switching Vdc_min control on/off (kinetic buffering)

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 re-established, the Vdc controller is automatically deactivated and the drives approach the speed setpoint again. If the power supply cannot be re-established, 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 e.g. be supplied from an uninterruptible power supply (UPS).

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)

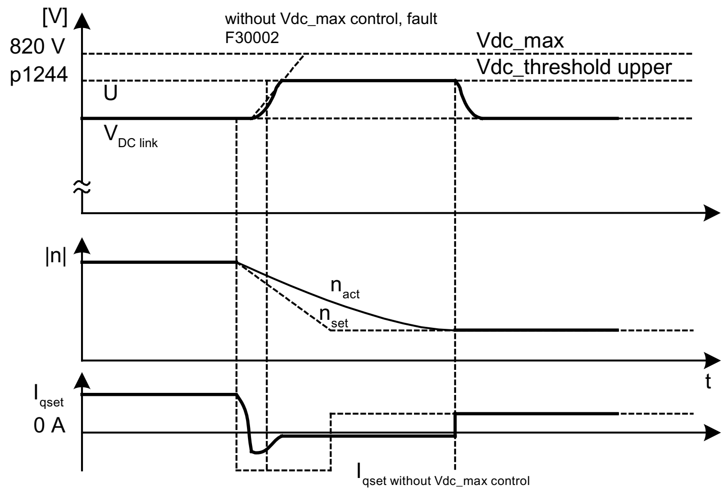

Figure 3-24 Switching-in/switching-out the Vdc_max control

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 S120/S150 List Manual)

- 5650 Vdc_max controller and Vdc_min controller
- 5300 V/f control

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0056.14 CO/BO: Status word, closed loop control: Vdc_max controller active
- r0056.15 CO/BO: Status word, closed loop control: Vdc_min controller active
- p1240[0...n] Vdc controller or Vdc monitoring configuration
- p1244[0...n] DC link voltage threshold, upper
- p1248[0...n] DC link voltage threshold, lower
- p1250[0...n] Vdc controller proportional gain

3.15 Dynamic Servo Control (DSC)

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.

If the drive reaches its torque limits when in the DSC mode, e.g. because of excessively fast setpoint inputs, then positioning motion can be overshot. With this so-called wind-up effect, the drive overshoots the specified target, the control enters a specific correction, the drive reverses, again overshoots the target, etc. In order to avoid this behavior, the drive limits the position controller to values, which the drive can always reliably maintain depending on the acceleration capability. Set p1400.17 = 1 in order to activate dynamic setpoint limiting in the DSC mode. In this case, the total weight (m_{tot}) must be precisely parameterizing (determine the weight p0341, p0342 and p1498 possibly using the mot ID). If the limiting responds then this is indicated in r1407.19. On this topic, also observe the description of parameter p1400.17 and function diagram 3090.

Preconditions

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 position deviation (XERR) must be included in the setpoint telegram of PROFIBUS DP 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 with IRT via the encoder interface Gx_XIST1.
- When DSC is activated, the speed setpoint N_SOLL_B from the PROFIdrive telegram from PROFIBUS DP or PROFINET IO with IRT is used as a speed pre-control value.
- The internal quasi position controller, DSC position controller (FP5030), use the position actual value G1_XIST1 from the motor measuring system or the position actual value from an additional encoder system (telegrams 6, 106, 116 and 118 or free telegrams).

The following PROFIdrive telegrams support DSC:

- Standard telegrams 5 and 6
- SIEMENS telegrams 105, 106, 116, 118, 125, 126, 136, 139

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.

A detailed description of the DSC mode of operation is provided in function diagram 3090 (see SINAMICS S120/S150 List Manual).

Operating states

The following operating states are possible for DSC (for details, see SINAMICS S120/S150 List Manual, function diagram 3090):

- Speed/torque precontrol with linear interpolation

  As a result of the step-like torque precontrol in the position controller clock cycle, a pulsed torque characteristic is obtained with the excitation clock cycle.
- Speed precontrol with splines
  - The position setpoint is made symmetrical.
  - The speed precontrol value is not made symmetrical.
- Speed/torque precontrol with splines
  - The position setpoint is made symmetrical.
  - The speed precontrol value is made symmetrical
  - The torque precontrol value is not made symmetrical.

The following improvements are achieved as a result of spline interpolation:

- A finer interpolation of the torque in the speed controller clock cycle and therefore softer motion; torque surges are also avoided.
- For torque-speed precontrol:

  Extremely high path accuracy (i.e. lower following error in the control behavior).
- High-frequency path motion is possible

Activation

If the preconditions for DSC are fulfilled, then the DSC structure is activated using a logical interconnection of the following parameters via a selected PROFIdrive telegram:

- p1190 "DSC position deviation XERR"
- p1191 "DSC position controller gain KPC"
- p1194 "CI: DSC control word DSC_STW"
- p1195 "CI: DSC Symmetrizing time constant T_SYMM"
- p1430 "CI: Speed precontrol"

If KPC = 0 is transferred, only speed control with the speed precontrol values can be used (p1430, PROFIdrive N_SOLL_B and p1160 n_set_2). 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.

Channel p1155 for speed setpoint 1, as well as channel r1119 for the extended setpoint, are disconnected when DSC is active.

When DSC is activated, p1160 for speed setpoint 2 and p1430 for the speed precontrol are added to the speed setpoint from the DSC, see function diagram 5030.

Deactivating

If the interconnection is removed at the connector input for KPC or XERR (p1191 = 0 or p1190 = 0), the DSC structure is dissolved and the "DSC" function" deactivated. The sum from r1119 and p1155 is then added to the values from p1160 and p1430 from the speed pre-control.

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 deselecting DSC, the value for KPC in the master must be reduced.

Speed setpoint filter

A speed setpoint filter for smoothing the speed setpoint steps is not 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: Telegrams 06,106,116,118 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

Parameter r1407 indicates which DSC closed-loop control structure is active, e.g. r1407.20 = 1 means "DSC with Spline on".

Preconditions for the indication:

- p1190 and p1191 must be connected to a signal source with a value of > 0 (DSC structure activated).
- OFF1, OFF3 and STOP2 must not be active.
- The motor data identification must not be active.
- Master control must not be active.

The following conditions can mean that although the bit is set, the DSC function is not active:

- Isochronous mode has not been selected (r2054 ≠ 4).
- PROFIBUS is not isochronous (r2064[0] ≠ 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 S120/S150 List Manual)

- 2420 PROFIdrive - standard telegrams and process data
- 2422 PROFIdrive - Manufacturer-specific telegrams and process data 1
- 2423 PROFIdrive - Manufacturer-specific telegrams and process data 2
- 2424 PROFIdrive - Manufacturer-specific/free telegrams and process data
- 3090 Dynamic Servo Control (DSC)
- 5020 Speed setpoint filter and speed pre-control
- 5030 Reference model

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1160 CI: Speed controller, speed setpoint 2
- p1190 CI: DSC position deviation XERR
- p1191 CI: DSC position controller gain KPC
- p1192[D]: DSC encoder selection
- p1193[D]: DSC encoder adaptation factor
- p1194 CI: DSC control word DSC_STW
- p1195 CI: DSC Symmetrizing time constant T_SYMM
- p1400.17 speed control configuration; DSC position controller limiting active
- r1407.4 CO/BO: Status word speed controller; speed setpoint of DSC
- r1407.19 CO/BO: Status word speed controller; DSC position controller limited
- r1407.20 CO/BO: Status word speed controller; DSC with spline on
- r1407.21 CO/BO: Status word speed controller; speed precontrol for DSC with spline on
- r1407.22 CO/BO: Status word speed controller; torque precontrol for DSC with spline on
- p1430 CI: Speed pre-control

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 established and is then continuously available.

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

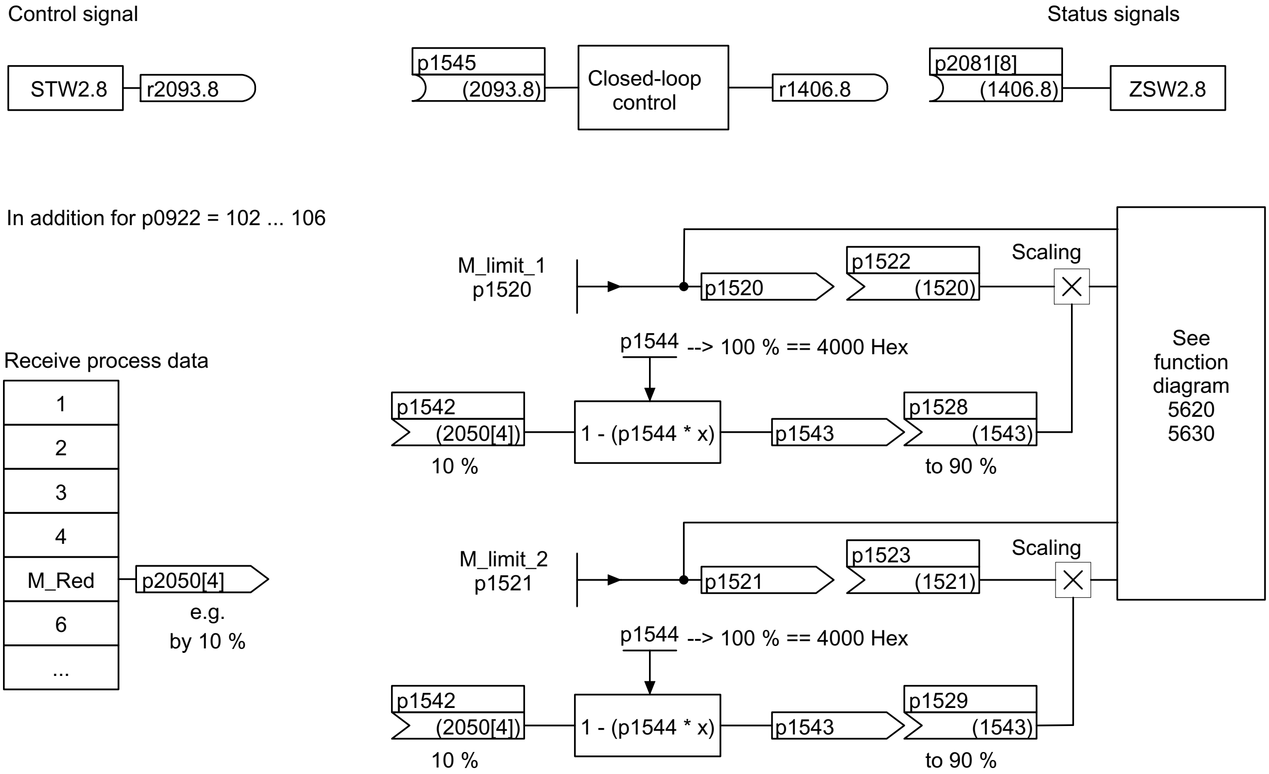

Figure 3-25 Signals for "Travel to fixed stop"

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

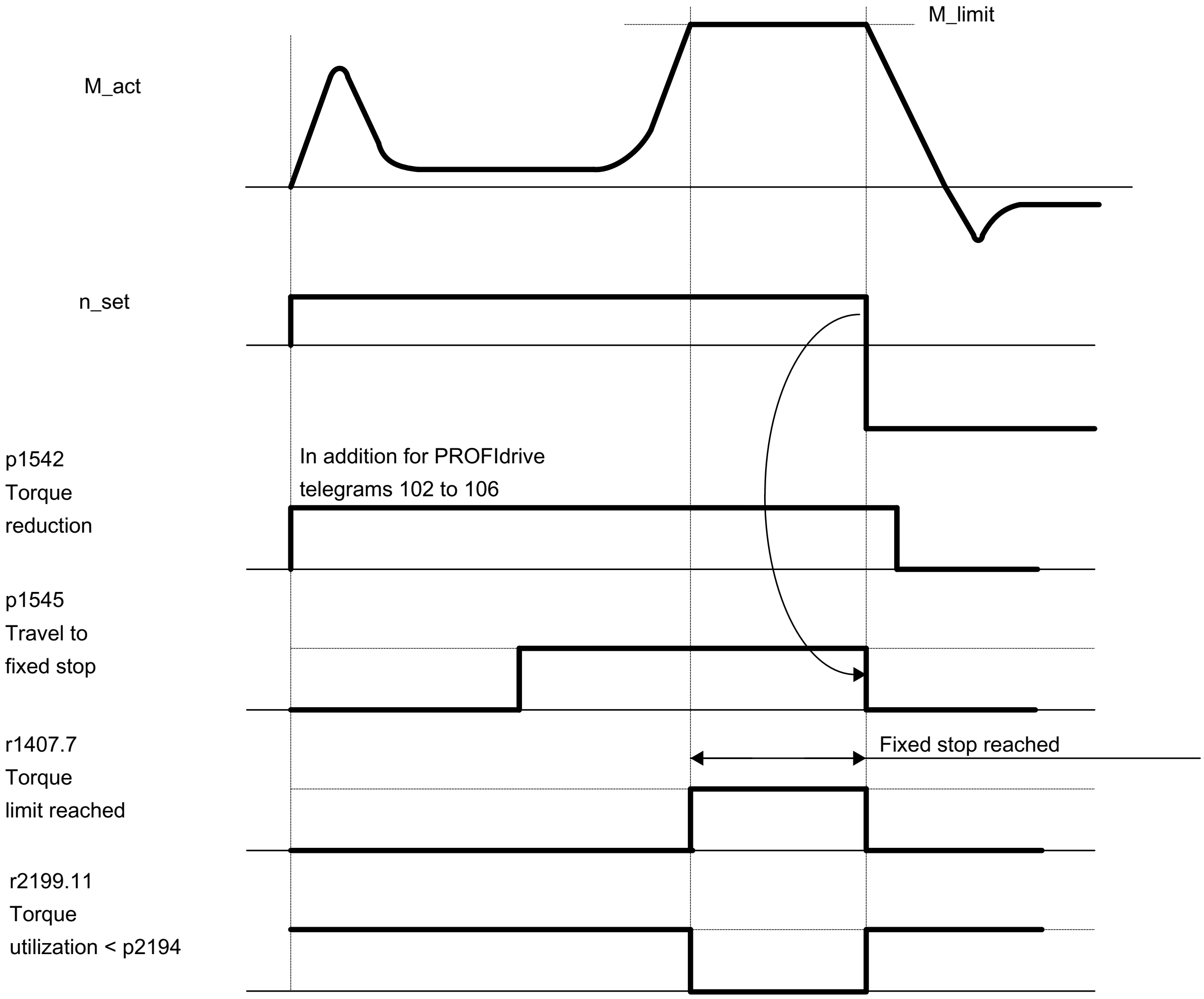

Figure 3-26 Signal chart for "Travel to fixed stop"

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- 19 Control: Travel to fixed stop

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

Table 3- 20 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 S120/S150 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 important parameters (see SINAMICS S120/S150 List Manual)

- p1400[0...n] Speed control configuration
- r1407.7 CO/BO: Status word speed controller; 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, evaluation torque reduction
- p1545[0...n] BI: Activate 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 S120/S150 List Manual)

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

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0031 Actual torque smoothed
- p1513[0...n] CI: Supplementary torque 2
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1532[0...n] CO: Torque limit, offset

3.18 Variable signaling function

The variable signaling function can be used to monitor BICO sources and parameters (with the attribute traceable) for violation of an upper or lower threshold (p3295).

A hysteresis (p3296) can be specified for the threshold value and a pull-in or drop-out delay (p3297/8) can be specified for the output signal (p3294).

The setting of a hysteresis results in a tolerance band around the threshold value. If the upper threshold value is exceeded the output signal is set to 1, if it drops below the lower threshold value the output signal is reset to 0.

After the configuration is completed, the variable signaling function must be activated with p3290.0.

Note

The variable signaling function works with an accuracy of 8 ms (also to be taken into account for pickup and dropout delay).

Example 1:

Heating should be switched on depending on the temperature. For this the analog signal of an external sensor is connected with the variable signaling function. A temperature threshold and a hysteresis is defined to prevent the heating from switching on and off constantly.

Example 2:

A process variable pressure is to be monitored, whereby a temporary overpressure is tolerated. For this the output signal of an external sensor is connected with the variable signaling function. The pressure thresholds and a pull-in delay are set as tolerance time.

When the output signal of the variable signaling function is set, bit 5 in message word MELDW is set during cyclic communication. The message word MELDW is a component of the telegrams 102, 103, 105, 106, 110, 111, 116, 118, 126.

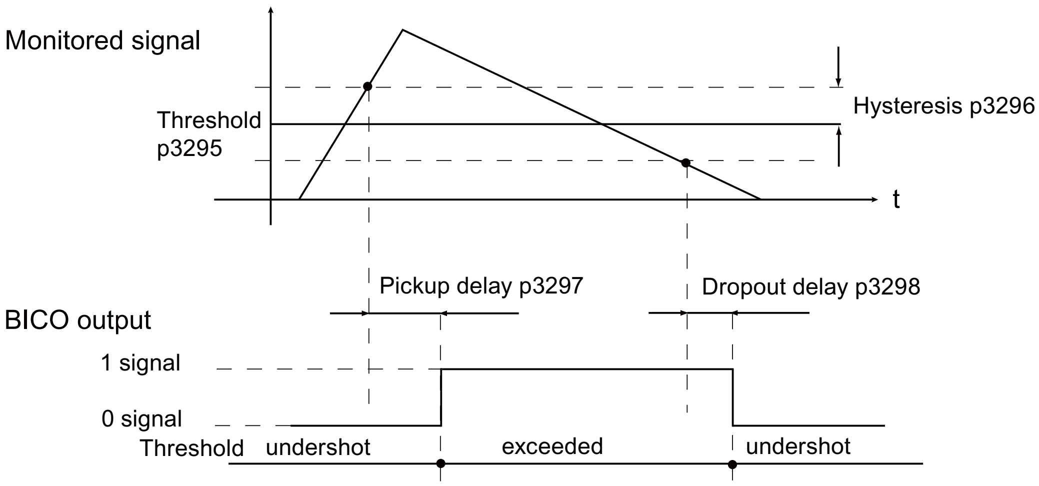

Figure 3-27 Variable signaling function

Function diagrams (see SINAMICS S120/S150 List Manual)

- 5301 Servo control - variable signaling function

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p3290 Variable signaling function start
- p3291 CI: Variable signaling function signal source
- p3292 Variable signaling function signal source address
- p3293 Variable signaling function signal source data type
- p3294 BO: Variable signaling function, output signal
- p3295 Variable signaling function, threshold value
- p3296 Variable signaling function, hysteresis
- p3297 Variable signaling function, pickup delay
- p3298 Variable signaling function, dropout delay

3.19 Central probe evaluation

Description

Frequently, motion control systems have to detect and save the positions of drive axes at an instant in time defined by an external event. For example, this external event may be the signal edge of a probe. In this case, it may be necessary to evaluate several probes or save the position actual values of several axes, triggered by a probe event.

For the central probe evaluation, the instant in time of the probe signal is detected and saved by a central function. From the available sample values of the position signals of the various axes, the position actual values at the probe instant are interpolated with respect to time in the control. For SINAMICS S, two techniques have been implemented:

- For the probe evaluation **with handshake**, for each probe and positive and/or negative probe edge, up to 1 measured value is evaluated each communication cycle / each four DP cycles.
- With a parameterizable probe evaluation **without handshake**, the evaluation frequency of the probe edges can be increased up to the communication frequency/application frequency of the probe evaluation (= SERVO cycle of the higher-level control).

  Precondition: T_DP = T_MACP (i.e. cycle ratio = 1:1, no cycle reduction ratio is possible).

Common features for central measuring with and without handshake

Both measuring techniques have the following points in common:

- PROFIBUS telegrams
- Synchronization between the control and drive as a precondition for measuring.
- System time: Resolution (0.25 μs), maximum value (16 ms)
- Time stamp: Format (drive increments, NC decrements)
- Monitoring functions (sign of life)
- Fault messages
- Incrementing

In the interface, the value "0" is not a valid time format and is used to express that a measured value is not available.

Central measuring with handshake

- Evaluation technique with handshake, as long as p0684 = 0.
- Transfer, control word probe (BICO p0682 to PZD3) at the instant To in the MAP cycle.
- A measurement is activated with a 0/1 transition of the control bit for falling or rising edge in the probe control word.
- If a measurement is activated, a check is made in the DP cycle as to whether a measured value is present.
- If the check indicates that there is a measured value, then the time stamp is entered into either p0686 or p0687.
- The time stamp is transferred until the control bit for falling or rising edge is set to zero in the control word. Then, the associated time stamp is set to zero.

Central measurement without handshake

When selecting the evaluation technique without handshake (p0684 = 1), the measurement for falling and rising edge is activated.

If a measurement is activated, a check is made in the DP cycle as to whether a measured value was detected:

- If the check indicates that a measured value is available, the time stamp is entered in either p0686 or p0687 and a new measurement is automatically activated.
- If the check indicates that a measured value is not available, then a time stamp of zero is entered into either p0686 or p0687.
- This means that a time stamp is only transferred once before it is overwritten with zero or a new time stamp.
- Max. edge detection cycle < 1 / T_DP

Remarks

Applications other than the application actually using the function can monitor the probe state and read the probe measured values.

Example:
EPOS axially controls "its" probe, a control can establish a connection to the probe to read its signals and the information can be integrated into the drive telegram.

Parameter p0684 (central probe evaluation technique) offers the following setting options:

- p0684 = 0: Measuring with handshake (factory setting)
- p0684 = 1: Measuring without handshake
- It cannot be guaranteed that the standard PROFIdrive connection will not fail.
- The function "without handshake" has been released for "integrated" platforms (e.g. SINAMICS integrated in SIMOTION D425).
- You must use the MIT handshake version to ensure absolute reliability when detecting the probe.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 4740 Encoder evaluation - probe evaluation

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0680[0...5] Central probe input terminal
- p0681 BI: Central probe synchronization signal, signal source
- p0682 CI: Central probe control word signal source
- p0684 Central probe evaluation technique
- r0685 Central probe control word display
- r0686[0...5] CO: Central probe measuring time, rising edge
- r0687[0...5] CO: Central probe measuring time, falling edge
- r0688 CO: Central probe status word display

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 for setpoint changes (→ better control behavior)
- Short settling times for load changes (→ better response to disturbances)
- 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)

Comparison of servo control and vector control

The table below shows a comparison between the characteristic features of servo and vector controls.

Table 4- 1 Comparison of servo control and vector control

Subject	Servo control	Vector control
Typical applications	• Drives with highly dynamic motion control • Drives with high speed and torque accuracy (servo synchronous motors) • Angular-locked synchronism with isochronous PROFIdrive. • For use in machine tools and clocked production machines	• Speed and torque-controlled drives with high speed and torque accuracy, particularly in operation without an encoder (sensorless operation).
Maximum number of drives that can be controlled by one Control Unit. **To be taken into account:** Chapter "Rules for wiring with DRIVE-CLiQ" in this document below	• 1 infeed + 6 drives (for current controller sampling rates 125 µs or speed controller 125 µs) • 1 infeed + 3 drives (for current controller sampling rates 62.5 µs or speed controller 62.5 µs) • 1 infeed + 1 drive (for current controller sampling rates 31.25 µs or speed controller 62.5 µs)	• 1 infeed + 3 drives (for current controller sampling times 250 µs or speed controller 1 ms) • 1 infeed + 6 drives (with current controller sampling times 400 µs/500 µs or speed controller 1.6 ms/2 ms) • V/f control: 1 infeed + 12 drives (with current controller sampling times 500 µs or speed controller 2000 µs)
Dynamic response	High	Medium
Sampling time, current controller / sampling time, speed controller / pulse frequency	• Booksize: 31.25 µs / 31.25 µs / ≥ 8 kHz (factory setting, 8 kHz) • Blocksize: 31.25 µs / 31.25 µs / ≥ 8 kHz (factory setting, 8 kHz) • Chassis: Frame size Fx : 250 µs / 250 µs / ≥ 2 kHz (factory setting, 2 kHz) Frame size Gx: 125 µs / 125 µs / ≥ 4 kHz	• Booksize: 250 µs / 1000 µs / ≥ 2 kHz (factory setting 4 kHz) 500 µs / 2000 µs / ≥ 2 kHz (factory setting, 4 kHz) • Blocksize: 250 µs / 1000 µs / ≥ 2 kHz (factory setting 4 kHz) 500 µs / 2000 µs / ≥ 2 kHz (factory setting, 4 kHz) Chassis: ≤ 250 kW: 250 µs / 1000 µs / ≥ 2 kHz > 250 kW: 400 µs / 1600 µs / ≥ 1.25 kHz 690 V: 400 µs / 1600 µs / ≥ 1.25 kHz
Note: Further information about the sampling conditions is contained in the "Rules for setting the sampling time" subsection later in this manual.		

Subject	Servo control	Vector control
Connectable motors	• Synchronous servomotors • Induction motors • Torque motors	• Induction motors • Synchronous motors (including torque motors) • Reluctance motors (only for V/f control) • Separately-excited synchronous motors **Note:** Synchronous motors of the 1FT6, 1FK6 and 1FK7 series cannot be connected.
Position interface via PROFIdrive for higher-level motion control	Yes	Yes
Encoderless speed control	Yes (from 10 % rated motor speed)	Yes (from standstill or 2% rated motor speed)
Motor identification (third-party motors)	Yes	Yes
Speed controller optimization	Yes	No, only parameter pre-assignment
V/f control	Yes	Yes (various characteristics)
Encoderless closed-loop torque control	No	Yes (open-loop control at low speeds)
Field-weakening range for induction motors	≤ 16 field-weakening threshold speed (with encoder) ≤ 5 field-weakening threshold speed (without encoder)	≤ 5 · rated motor speed
Maximum output frequency with closed-loop control	• 1300 Hz with 62.5 μs / 8 kHz • 650 Hz with 125 μs / 4 kHz • 300 Hz with 250 μs / 2 kHz **Note:** The specified values have been dimensioned so that they can be achieved by SINAMICS S without optimization. Higher frequencies can be set under the following secondary conditions and additional optimization runs: • Up to 1500 Hz – Operation without an encoder – In conjunction with controlled infeeds • Up to 1600 Hz – Operation with encoder – In conjunction with controlled infeeds • Absolute upper limit 1600 Hz	• 300 Hz with 250 μs / 4 kHz or with 400 μs / 5 kHz • 240 Hz with 500 μs / 4 kHz
Note: The derating characteristics in the various Manuals must be carefully observed! Max. output frequency when using dv/dt and sine-wave filters: 150 Hz		

Subject	Servo control	Vector control
Response when operating at the thermal limit of the motor	Reduction of the current setpoint or shutdown	Reduction in the pulse frequency and / or the current setpoint or shutdown (not applicable with parallel connection / sine-wave filter)
Speed setpoint channel (ramp-function generator)	Optional (reduces the number of drives from 6 to 5 Motor Modules for current controller sampling times of 125 µs - or speed controller sampling times of 125 µs)	Standard
Parallel connection of power units	No	• Booksize: No • Chassis: Yes

4.1 Sensorless vector control (SLVC)

In sensorless vector control (SLVC), the position of the flux and actual speed must be determined using the electric motor model. The motor model is buffered by the incoming currents and voltages. At low frequencies (approx. 0 Hz), the motor model cannot determine the speed with sufficient accuracy. For this reason, the motor can be switched over from closed-loop to open-loop control.

Three-phase induction motors

The changeover between closed-loop/open-loop control is controlled by means of the time and frequency conditions (p1755, p1756, p1758 for induction motors only). 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.

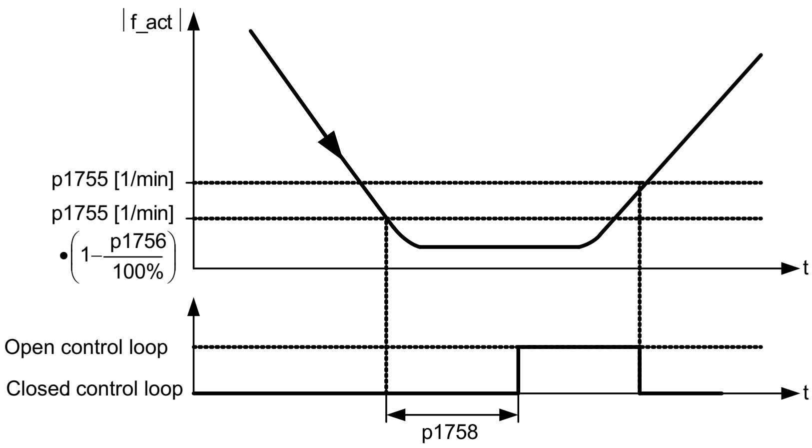

Figure 4-1 Changeover conditions for SLVC

Torque setpoint setting

In open-loop operation, the calculated actual speed value is the same as the setpoint value. For vertical loads and when accelerating, parameters p1610 (constant torque boost) and p1611 (acceleration torque boost) must be adapted to the necessary maximum torque 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 prevailing load torques (motor or regenerative), parameters p1610 (constant torque boost) and p1611 (acceleration torque boost) must be adapted to the necessary maximum torque in order to generate the static or dynamic load torque of the drive. 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 prevent stalling of the drive during acceleration, p1611 can be increased or acceleration pre-control for the speed controller can be used. This avoids thermal overloading of the motor at low speeds.

Encoderless vector control has the following characteristics at low frequencies:

- Closed-loop operation to approx. 0 Hz output frequency (p0500=2), at p1750 = 15.
- Starting in closed-loop controlled operation (directly after the drive has been fully energized) (only ASM).

Note

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

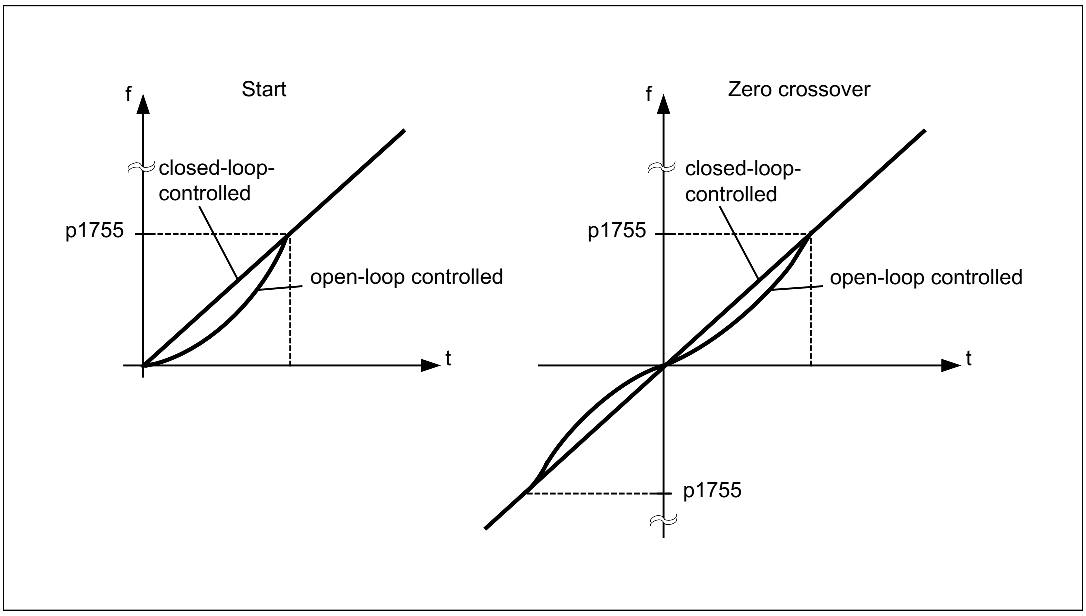

Figure 4-2 Zero crossover and when induction motors start in closed-loop or open-loop controlled operation

Closed-loop operation to approx. 0 Hz (can be set using parameter p1755) and the ability to start or reverse at 0 Hz directly in closed-loop operation (can be set using parameter p1750) result in the following benefits:

- No switchover operation required within closed-loop control (bumpless behavior, no frequency dips, no discontinuities in the torque).
- Closed-loop speed and torque control without encoder up to and including 0 Hz.
- passive loads to frequency 0 Hz
- Steady-state speed-torque control is possible up to approx. 0 Hz
- Higher dynamic performance when compared to open-loop controlled operation
- Encoderless operation of drive line-ups (e.g. in the paper industry, master-slave operation).

Note

When the motor is started or reversed in closed-loop control at 0 Hz, it is important to take into account that a changeover 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).

NOTICE
Sine-wave filter
When using a sine-wave filter, use the previous open-loop controlled method.

Passive loads

With the restriction that the load has to be passive when starting, it is now possible to maintain induction motors in steady-state, closed-loop-controlled operation down to zero frequency (standstill) without switching over to open-loop-controlled operation at any time.

To implement this set

1. p0500 = 2 (technological application = passive loads for encoderless control to f = 0).

   The following parameters are then set automatically:

   – p1574 = 2 V (for separately-excited synchronous motors = 4V)

   – p1750.2 = 1 encoderless control of induction motors, effective down to n = 0 Hz

   – p1802 = 4 (SVM/FLB without overcontrol)

   – p1803 = 106 %

2. Finally, set p0578 = 1 (calculate technology-dependent parameters).
   As a consequence, the passive load function is automatically activated.

Closed-loop control without changeover between closed-loop and open-loop speed control is restricted to applications with passive load:
A passive load has only a reactive effect on the drive torque of the driving motor during starting, e.g. inert masses, brakes, pumps, fans, centrifuges, extruders.
Standstill without a holding current is possible for as long as required. At standstill, only the magnetizing current is impressed in the motor.

NOTICE
Generator operation
Steady-state generator operation at frequencies close to zero is not permissible in this operating mode.

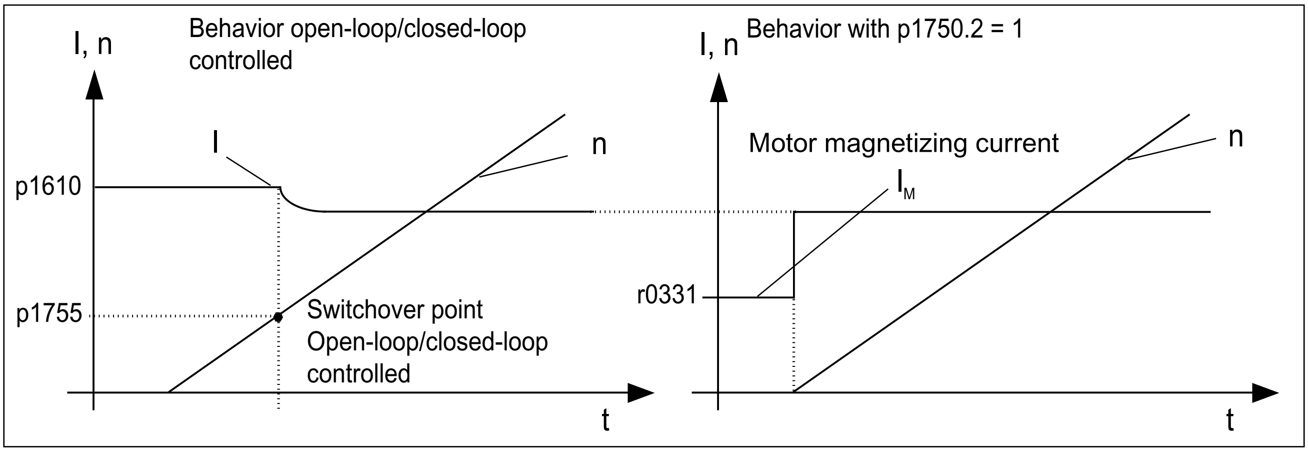

Figure 4-3 Vector control without an encoder

Active loads

Active loads, e.g. hoisting gear, must be started in the open-loop controlled mode. In this case, bit p1750.6 must be set to 1 (closed-loop controlled operation when the motor is blocked).

Permanent-magnet synchronous motors

Permanent-magnet synchronous motors (PEM) are always started and reversed in the open-loop controlled mode. 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.

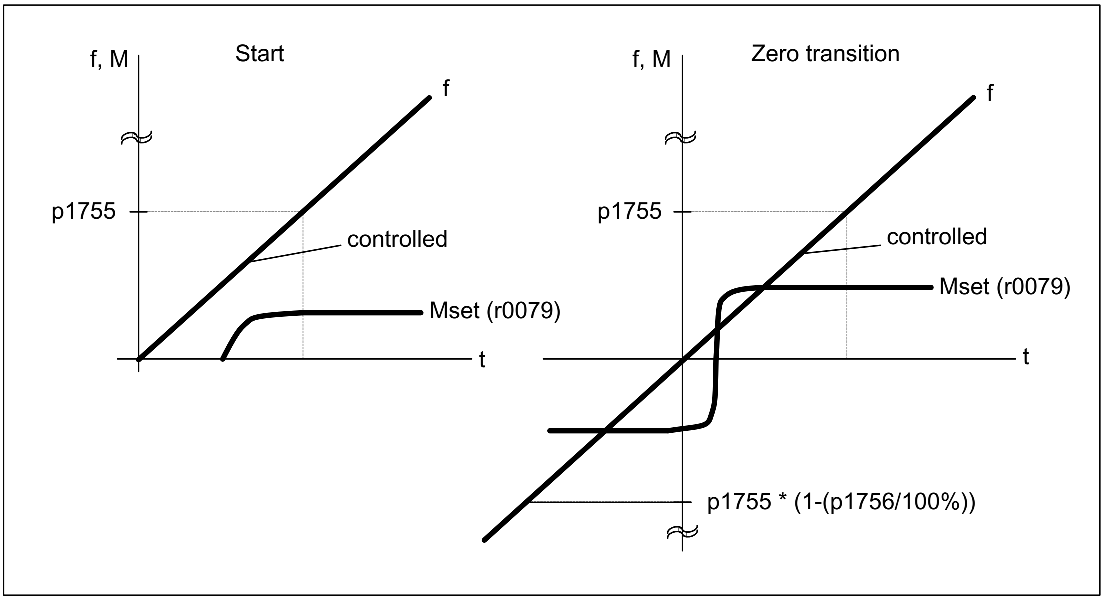

Figure 4-4 Zero point and starting in open-loop operation at low speeds

Extended method: closed-loop operation down to zero speed

By superimposing high-frequency pulses onto the driving fundamental voltage and evaluating the superimposed pulses occurring as a result in the machine current, it is possible to determine the continuous rotor position down to zero frequency (standstill). With Siemens series 1FW4 and 1PH8 torque motors, it is possible to approach the rated torque from a standstill at any load, or even to stop the load at a standstill.

If the technique is activated, then at low speeds additional noise is possible - depending on the motor design.

This method is suitable for motors with internal magnets.

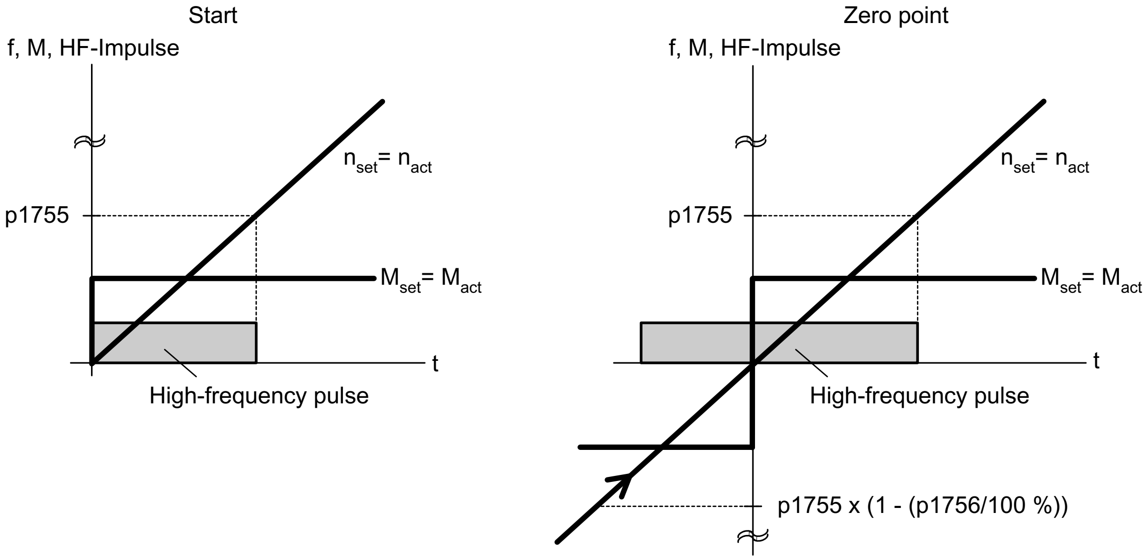

Figure 4-5 Zero point in closed-loop operation down to zero speed

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Note

When using a sine-wave filter, apply the open-loop method.

Note

Siemens 1FW4 torque motors

Siemens 1FW4 torque motors can be started from standstill and operated in the closed-loop torque controlled mode. The function is activated using parameter p1750 bit 5.

For third-party motors, this must be checked on a case-by-case basis.

Basic conditions for the use of third-party motors

- Experience shows that this method is extremely well suited for interior permanent magnet synchronous motors (IPMSM).
- The ratio of stator quadrature reactance (Lsq): Stator direct-axis reactance (Lsd) must be > 1 (recommendation: at least > 1.5).
- The asymmetrical reactance ratio (Lsq:Lsd) is maintained in the motor up to a certain current; this determines the possible operating limits of the method. If it you want to be able to operate the method up to the rated motor torque, the reactance ratio must be maintained up to the rated motor current.

The following parameter input is prerequisite for optimal performance:

- Input of the saturation characteristic: p0362 - p0369
- Input of the load characteristic: p0398, p0399

Commissioning sequence for closed-loop controlled operation down to zero speed:

- Perform commissioning with motor identification at standstill.
- Enter the parameters for saturation characteristic and load characteristic.
- Activate closed-loop operation down to zero speed via parameter p1750 bit 5.

The following advantages are obtained by maintaining closed-loop controlled operation:

- No torque irregularities as a result of changeover operations in the closed-loop control structure
- Closed-loop speed and torque control without encoder (sensorless) up to and including 0 Hz.
- Higher dynamic performance when compared to open-loop controlled operation
- Encoderless operation of drive line-ups (e.g. in the paper industry, master-slave operation) is possible.
- Active (including hanging/suspended) loads down to a frequency equal to zero.

NOTICE
Output filter
The technique cannot be used with the existing output filter.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6730 Interface to Motor Module (ASM, p0300 = 1)
- 6731 Interface to the Motor Module (PEM, p0300 = 2)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0305[0...n] Rated motor current
- r0331[0...n] Actual motor magnetizing current/short-circuit current
- p0500 technology application
- 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 encoderless operation
- p1756 Motor model changeover speed hysteresis encoderless operation
- p1758[0...n] Motor model changeover delay time, closed/open-loop control
- p1802[0...n] modulator mode
- p1803[0...n] modulation depth maximum

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%-p1753) 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 ... 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 temperature detection 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.

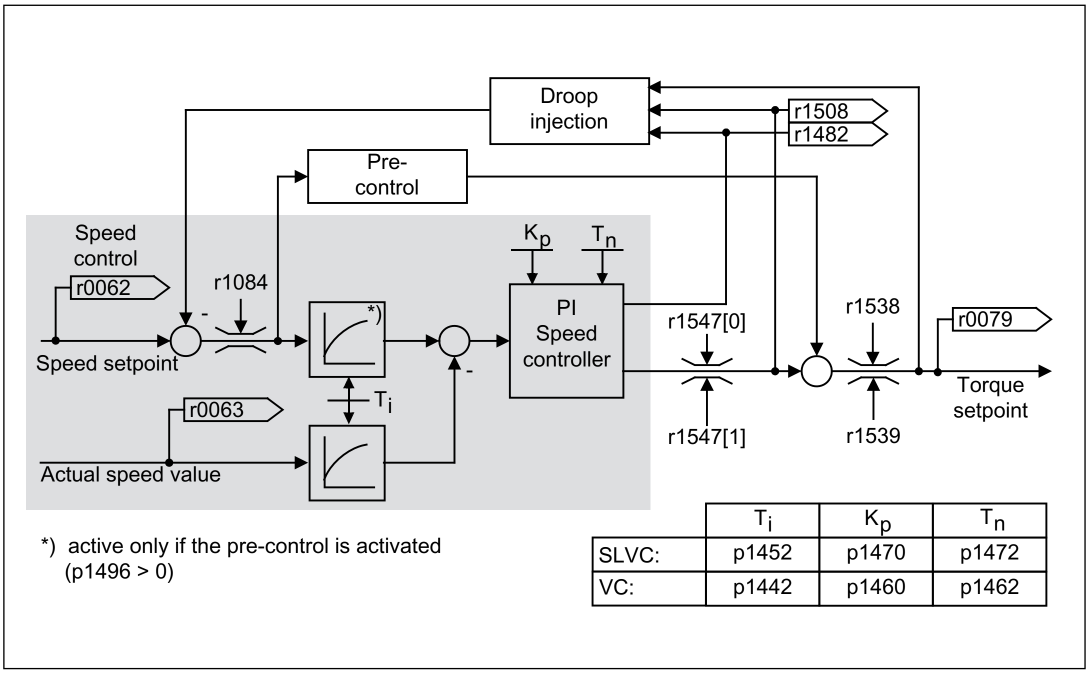


Figure 4-6 Speed controller

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 S120/S150 List Manual)

- 6040 Speed controller with/without encoder

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0062 CO: Speed setpoint after the filter
- r0063[0...1] CO: Speed actual value
- p0340[0...n] Automatic calculation of motor/control parameters
- r0345[0...n] Rated motor starting time
- p1442[0...n] Speed controller actual speed smoothing time
- p1452[0...n] Speed controller 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 encoderless operation P gain
- p1472[0...n] Speed controller encoderless operation integral time
- r1482 CO: Speed controller I torque output
- r1508 CO: Torque setpoint before supplementary torque
- p1960 Rotating measurement selection

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".

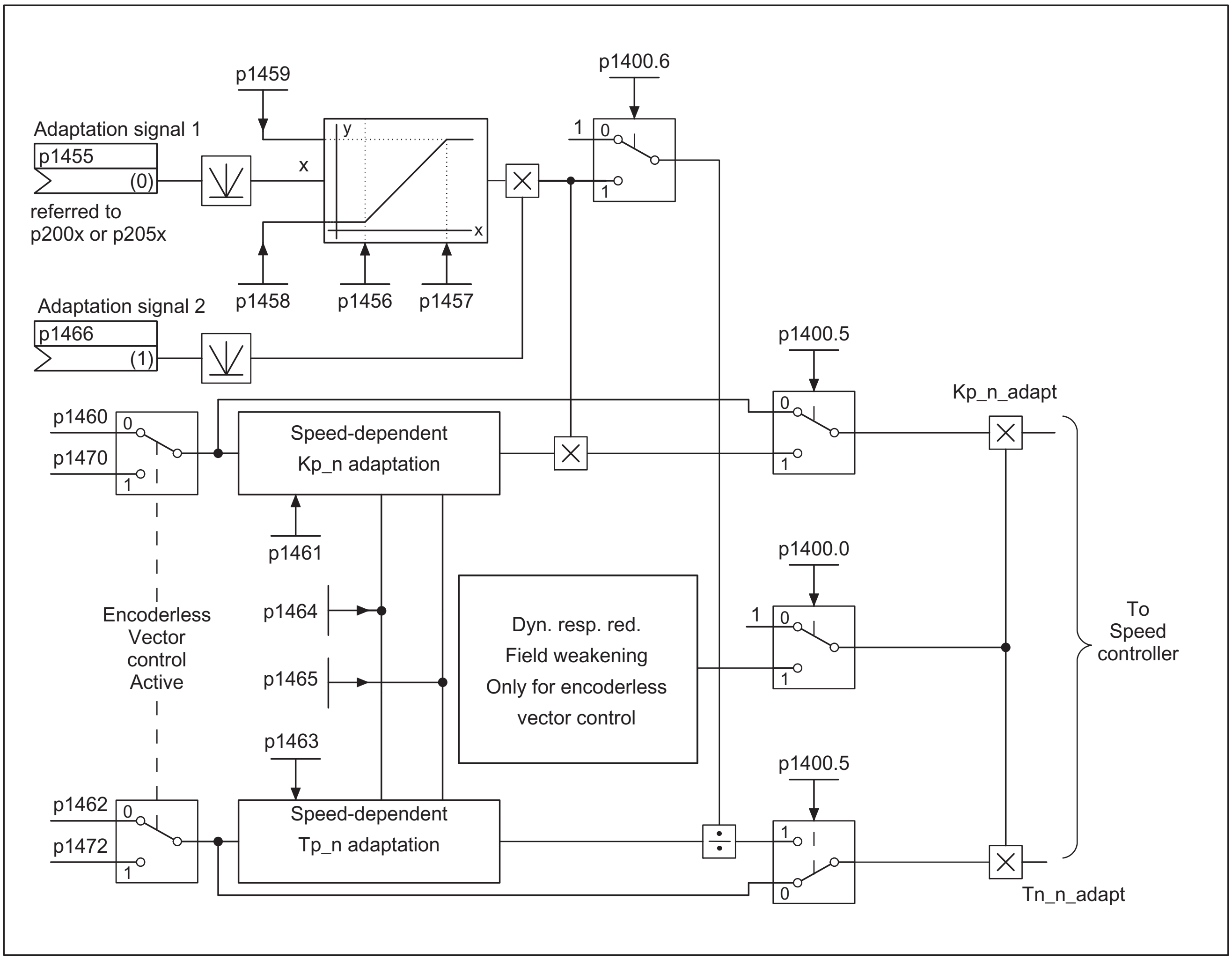


Figure 4-7 Kp_n-/Tn_n adaptation

Dynamic response reduction in the field-weakening range can be activated (p1400.0) with encoderless 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 when the drive is operated with an encoder!

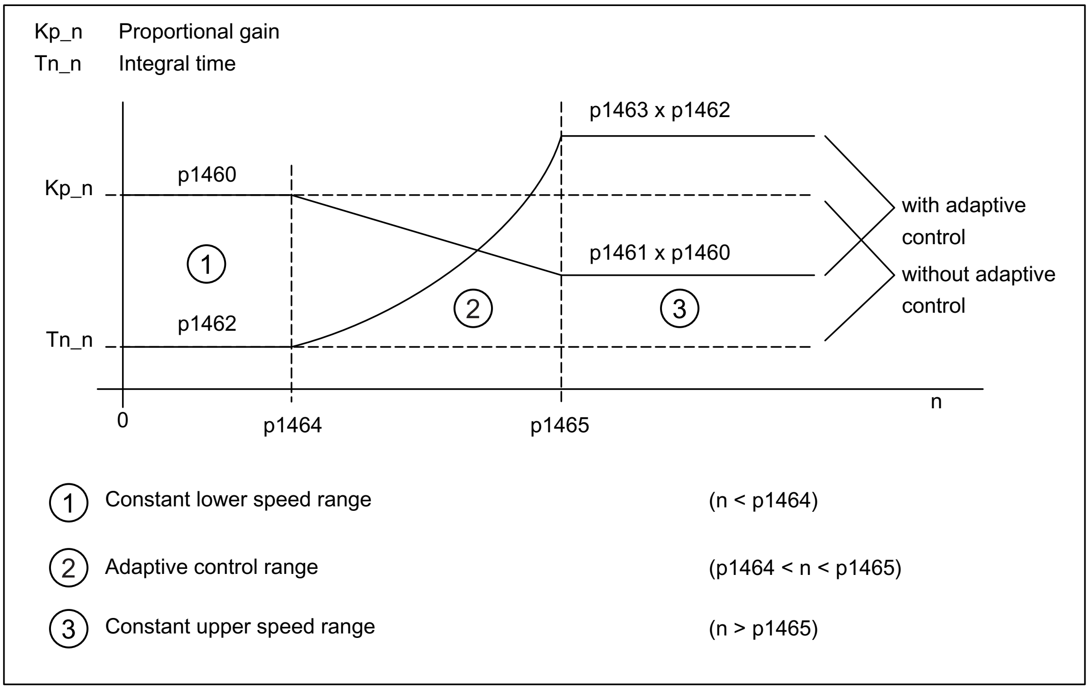


Figure 4-8 Speed controller Kp_n/Tn_n adaptation

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6050 Kp_n and Tn_n adaptation

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

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] Speed controller P gain adaptation upper starting point
- p1458[0...n] Lower adaptation factor
- p1459[0...n] Upper adaptation factor
- p1466[0...n] CI: Speed controller P gain scaling

Speed-dependent Kp_n/Tn_n adaptation (VC only)

- p1460[0...n] Speed controller P gain lower adaptation speed
- p1461[0...n] Speed controller Kp adaptation speed upper scaling
- p1462 Speed controller integral action time adaptation speed, lower
- p1463 Speed controller Tn adaptation speed upper scaling
- 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

Parameterization with STARTER

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

Figure 4-9 STARTER icon for "speed controller"

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.

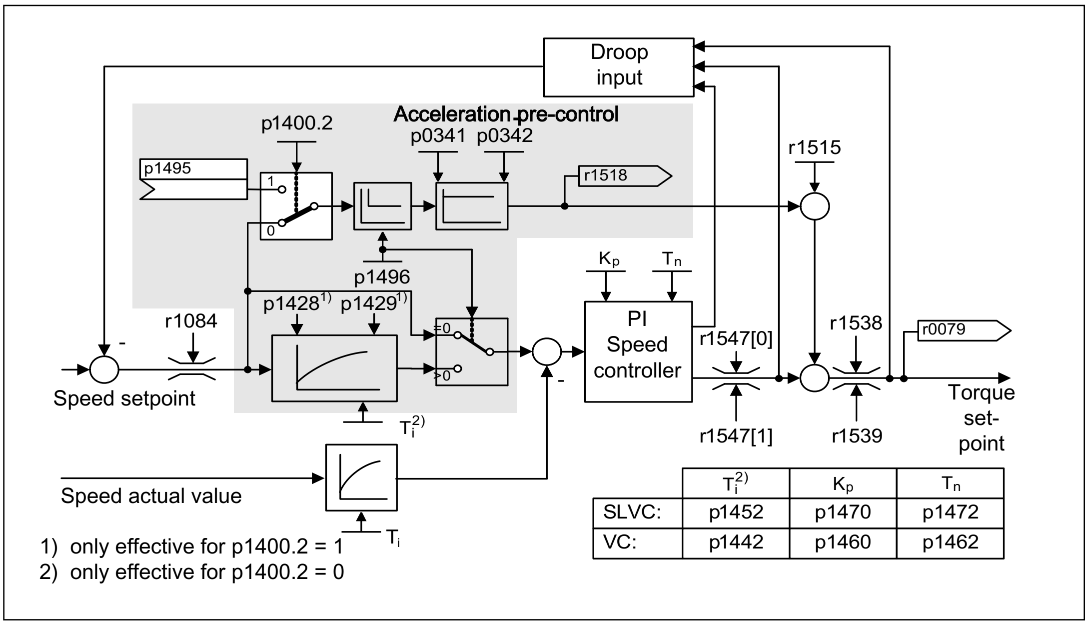


Figure 4-10 Speed controller with pre-control

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 ($n_{mot,rated}$).

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

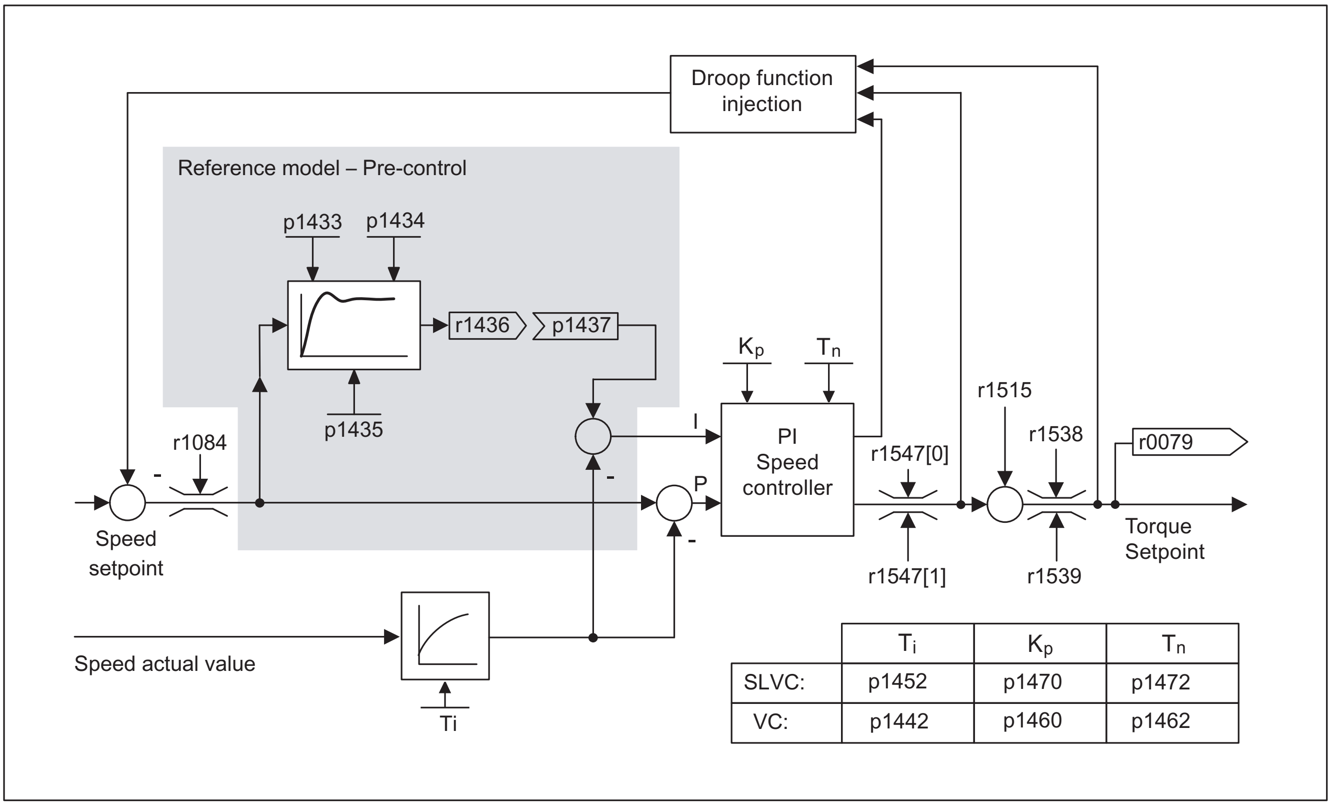
If these supplementary conditions are in line with the application, the starting time can be used as the lowest value for the ramp-up or ramp-down time.

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 4-11 Reference model

The reference model is activated with p1400.3 = 1.

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 S120/S150 List Manual)

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

Overview of important parameters (see SINAMICS S120/S150 List Manual)

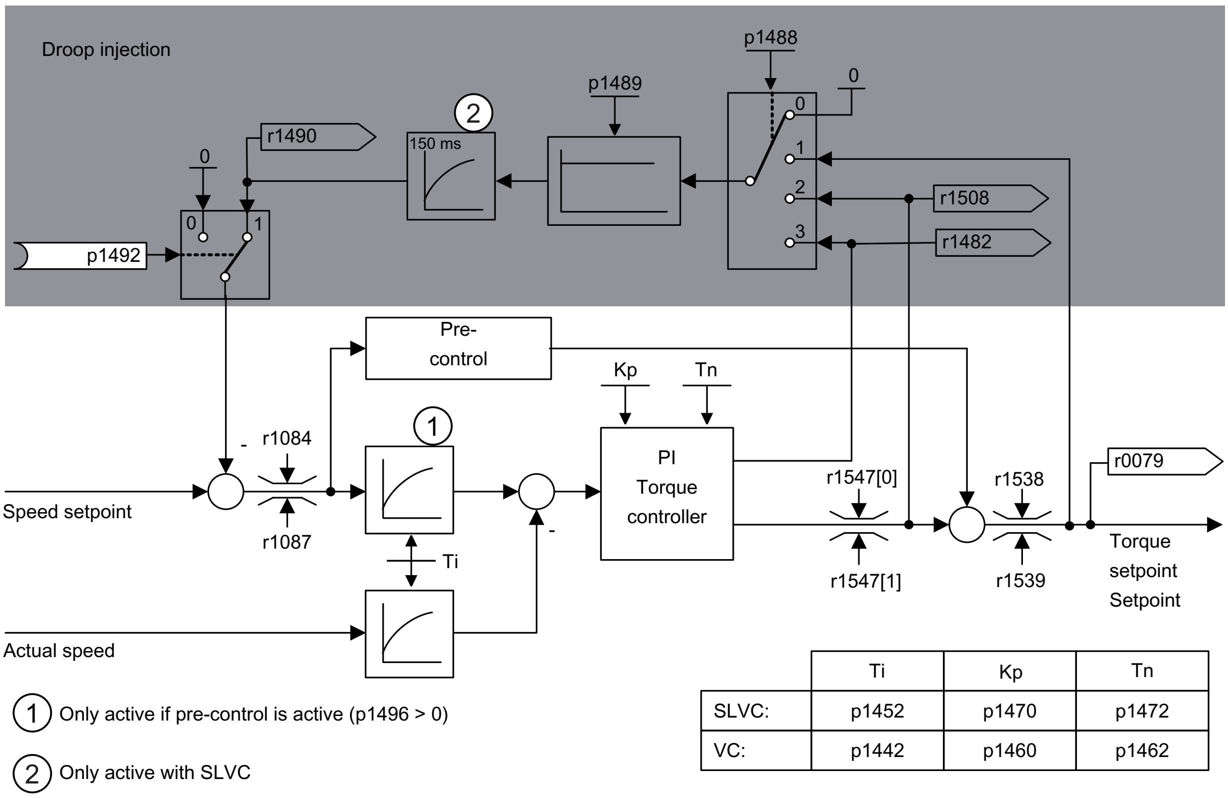
- p0311[0...n] Rated motor speed
- r0333[0...n] Rated motor torque
- p0341[0...n] Motor moment of inertia
- p0342[0...n] Ratio between the total moment of inertia and that of the motor
- r0345[0...n] Rated motor starting time
- p1400.2[0...n] Speed control configuration: Acceleration pre-control source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

Overview of important parameters (see SINAMICS S120/S150 List Manual) for the reference model

- p1400.3[0...n] Speed control configuration: 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 4-12 Speed controller with droop

The droop has a torque limiting effect on a drive that is mechanically coulped 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).

Preconditions

- All connected drives must be operated with vector control and speed control (with or without an encoder).
- Only one (1) common ramp-function generator may be used for mechanically coupled drives.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6030 Speed setpoint, droop, acceleration model

Overview of important parameters (see SINAMICS S120/S150 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 Open actual speed value

Description

The signal source for the actual speed value of the speed controller is specified via parameter p1440 (CI: speed controller actual speed value). The unsmoothed actual speed value r0063[0] has been preset as the signal source in the factory.

Depending on the machine, parameter p1440 can be used, for example, to switch on a filter in the actual value channel or feed in an external actual speed value.

Parameter r1443 is used to display the actual speed value present at p1440.

Note

When infeeding an external actual speed value, care should be taken that the monitoring functions continue to be derived from the motor model.

Behavior for speed control with an encoder (p1300 = 21)

A motor encoder must always be available for the speed or position signal of the motor model (e.g. evaluation via SMC, see p0400). The actual speed of the motor (r0061) and the position information for synchronous motors still come from this motor encoder and are not influenced by the setting in p1440.

Interconnection of p1440:
When interconnecting connector input p1440 with an external actual speed value, ensure the speed scaling is the same (p2000).

The external speed signal should correspond to the average speed of the motor encoder (r0061).

Behavior for speed control without an encoder (p1300 = 20)

Depending on the transmission path of the external speed signal, dead times will occur; these dead times must be taken into account in the speed controller's parameter assignment (p1470, p1472) and can lead to corresponding losses in the dynamic performance.
Signal transmission times must therefore be minimized.

p1750.2 = 1 should be set so that the speed controller is also able to work at standstill (closed-loop controlled operation to zero frequency for passive loads). Otherwise, at low speeds it switches over to speed-controlled operation, so that the speed controller is switched off and the measured actual speed no longer has an influence.

Monitoring of the speed deviation between motor model and external speed

The external actual speed (r1443) is compared with the actual speed of the motor model (r2169). If the deviation is greater than the tolerance threshold set in p3236, after the switch-off delay time set in p3238 expires, fault F07937 (Drive: Speed deviation motor model to external speed) is generated and the drive switched-off corresponding to the set response (factory setting: OFF2).

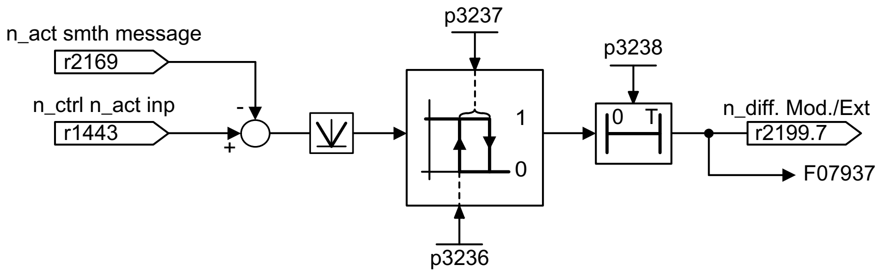


Figure 4-13 Monitoring "Speed deviation model / external in tolerance"

Function diagrams (see SINAMICS S120/S150 List Manual)

- FP 6040 Vector control – Speed controller with/without encoder
- FP 8012 Signals and monitoring function – Torque messages, motor locked/stalled

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0063[0...2] Speed actual value
- p1440 CI: Speed controller actual speed value
- p1443 CO: Actual speed value at speed controller actual speed value input
- r2169 CO: Actual speed value smoothed messages
- r2199.7 Speed deviation of model / external in tolerance
- p3236 Speed threshold value 7
- p3237 Hysteresis speed 7
- p3238 Switch-off delay n_act_motor model= n_act_external

4.8 Torque control

With sensorless speed control SLVC (p1300 = 20) or speed control with sensor VC (p1300 = 21), a changeover can be made to torque control (slave drive) via BICO parameter p1501. A changeover 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.

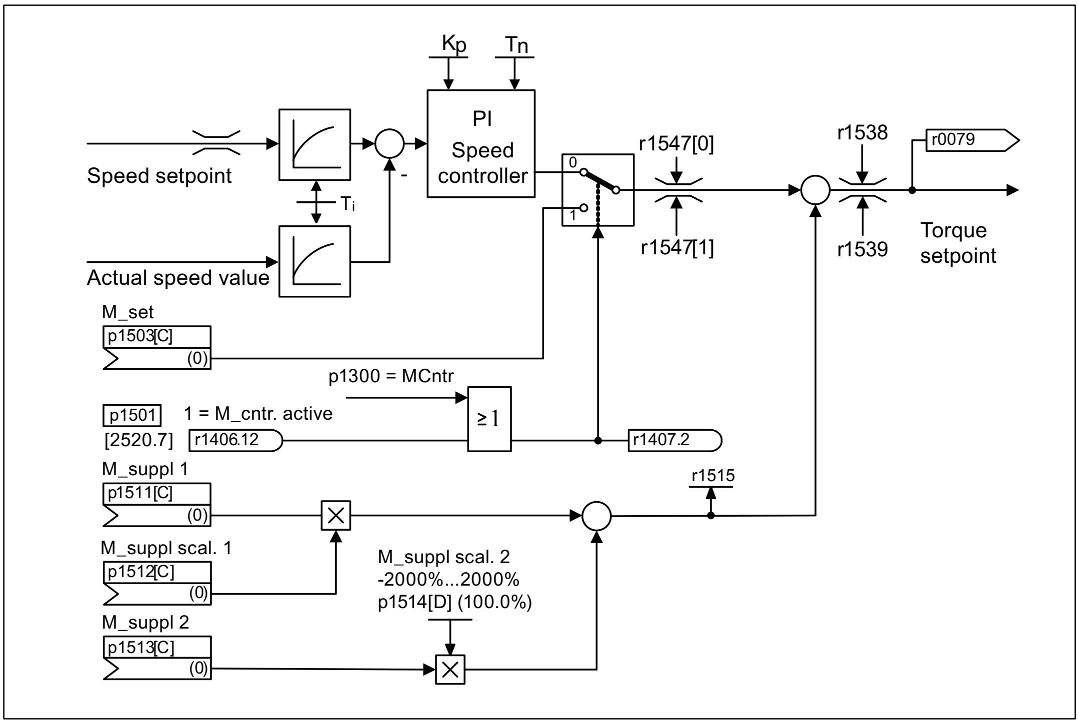


Figure 4-14 Closed-loop speed/torque control

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.

A "real" 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, encoderless 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.
  - Switching on inhibited is activated.
- OFF2
  - Immediate pulse suppression, the drive coasts to standstill.
  - The motor brake (if parameterized) is closed immediately.
  - Switching on inhibited 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.
  - Switching on inhibited is activated.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6060 Torque setpoint

Overview of important parameters (see SINAMICS S120/S150 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

4.9 Torque limiting

Description

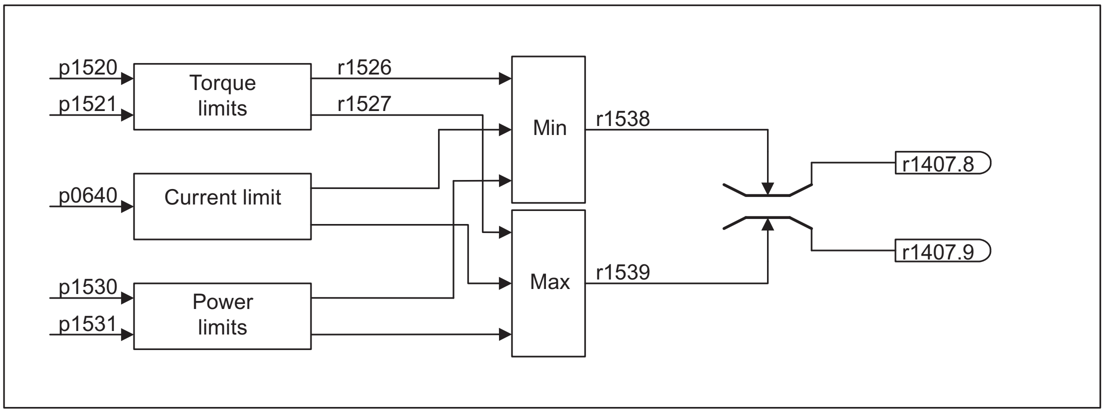


Figure 4-15 Torque limiting

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/regenerative 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 S120/S150 List Manual)

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

4.10 Vdc control

Description

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).

Note

You must observe the following for chopper operation:

- You must set the chopper threshold below the Vdc_max threshold

  and
- deactivate the Vdc_max controller.

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

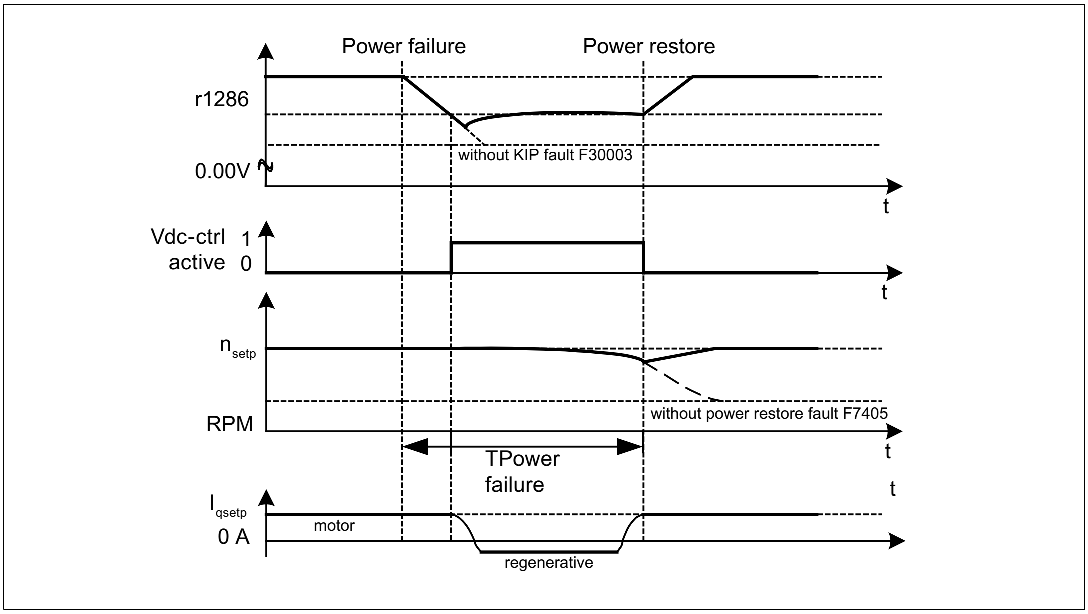


Figure 4-16 Switching Vdc_min control on/off (kinetic buffering)

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-in level. The motor continues operating normally.

If the power supply is not re-established, 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 re-established, 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

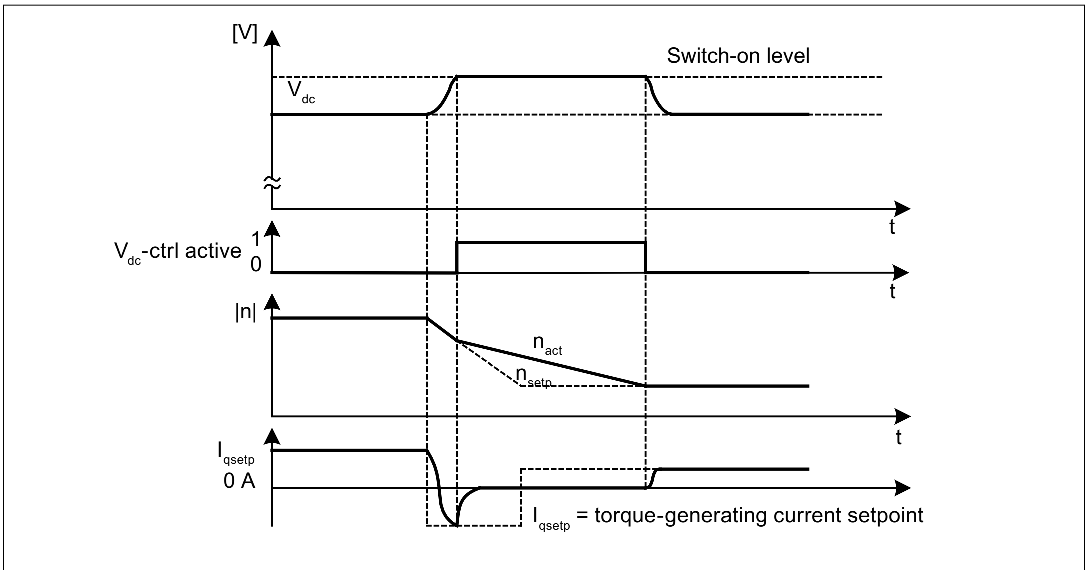


Figure 4-17 Switching Vdc_max control on/off

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

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

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6220 Vdc_max controller and Vdc_min controller

Overview of important parameters (see SINAMICS S120/S150 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 (ctrl)

4.11 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 S120/S150 List Manual)

- 6710 Current setpoint filters

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

4.12 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. The current controller adaptation is directly activated with setting p1402.2 = 1 or deactivated with p1402.2 = 0. It is automatically activated with p1959.5 (p1959.5 = 1) or deactivated (p1959.5 = 0).

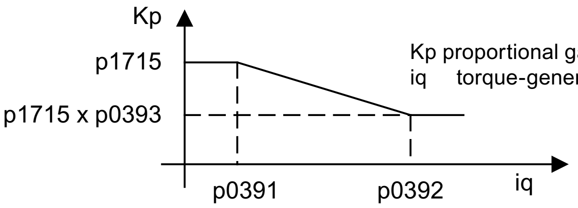


Figure 4-18 Current controller adaptation for p0393 < 1, with p0391 < p0392

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

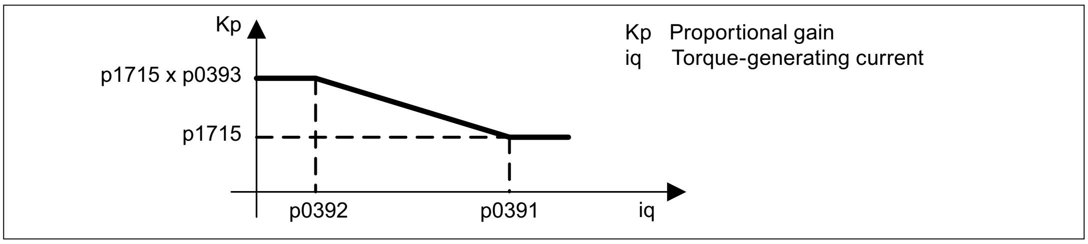


Figure 4-19 Current controller adaptation with swapped iq interpolation points for p0393 > 1, with p0392 < p0391

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6710 Current setpoint filters
- 6714 Iq and Id controller

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0391 Current controller adaptation starting point KP
- p0392 Current controller adaptation starting point KP adapted
- p0393 Current controller adaptation P gain scaling
- p1402[0...n] Closed-loop current control and motor model configuration
- p1703 Isq current controller pre-control scaling
- p1715 Current controller P gain
- p1717 Current controller integral time
- p1959[0...n] Rotating measurement configuration

4.13 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 Off 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 rating plate is used. For this reason, the stator resistance is a very important for the stability of sensorless vector control or for the voltage boost in the V/f curve. 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 are determined with p1910 on the basis of the data on the rating plate:

Table 4- 2 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 rating 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.

It is advisable to enter the motor supply cable resistance (p0352) before the standstill measurement (p1910) is performed, so that it can be subtracted from the total measured resistance when the stator resistance is calculated (p0350).

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 encoderless vector control.

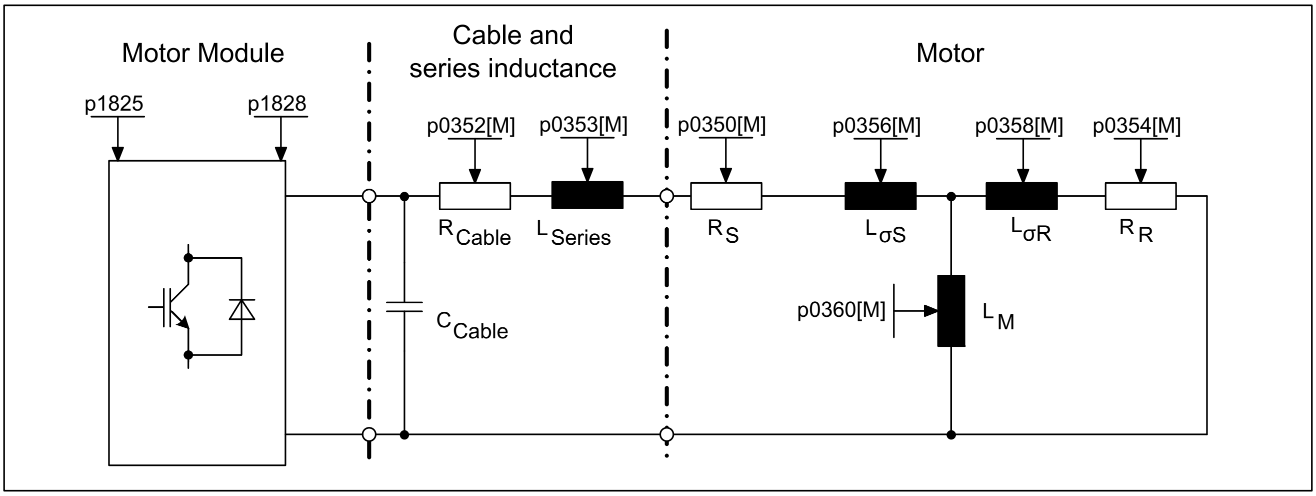


Figure 4-20 Equivalent circuit diagram for induction motor and cable

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 sine-wave 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.

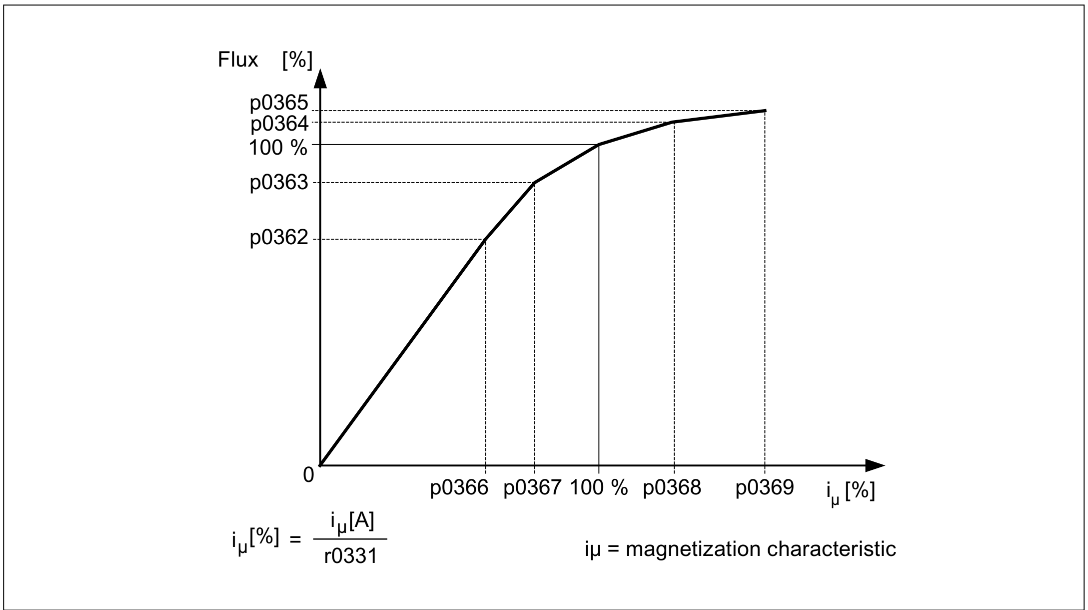


Figure 4-21 Magnetization characteristic

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).
  The saturation characteristic recording is automatically deactivated in parameter p1959 during the speed optimization run.

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.

⚠ DANGER

During speed controller optimization, the drive triggers movements in the motor that can reach the maximum motor speed. The Emergency Off 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 important parameters (see SINAMICS S120/S150 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

4.14 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

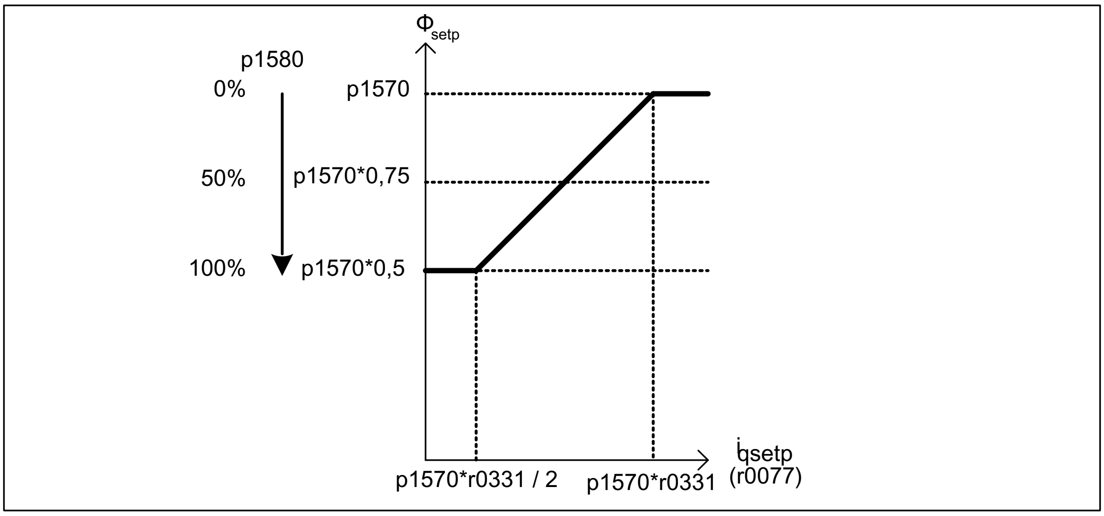


Figure 4-22 Efficiency optimization

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 S120/S150 List Manual)

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

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

4.15 Quick magnetization for induction motors

Description

Application example for the "quick magnetization for induction motors" function: In crane applications, a frequency converter is often used to operate a number of motors alternately. Following a changeover to a different motor, a new data set must be loaded in the frequency converter and the motor magnetized. This can result in excessive waiting times, which can be significantly reduced by means of quick magnetization.

Features

- Application for induction motors in closed-loop vector control.
- Fast flux build-up through injection of a field-generating current at the current limit, resulting in a significant reduction in magnetizing time.
- The "flying restart" function continues working with parameter p0346 (magnetization time).
- Magnetization is not dependent on a brake configuration (p1215) as it is with servo drives.

Commissioning

Parameter p1401.6 = 1 (flux control configuration) is set in order to activate quick magnetization.

This setting initiates the following sequence during motor starting:

- The field-producing current setpoint jumps to its limit value: 0.9 * r0067 (I_{max}).
- The flux increases as fast as physically possible with the specified current.
- The flux setpoint r0083 is made to follow accordingly.
- As soon as the flux threshold value programmed in p1573 is reached (min.: 10% and max. 200%, factory setting 100%), excitation is ended and the speed setpoint is enabled. The flux threshold value must not be set too low for a large load because the torque-producing current is limited during magnetization.

Note

The flux threshold value set in parameter p1573 is effective only if the actual flux during magnetization reaches the value programmed in p1573 before the timer set in p0346 runs down.

- The flux is increased further until the flux setpoint in p1570 has been reached.
- The field-producing current setpoint is reduced by means of a flux controller with P gain (p1590) and the parameterized smoothing factor (p1616).

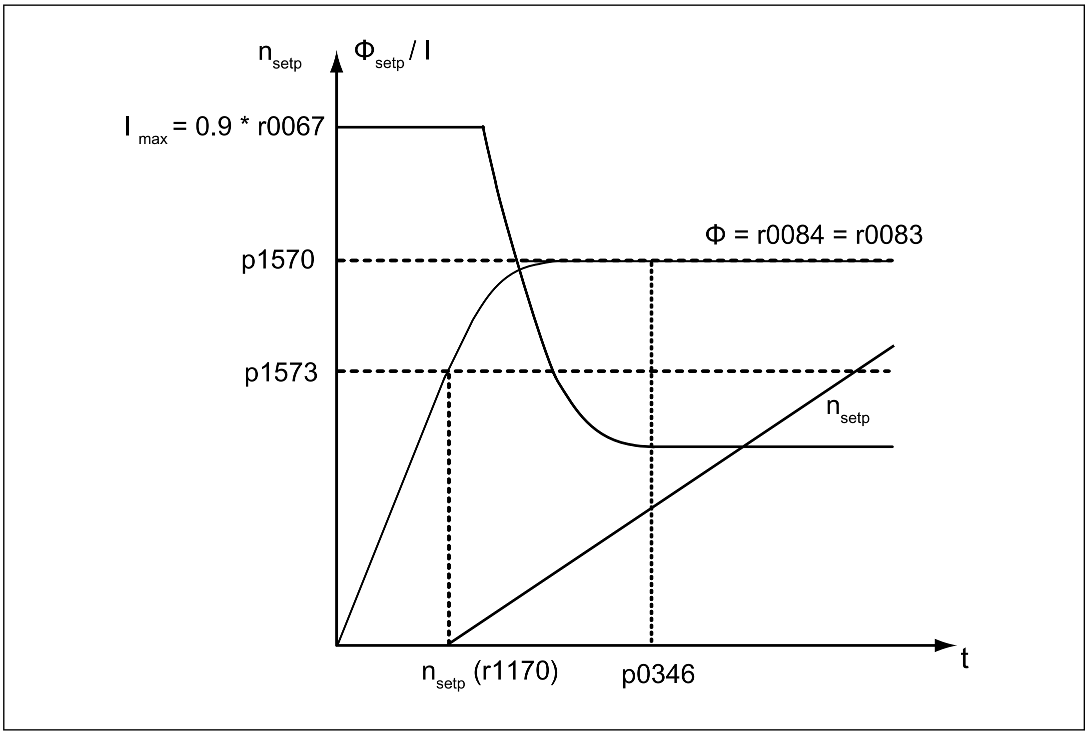


Figure 4-23 Quick magnetization characteristics

Notes

When quick magnetization is selected (p1401.6 = 1), smooth starting is deactivated internally and alarm A07416 displayed.

When the stator resistance identification function is active (see p0621 "Identification of stator resistance after restart") is active, quick magnetization is deactivated internally and alarm A07416 displayed.

The parameter does not work when combined with the "flying restart" function (see p1200), i.e. flying restart is performed without quick magnetization.

Alarms and fault messages

A07416 Drive: Flux controller configuration

When a function controlled by parameter p1401 (flux controller configuration) and p0621 (identification of stator resistance after restart) is activated, the system checks whether any other incompatible function is already selected. If this is the case, alarm A07416 is displayed with the number of the parameter which is incompatible with the configuration parameter, i.e. p0621 or p1401.

As these are data-set-dependent parameters (p1401 is DDS-dependent and p0621 MDS-dependent), the number of the data set is also specified in the alarm value.

The flux control configuration (p1401) settings are inconsistent.
Fault codes:
1 = quick magnetization (p1401.6) and smooth starting (p1401.0)
2 = quick magnetization (p1401.6) and flux build-up control (p1401.2)
3 = quick magnetization (p1401.6) and Rs identification (stator resistance identification) after restart (p0621 = 2)

Remedy:
For fault code 1:

- Deactivate smooth starting: p1401.0 = 0
- Deactivate quick magnetization: p1401.6 = 0

For fault code 2:

- Activate flux build-up control: p1401.2 = 1
- Deactivate quick magnetization: p1401.6 = 0

For fault code 3:

- Change Rs identification parameter settings: p0621 = 0, 1
- Deactivate quick magnetization: p1401.6 = 0

F07411 Drive: Flux controller output limited

If the current limit p0640[D] is set very low (below the rated magnetization current value in p0320[M]), the parameterized flux setpoint p1570 [D] might not be reached at all.

In this case, fault F07411 is displayed as soon as the period set in p0346 (magnetization time) is exceeded. This is generally significantly longer than the flux build-up time associated with quick magnetization.
Reaction: OFF2
Acknowledgement: Immediately

Cause: With quick magnetization configured (p1401.6 = 1), the specified flux setpoint is not reached even though the current setpoint = 90 % of maximum current.

- Motor data are incorrect.
- Motor data and motor connection type (star/delta) do not match.
- Current limit in p0640 is set too low for the motor concerned.
- Induction motor (encoderless, open-loop control) at I2t limit.
- Motor Module rating is too low.

Remedy:

- Correct the motor data.
- Check the motor connection type.
- Correct the current limits (p0640).
- Reduce the load on the induction motor.
- Use a larger Motor Module if necessary.
- Check the motor supply cable.
- Check the power unit.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6491 Flux control configuration
- 6722 Field weakening characteristic, Id setpoint (ASM, p0300 = 1)
- 6723 Field weakening controller, flux controller (ASM, p0300 = 1)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0320 [0...n] Motor rated magnetizing current/short-circuit current
- p0346 Motor excitation build-up time
- p0621[0...n] Identification of stator resistance after restart
- p0640[0...n] Current limit
- p1401[0...n] Flux control configuration
- p1570[0...n] CO: Flux setpoint
- p1573[0...n] Flux threshold value magnetizing
- p1590[0...n] Flux controller P gain
- p1616[0...n] Current setpoint smoothing time

4.16 Instructions for commissioning induction motors (ASM)

Equivalent circuit diagram for induction motor and cable

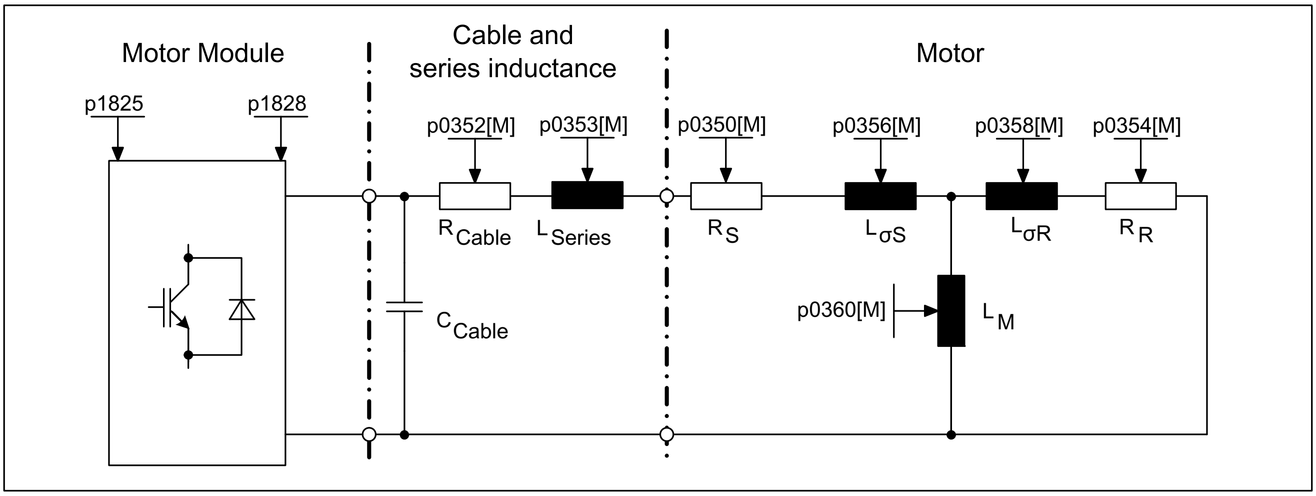


Figure 4-24 Equivalent circuit diagram for induction motor and cable

Induction motors, rotating

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

Table 4- 3 Motor data rating 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- 4 Optional motor data

Parameter	Description	Remark
p0320	Motor rated magnetization current/short-circuit current	-
p0322	Maximum motor speed	-
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)	• Especially for vector control without encoder (SLVC) this parameter has a significant influence on the quality of the closed-loop control at low speeds • This parameter is required for the correct function of flying restart operating mode.
p0353	Motor series inductance	-

Table 4- 5 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 supplementary conditions).
- Flying restart
- Vector closed-loop speed and torque control
- Vector V/f control
- 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 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.

4.17 Instructions for commissioning permanent-magnet synchronous motors

Equivalent circuit diagram for synchronous motor and cable

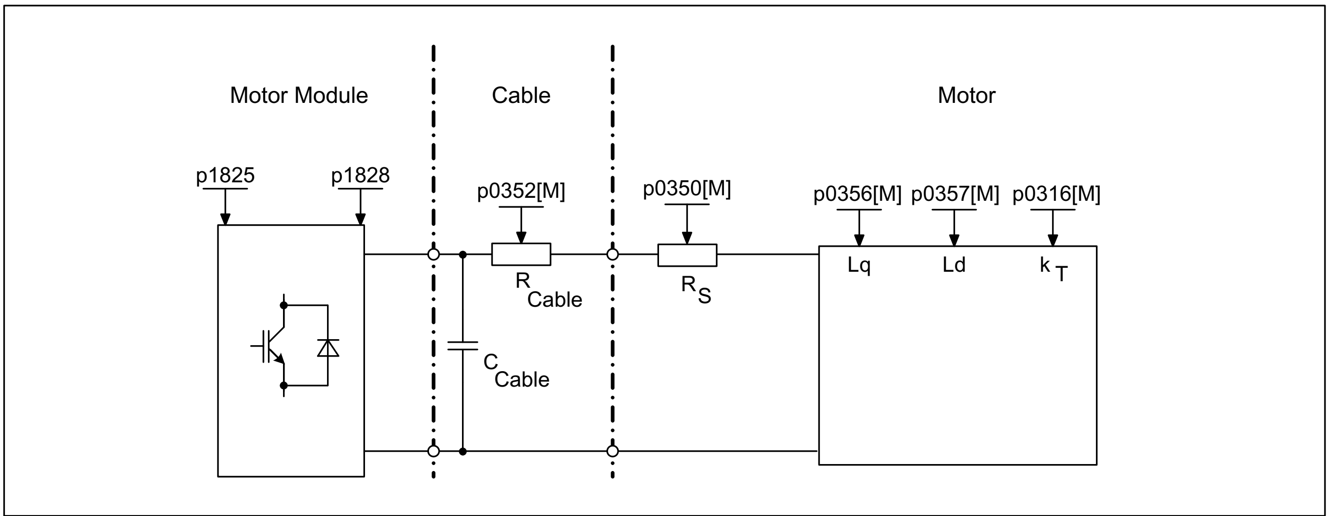


Figure 4-25 Equivalent circuit diagram for synchronous motor and cable

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- 6 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 (index n) or from the stall current I_o and stall torque M_o as follows:

$$k_T = \frac{M_N}{I_N} = \frac{P_N}{2\pi \cdot \frac{min}{60} n_N \cdot I_N} \quad \text{or} \quad k_T = \frac{M_o}{I_o}$$

Table 4- 7 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- 8 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 supplementary conditions)
- 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:

$$n_{max} = n_N \cdot \sqrt{\frac{3}{2}} \cdot \frac{V_{DC,lim} \cdot I_N}{P_N}$$

or

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

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

Figure 4-26 Formula vector maximum speed

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 first 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.

4.17.1 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, DRIVE-CLiQ encoder, 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.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

4.17.2 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.

Overview of important parameters (see SINAMICS S120/S150 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
- 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

4.18 Instructions for commissioning separately-excited synchronous motors

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Note

Separately excited synchronous motor

Please consult Siemens technical support if you wish to commission a separately-excited synchronous motor.

4.19 Flying restart

Description

After power ON, the "flying restart" function automatically connects a Motor Module to a motor which may already be turning. This function can be activated during operation and without encoder.

The "Flying restart" function should be activated via p1200 for loads which may coast after power interruption. 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 document: SINAMICS S120 Manual Control Units).

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.

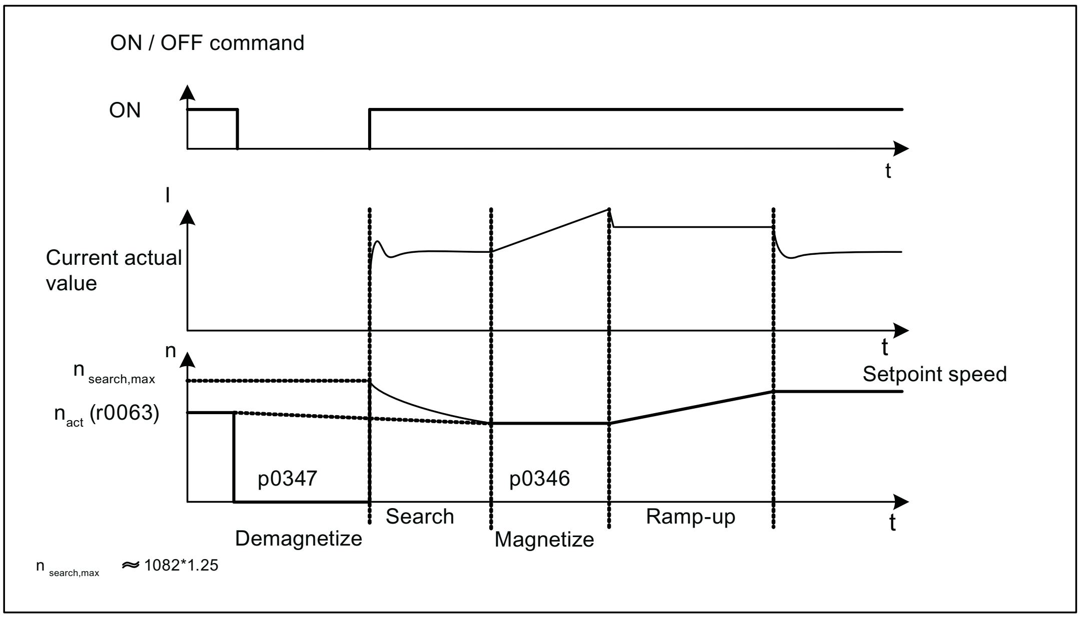


Figure 4-27 Flying restart, example of induction motor without encoder

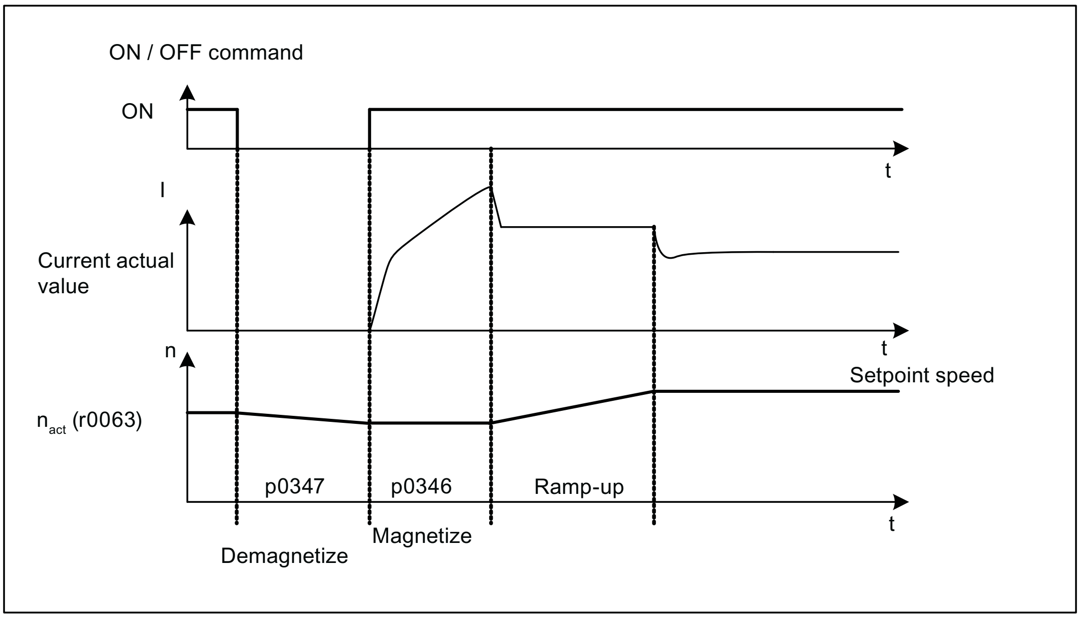


Figure 4-28 Flying restart, example of induction motor with encoder

> ⚠ **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.

Flying restart in encoderless operation for long cables

As a rule, it is important to consider the cable resistance. The cable resistance is required for calculation of the thermal motor model.

Enter the cable resistance in parameter p0352 before you carry out motor identification. Set parameter p1203[0...n] to at least 300%. This operation can take a little longer than for the factory setting (100%). Flying restart for long cables is optimized by changing the flying restart algorithm.

Note

Flying restart for long cables

Use a trace recording to check and optimize the flying restart function. If necessary, optimize the settings of parameters p1202 and p1203.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0352[0...n] Cable resistance
- p1082[0...n] Maximum speed
- p1200[0...n] Flying restart operating mode
- p1202[0...n] Flying restart search current
- p1203[0...n] Flying restart search rate factor
- r1204.0...13 CO/BO: Flying restart, U/f control status
- r1205.0...15 CO/BO: Flying restart, vector control status

4.20 Synchronization

Features

- For the vector mode
- For induction motors without encoder
- Line supply sensing using the Voltage Sensing Module (VSM10) connected to 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, the converter phase angle can be synchronized with the line phase angle in order, for example, to switch over (bypass) directly to the mains supply afterwards. 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. With internal actual voltage sensing (p3800 = 1), the voltage setpoints of the electrical motor model are used for the synchronization. For external actual voltage sensing (p3800 = 0), the voltage is sensed using a VSM, which is connected to the line phases. The voltage values must be transferred to the synchronization via connectors r3661 and r3662.

Prerequisite

- Drive object, INFEED or VECTOR with connected VSM10
- Induction motor without encoder
- Vector control

Function diagrams (see SINAMICS S120/S150 List Manual)

- 7020 Synchronization

Overview of important parameters (see SINAMICS S120/S150 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

4.21 Voltage Sensing Module

Description

The Voltage Sensing Module (VSM) must be used for the following applications in control types vector and V/f:

- Synchronization
  With the "synchronization" function, the converter phase angle can be synchronized with the line phase angle in order, for example, to switch over (bypass) directly to the mains supply afterwards. A further 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 switching off the plant.
  For external actual voltage sensing (p3800 = 1), the voltage is sensed using a VSM which is connected to the line phases. The voltage values must be transferred to the synchronization via connectors r3661 and r3662.
- Flying restart
  After power ON, the "flying restart" function automatically connects a Motor Module to a motor which may already be turning.
  In operation without an encoder, a search is carried out first for the current speed. The search starts at the maximum speed plus 25 %.
  This function requires a Voltage Sensing Module (VSM) for permanent-magnet synchronous motors (for additional information, refer to document: SINAMICS S Manual Control Units).

The VSM is used on the encoder side for SINAMICS S120 drives. In this case, it must always be used as a substitute for the motor encoder and is therefore inserted at the motor encoder position in the topology.

Topology view

The VSM is only used at the VECTOR drive object in sensorless operating modes. For this reason, the VSM is linked into the topology at the position at which a motor encoder would normally be connected.

VSM commissioning using STARTER

The VSM for the VECTOR drive object is selected in STARTER using the drive wizard. As the VSM is not assigned to the encoder data sets (EDS), it cannot be selected on the encoder side. The component number of the VSM from the current topology must be entered in parameter p0151[0,1]. This parameter assigns the VSM data set to a VSM evaluation routine. With parameter p0155[0...n] "Activate/deactivate Voltage Sensing Module", it is possible to activate or deactivate the VSM explicitly as a topology component.

VSM parameters are independent of the SINAMICS data set model. A maximum of two VSMs may be used for each VECTOR drive object, i.e. two VSM data sets are available.

Identification via LED and firmware version

VSM identification via LED is activated in parameter p0154 on the VECTOR drive object.

When p0154 = 1, the LED READY on the relevant VSM flashes green/orange or red/orange at a frequency of 2 Hz.

The firmware version of the VSM can be displayed using parameter p0158[0,1] on the VECTOR drive object.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 7020 Synchronization
- 9880 VSM analog inputs
- 9886 VSM temperature evaluation
- 9887 VSM sensor monitoring KTY/PTC

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p3800[0...n] Sync-line-drive activation
- p3801[0...n] Sync-line-drive object number

Drive object A_INF

- p0140 VSM number of data sets
- p0141[0...n] VSM component number
- p0144[0...n] Voltage Sensing Module identification via LED
- p0145[0...n] Activate/deactivate Voltage Sensing Module
- r0146[0...n] Voltage Sensing Module active/inactive
- r0147[0...n] Voltage Sensing Module EPROM data version
- r0148[0...n] Voltage Sensing Module firmware version

VECTOR drive object

- p0151[0...n] Voltage Sensing Module component number
- p0154[0...n] Voltage Sensing Module identification via LED
- p0155[0...n] Activate/deactivate Voltage Sensing Module
- p0158[0...n] Voltage Sensing Module firmware version

4.22 Simulation mode

4.22.1 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 encoderless 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. IThis is implemented using V/f control or encoderless closed-loop speed control.

Note

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

4.22.2 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.

4.22.3 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).

4.23 Redundance operation power units

Features

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

Description

Redundancy mode can be used so that operation can be continued in spite of the failure of one power unit connected in parallel.

Note

Despite this redundancy circuit, the entire plant may shut down when defects develop in one power unit (feedback effects due to absence of electrical isolation).

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 or DME20). 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.

Preconditions

- Parallel connection only works with equivalent (order number) chassis power units.
- Maximum number of parallel power units is 4
- Parallel connection of power units with suitable power reserves
- DRIVE-CLiQ star topology (possibly a DMC20 or a DME20, refer to the Equipment Manual)
- Motor with one single-winding system (p7003 = 0)
- No safe standstill

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

4.24 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 is started up again after POWER ON, the status 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 for operation 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 encoderless 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.

4.24.1 Bypass with synchronization with overlap

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%.

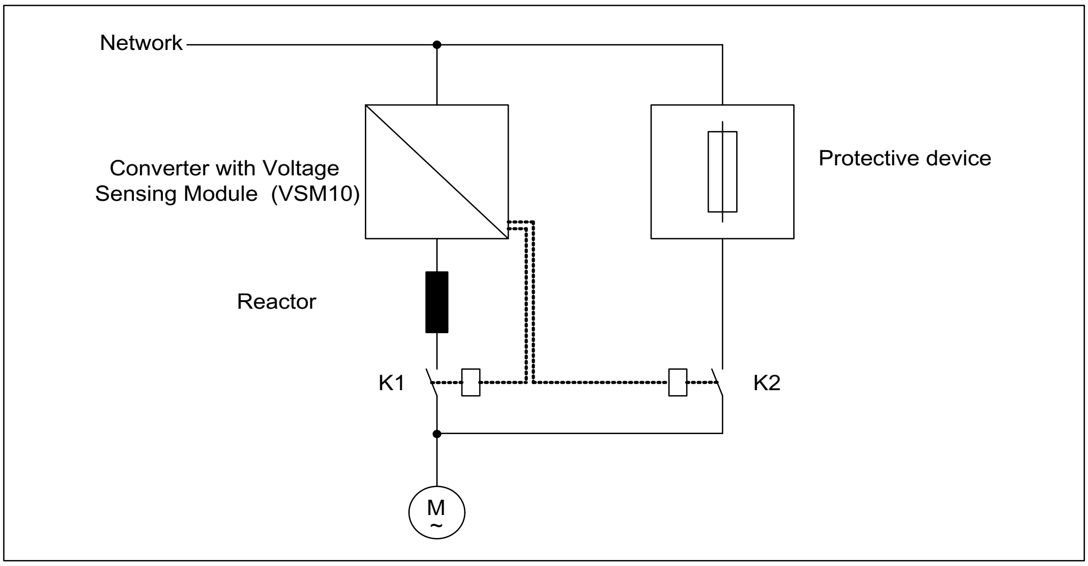


Figure 4-29 Circuit example: Bypass with synchronization with overlap

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- 9 Parameter setting for bypass function with synchronization with overlap

Parameter	Description
r1261.0 =	Control signal for contactor K1
r1261.1 =	Control signal for contactor K2
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.

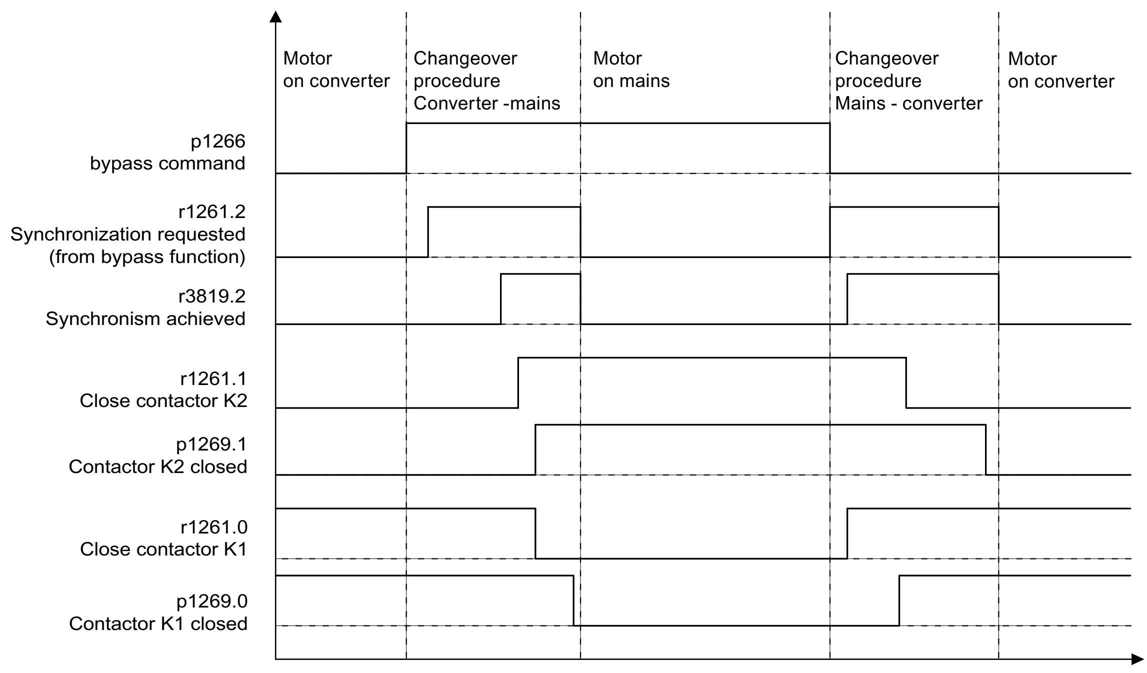


Figure 4-30 Signal diagram, bypass with synchronization with overlap

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.

4.24.2 Bypass with synchronization without overlap

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.

In order for the function to run correctly, the moment of inertia must be sufficiently high.

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

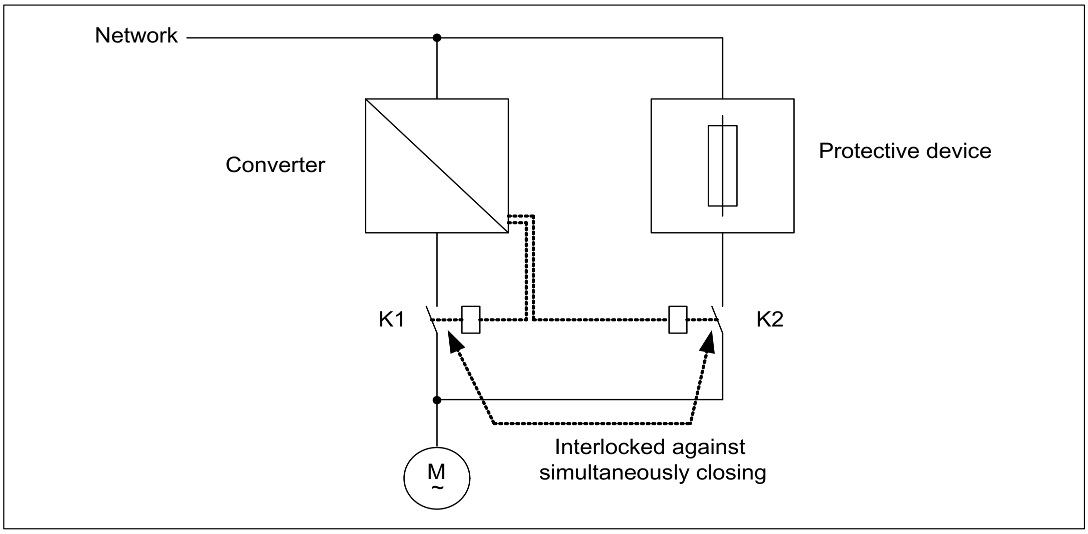


Figure 4-31 Circuit example, bypass with synchronization without overlap

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- 10 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.

4.24.3 Bypass without synchronization

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).

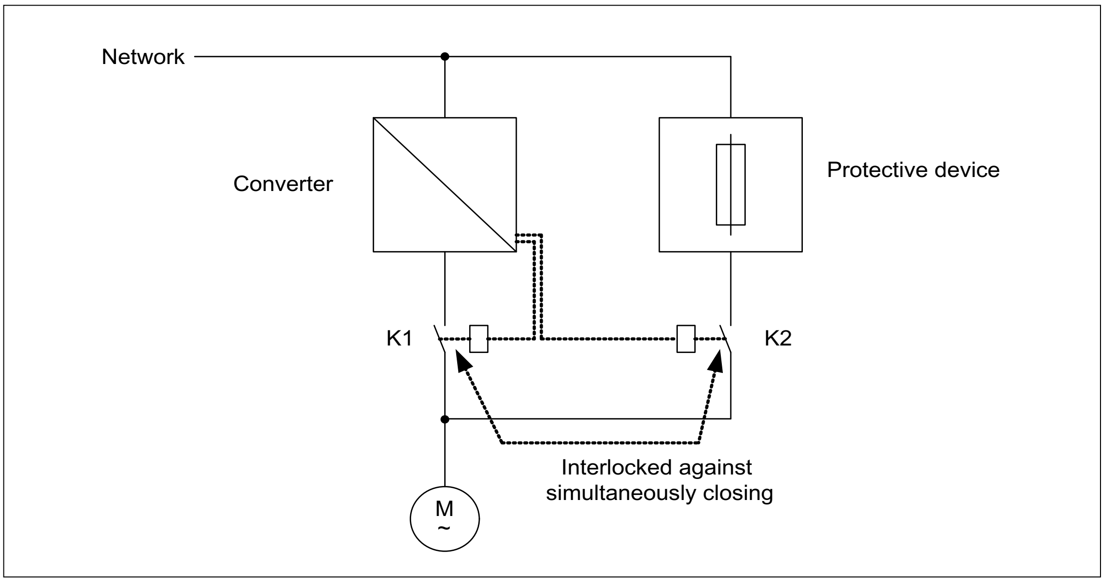


Figure 4-32 Circuit example, bypass without synchronization

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- 11 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 S120/S150 List Manual)

- 7020 Synchronization

Overview of important parameters (see SINAMICS S120/S150 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

U/f control 5

The U/f control characteristic is the simplest way to control an induction motor. When configuring the drive using the STARTER commissioning tool, U/f control is activated in the "Closed-loop control structure" screen (also see p1300).

The stator voltage of the induction motor is set proportional to the stator frequency. This technique is used for many standard applications where the dynamic performance requirements are low, for example:

- Pumps
- Fans
- Belt drives

U/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 (V) to frequency (f).

Φ ~ Iμ ~ U/f

The torque (M) generated by an induction motor is proportional to the product of the flux and current (the vector product Φ x I).

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). U/f characteristic control is derived from these basic premises.

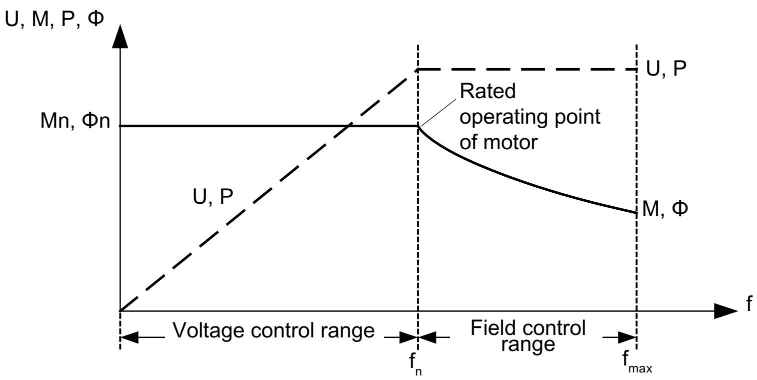
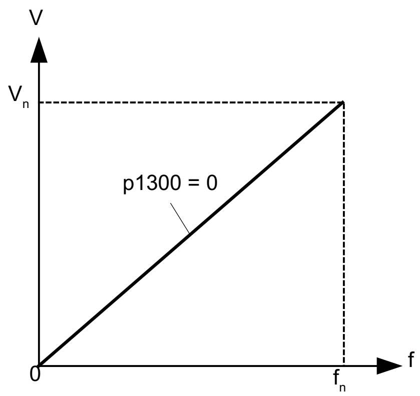
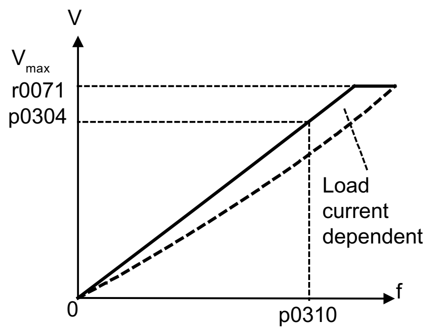
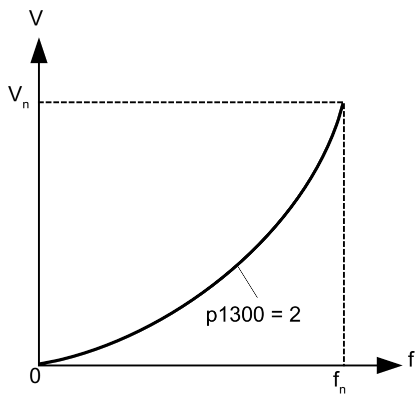
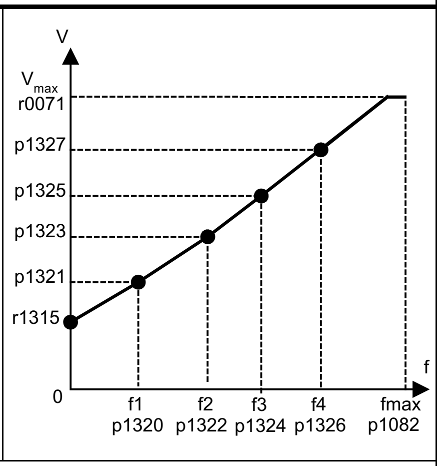


Figure 5-1 Operating areas and characteristic curves for the induction motor with converter supply

Several variations of the U/f characteristic exist, which are shown in the following table:

Table 5- 1 U/f characteristic (p1300)

Parameter values	Meaning	Application / property	
0	Linear characteristic	Standard (w/o voltage boost)	
1	Linear characteristic with flux current control (FCC)	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.	
2	Parabolic characteristic	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.	

Parameter values	Meaning	Application / property
3	Programmable characteristic	Characteristic that takes into account motor/machine torque curve (e.g. synchronous motor). 
4	Linear characteristic and ECO	Characteristic, see parameter 0 and Eco mode at a constant operating point. • In the Eco mode, the efficiency at a constant operating point is optimized. This optimization is only effective in steady-state operation and when the ramp-function generator is not bypassed. • You must activate slip compensation and set the scaling of the slip compensation (p1335) so that the slip is completely compensated (generally, 100%).
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 function is required for small motors, as, in comparison to large motors, they have a relatively high stator resistance.
7	Parabolic characteristic and ECO	Characteristic, see parameter 1 and Eco mode at a constant operating point. • In the Eco mode, the efficiency at a constant operating point is optimized. This optimization is only effective in steady-state operation and when the ramp-function generator is not bypassed. • You must activate slip compensation and set the scaling of the slip compensation (p1335) so that the slip is completely compensated (generally, 100%).
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]).

Function diagram

- FP 6300 U/f characteristic and voltage boost

Parameter

- p1300[0...n] Open-loop/closed-loop control operating mode

5.1 Voltage boost

According to the V/f characteristic, at an output frequency of 0 Hz, the control supplies an output voltage of 0 V. This means that at 0 V, the motor cannot generate any torque. The voltage booster function is used to

- magnetize an induction motors at n = 0 rpm,
- establish a torque at n = 0 rpm, e.g. in order to hold a load,
- generate a breakaway, acceleration or braking torque,
- compensate ohmic (resistive) losses in the windings and feeder cables.

Three types of voltage boost can be selected:

1. Permanent voltage boost with p1310
2. Voltage boost only while accelerating with p1311
3. Voltage boost only while first starting with p1312

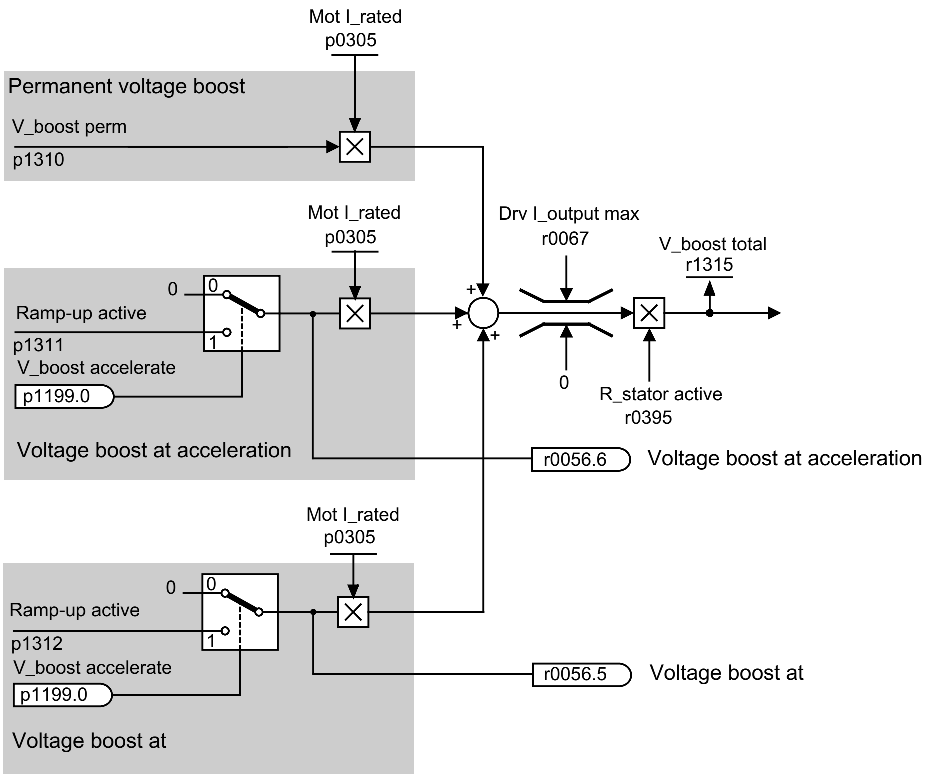


Figure 5-2 Voltage boost total

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.

Voltage boost, permanent

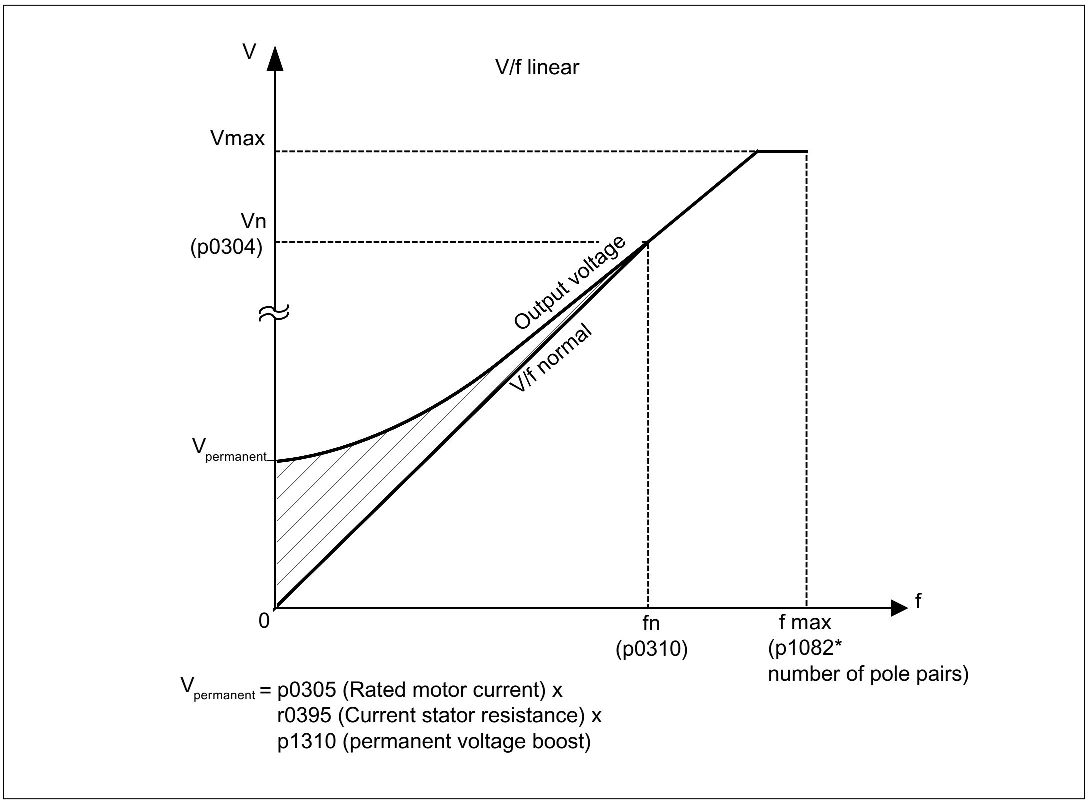


Figure 5-3 Permanent voltage boost (example: p1300 = 0 and p1310 > 0)

Voltage boost while accelerating

Voltage boost at acceleration is effective if the ramp-function generators provide the feedback signal "ramp-up active" (r1199.0 = 1).

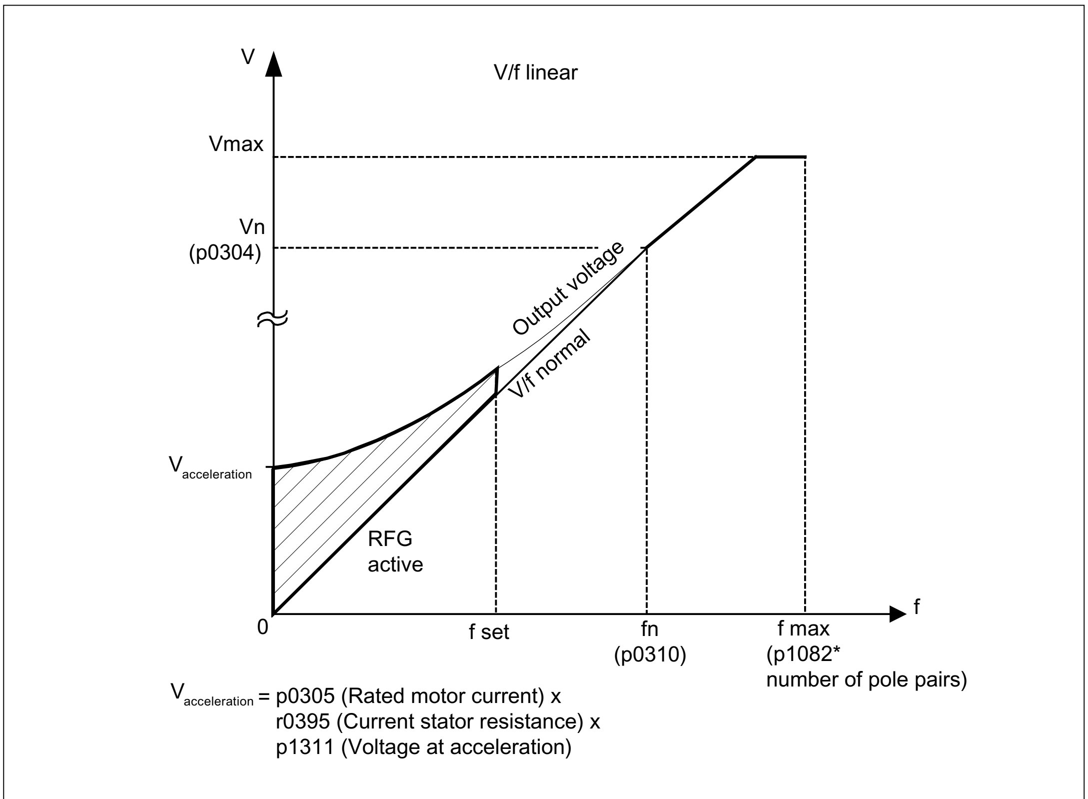


Figure 5-4 Voltage boost at acceleration (example: p1300 = 0 and p1311 > 0)

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6300 V/f characteristic and voltage boost

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0304[0...n] Rated motor voltage
- p0305[0...n] Rated motor current
- r0395[0...n] Stator resistance current
- p1300[0...n] Open-loop/closed-loop control operating mode
- p1310[0...n] Voltage boost permanent
- p1311[0...n] Voltage boost at acceleration
- r1315 Voltage boost total

5.2 Slip compensation

Description

The slip compensation ensures that the motor setpoint speed n_{set} of induction motors is essentially kept constant independent of the load. For a load step from M1 to M2, the setpoint frequency should be automatically increased, so that the resulting frequency and therefore the motor speed is kept constant. When the load decreases from M2 to M1, then the setpoint frequency is automatically reduced.

If a motor holding brake is used, a setting value can be specified at the slip compensation output via p1351. A parameter setting of p1351 > 0 automatically activates the slip compensation (p1335 = 100%).

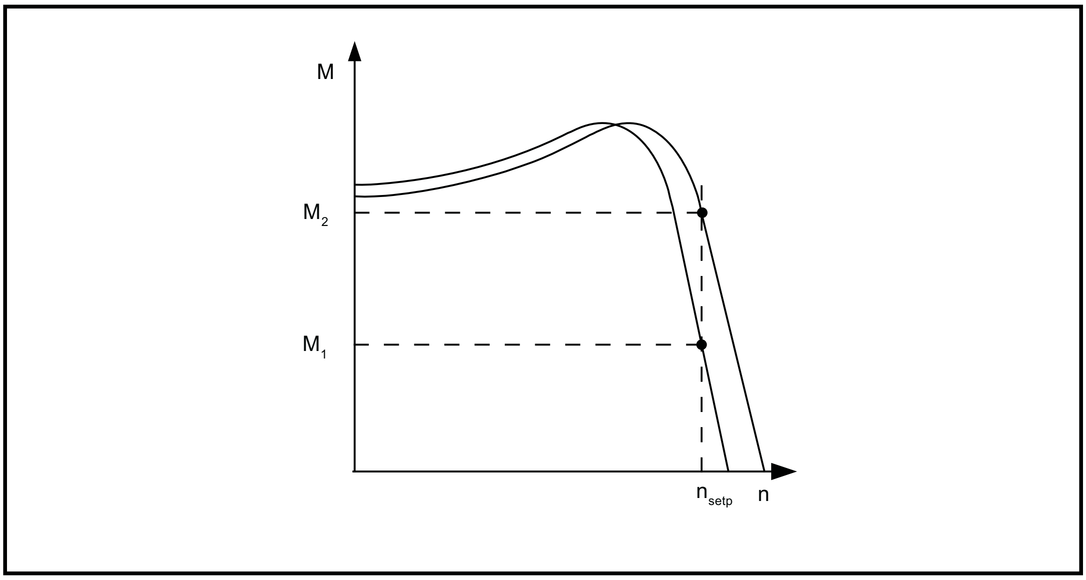


Figure 5-5 Slip compensation

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1334[0...n] V/f control, slip compensation start frequency
- r0330[0...n] Rated motor slip
- 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 Slip compensation actual value

5.3 Resonance damping

Description

The resonance damping function dampens active current oscillations that can occur under no-load conditions. Resonance damping is active in a range between 5% and 90% of the rated motor frequency (p0310), but only up to 45 Hz.

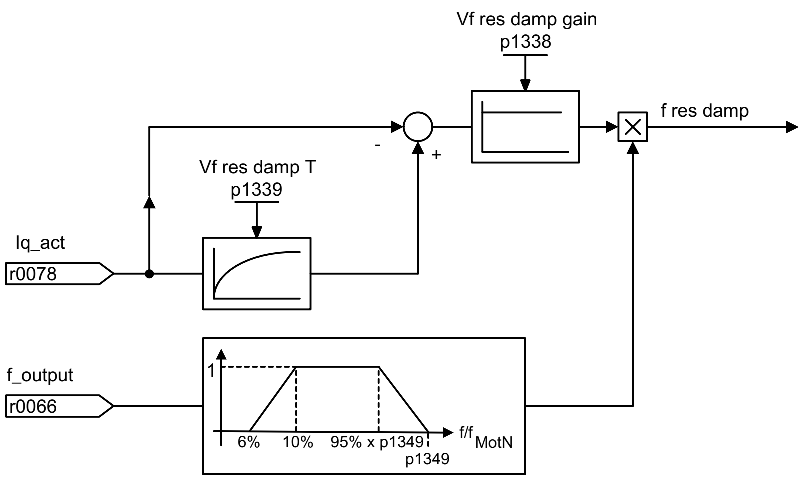


Figure 5-6 Resonance damping

Note

Maximum frequency resonance damping

When p1349 = 0, the changeover limit is automatically set to 95% of the rated motor frequency, but only up to a maximum of 45 Hz.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6310 Resonance damping and slip compensation

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0066 CO: Output frequency
- r0078 CO: Torque-generating current actual value
- p0310[0...n] Rated motor frequency
- p1338[0...n] V/f mode resonance damping gain
- p1339[0...n] V/f mode resonance damping filter time constant
- p1349[0...n] V/f mode resonance damping maximum frequency

5.4 Vdc control

Description

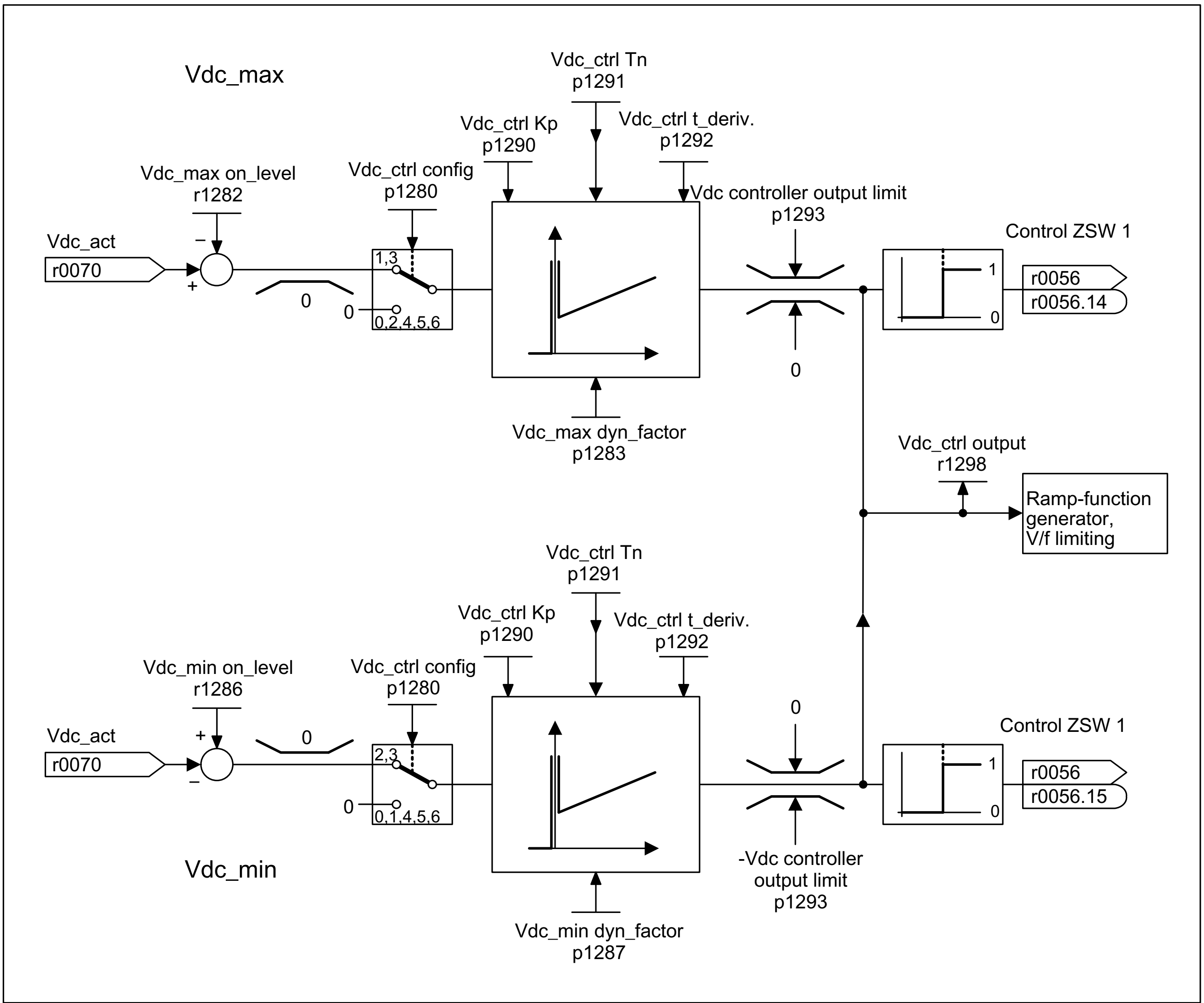


Figure 5-7 Vdc control V/f

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 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.

Description of Vdc_min control

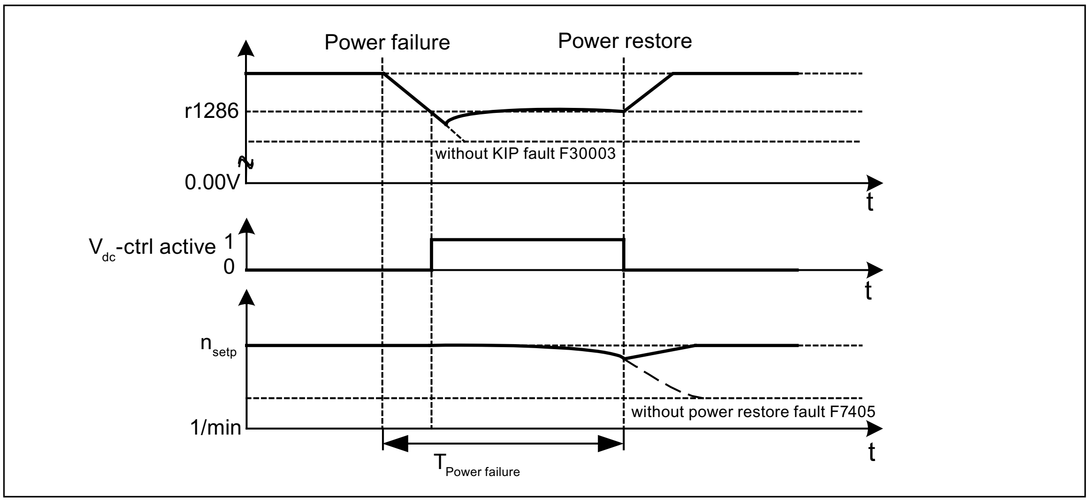


Figure 5-8 Switching Vdc_min control on/off (kinetic buffering)

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-in level. The motor continues operating normally.

If the power supply is not re-established, 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 re-established, 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

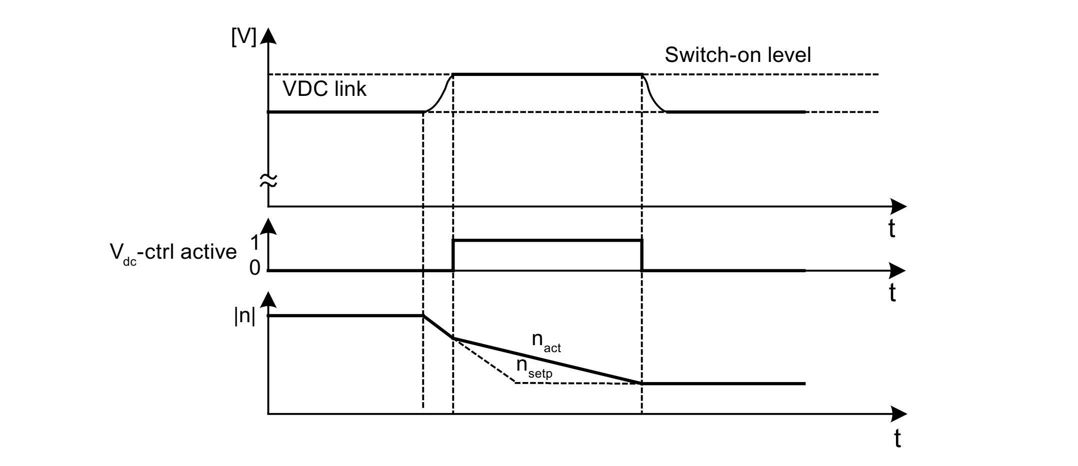


Figure 5-9 Switching Vdc_max control on/off

The switch-in level for Vdc_max control (r1282) is calculated as follows:

- When the function for automatically detecting the switch-in level is switched off (p1294 = 0) r1282 = 1.15 * p0210 (device connection voltage, DC link).
- When the function for automatically detecting the switch-in level is switched on (p1294 = 1) r1282 = Vdc_max - 50 V (Vdc_max: overvoltage threshold of the Motor Module)

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6320 Vdc_max controller and Vdc_min controller

Overview of important parameters (see SINAMICS S120/S150 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 rating 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 variables (p2000 to p2007) are changed offline in STARTER, there is a risk that the parameter value ranges will be violated. In this case, appropriate fault messages will be displayed when the parameters are loaded to the drive units.

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 S120/S150 List Manual.
The unit groups can be individually switched using 4 parameters (p0100, p0349, p0505 and p0595).

Overview of important parameters (see SINAMICS S120/S150 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

Function in STARTER

The function for converting units in STARTER, can be found under Drive object → Configuration → Units. The reference parameters can be found under Drive object → Configuration → Reference parameters.

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.

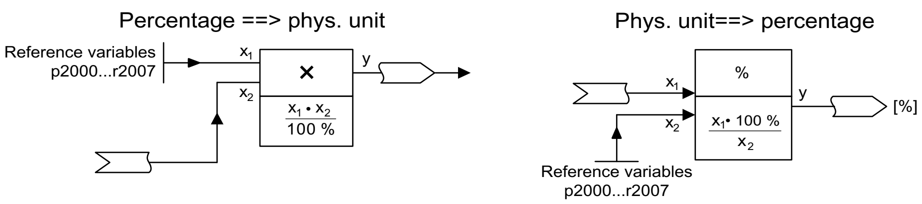


Figure 6-1 Illustration of conversion with reference values

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 the 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 fault messages during loading to the drive.

Scaling for the VECTOR drive object

Table 6- 1 Scaling for the VECTOR drive object

Size	Normalization parameter	Default at first 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°	-

Note

Operation of motors in the field-weakening range

If the motors are to be operated in the field-weakening range > 2:1, the value of parameter p2000 must be set ≤ 1/2 x maximum speed of the drive object.

Scaling for the SERVO drive object

Table 6- 2 Scaling for the SERVO drive object

Size	Normalization parameter	Default at first 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 $1/s^2$
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°	-

Note

Operation of motors in the field-weakening range

If the motors are to be operated in the field-weakening range > 2:1, the value of parameter p2000 must be set ≤ 1/2 x maximum speed of the drive object.

Scaling for the A_INF drive object

Table 6- 3 Scaling for the A_INF drive object

Size	Normalization parameter	Default at first 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 the B_INF drive object

Table 6- 4 Scaling for the B_INF drive object

Size	Normalization parameter	Default at first 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
Reference temperature	100% = 100°C	-
Reference electrical angle	100 % = 90°	-

Overview of important parameters (see SINAMICS S120/S150 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 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 source 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.

- Object "Drive 1" must be removed from the target topology via p0105 = 2 in the "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.

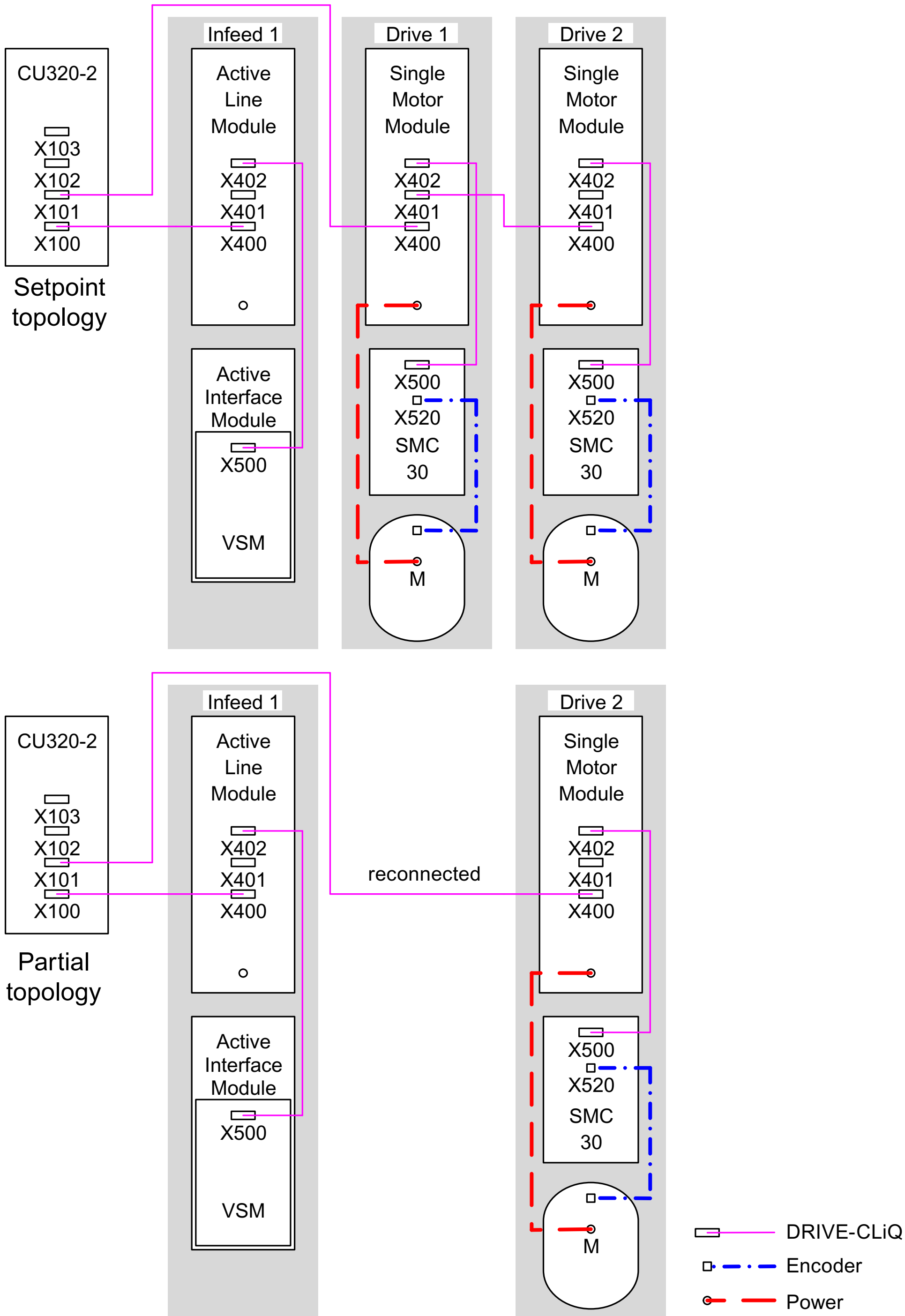


Figure 6-2 Example of a sub-topology

> ⚠ 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: /FH1/ SINAMICS S120 Function Manual, chapter "Safety Integrated".

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0105 Activate/deactivate drive object
- r0106 Drive object active/inactive
- p0125 Activate/deactivate power unit component
- r0126 Power unit component active/inactive
- p0145 Activate/deactivate encoder interface
- r0146 Encoder interface active/inactive
- p9495 BICO response to deactivated drive objects
- p9496 Re-establish BICO to the now activated drive objects
- r9498[0 ... 29] BICO BI/CI parameter to deactivated drive objects
- r9499[0 ... 29] BICO BO/CO parameter to deactivated drive objects

6.4 Sinusoidal filter

Description

The sine-wave 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 sine-wave filter is connected to the Power Module or Motor Module, the converter must be activated during commissioning (p0230 = 3) to prevent the filter from being destroyed. If a sine-wave filter is connected to the Power Module or Motor Module, the Power Module or Motor Module must not be operated without a connected motor because otherwise the filter can be destroyed.

Usage restrictions for sine-wave filters

The following restrictions must be taken into account when a sine-wave 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. 450 m
  - Shielded cables: max. 300 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 sine-wave filter.

Table 6- 5 Parameter settings for sine-wave filters

Parameter number	Name	Setting
p0233	Power unit motor reactor	Filter inductance
p0234	Power unit sine-wave 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 Voltage Peak Limiter comprises two components: the dv/dt reactor and the **V**oltage **P**eak **L**imiter, which cuts off the voltage peaks and returns the energy to the DC link.

The dv/dt filter plus Voltage Peak Limiter is designed for use with 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 Voltage Peak Limiter limits 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):

- Voltage peaks ÛLL (typically) < 1000 V for V_{line} < 575 V
- Voltage peaks ÛLL (typically) < 1250 V for 660 V < V_{line} < 690 V

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.

⚠ WARNING
When a dv/dt filter with Voltage Peak Limiter is used, the maximum permissible pulse frequency of the Power Module or Motor Module is 4 kHz (chassis power units up to 250 kW at 400 V) or 2.5 kHz (chassis power units from 315 kW to 800 kW at 400 V or 75 kW up to 1200 kW at 690 V). If a higher pulse frequency is set, then this could destroy the dv/dt filter.

Commissioning

The dv/dt filter must be activated when commissioning the system (p0230 = 2).

6.6 dv/dt filter compact plus Voltage Peak Limiter

Description

The dv/dt filter compact plus Voltage Peak Limiter comprises two components: the dv/dt reactor and the Voltage Peak Limiter, which cuts off the voltage peaks and returns the energy to the DC link.

The dv/dt filter compact plus Voltage Peak Limiter is designed for use with motors for which the voltage strength of the insulation system is unknown or insufficient.

The dv/dt filter compact plus Voltage Peak Limiter limits the voltage load on the motor cables to values in accordance with the limit value curve A in compliance with IEC/TS 60034-25:2007.

The rate of voltage rise is limited to < 1600 V/µs, the peak voltages are limited to < 1400 V.

> ⚠ WARNING
>
> When a dv/dt filter compact plus Voltage Peak Limiter is used, the drive must not be continuously operated with an output frequency lower than 10 Hz.
>
> A maximum load duration of 5 minutes at an output frequency lower than 10 Hz is permissible, provided that the drive is operated with an output frequency higher than 10 Hz for a period of 5 minutes thereafter.
>
> Uninterrupted duty at an output frequency less than 10 Hz can produce thermal overload and destroy the dv/dt filter.

> ⚠ WARNING
>
> When a dv/dt filter compact with Voltage Peak Limiter is used, the maximum permissible pulse frequency of the Power Module or Motor Module is 4 kHz (chassis power units up to 250 kW at 400 V) or 2.5 kHz (chassis power units from 315 kW to 800 kW at 400 V or 75 kW up to 1200 kW at 690 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. 100 m
  - Unshielded cables: Max. 150 m
- Other restrictions: see the Equipment Manual.

Commissioning

The dv/dt filter must be activated when commissioning the system (p0230 = 2).

6.7 Pulse frequency wobbling

Description

The function is available for Motor Modules in chassis format with DRIVE-CLiQ (order numbers: 6SL3xxx-xxxxx-xxx3) available in the vector control mode.

Pulse frequency wobbling damps the spectral components, which can generate unwanted noise in the motor. Wobbling can be activated only for pulse frequencies that are lower than or equal to the current controller frequency (see also p0115[0]).

Wobbling causes the pulse frequency in a modulation interval to deviate from the setpoint frequency. This means that the actual pulse frequency might be higher than the average pulse frequency required.

A noise generator can be used to vary the pulse frequency around an average value. In this case, the average pulse frequency is equal to the setpoint pulse frequency. The pulse frequency can be varied in every current controller cycle if the cycle is constant. Current measurement errors resulting from asynchronous pulse and control intervals are compensated by a correction in the actual current value.

Pulse frequency wobbling can be parameterized with parameter p1810 "Modulator configuration".

Parameters (see SINAMICS S120/S150 List Manual)

p1810 Modulator configuration

- Bit 0: DC link voltage limitation
  Bit 0 = 0:
  Voltage limitation derived from DC link voltage minimum (lower ripple in the output current; reduced output voltage).
  Bit 0 = 1:
  Voltage limitation derived from mean DC link voltage (increased output voltage with increasing ripple in the output current).
  The selection is valid only if the DC link voltage is not compensated in the CU (Bit 1 = 0).
- Bit 1: DC link voltage compensation
  Bit 1 = 0:
  DC link voltage compensation in the modulator.
  Bit 1 = 1:
  DC link voltage compensation in the closed-loop current control (CU)
  This bit can be set only in conjunction with a pulse inhibit and when r0192 bit 14 = 1 (DC link voltage can be compensated in the power unit).

- Bit 2: Activate pulse frequency wobbling
  Pulse frequency wobbling is deactivated in the default setting (p1810.2 = 0). Exception: For a parallel connection, pulse frequency wobbulation is only activated after the first commissioning (p1810.2 = 1).

  When the sine-wave filter is active (p0230 = 3 or 4), the wobbling function is locked out in order to protect the filter.
  Pulse frequency wobbling can be activated (p1810.2 = 1) only if:

  – p1800 (pulse frequency) <= 2* 1000/p0115[0] (in all indices)
  – p1802 (modulator mode) <= 6 (no optimized pulse patterns)
  – A pulse inhibit is applied
  – r0192 bit 16 = 1 gating unit with pulse frequency wobbulation available

p1811[0...n] Pulse frequency wobbling amplitude

Parameter p1811[0...n] "Pulse frequency wobbling amplitude" can be set to adjust the magnitude of variation in the pulse frequency wobble to between 0 and 20 %. The factory setting is 0%. For a wobble amplitude of p1811 = 0%, the maximum possible pulse frequency
p1800 = 2 * 1/current controller cycle (1000/p0115[0]). With a wobble amplitude setting of p1811 > 0, the maximum possible pulse frequency p1800 = 1/current controller cycle (1000/p0115[0]). These conditions apply to all indices.

p1811 > 0 is possible under the following conditions:

- p1810.2 (modulator configuration) = 1 (wobbling activated)
- p1800 (pulse frequency) <= 1000/p115[0]
- p0230 (output filter) < 3 (no sine-wave filter)

Note

If pulse frequency wobbling is deactivated, all the indices of parameter p1811 are set to 0.

6.8 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.

Note

Rotating/moving measurement for motor identification for servos drives

Use parameter p1959[0...n].14/15 = 0 to activate a direction inhibit for the rotating measurement for motor identification where necessary. The direction inhibit should be deactivated with p1959[0...n].14/15 = 1 for complete and accurate identification of the motor.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0069 Phase current, actual value
- r0089 Actual phase voltage
- p1820 Direction of rotation reversal of the output phases (vector)
- p1821 Rotational direction
- p1959[0...n] Rotating measurement configuration
- p2507 LR absolute encoder adjustment status

6.9 Automatic restart (vector, servo, infeed)

Description

The automatic restart function is used to automatically restart the drive/drive line-up - e.g. 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. Before the automatic restart starts, it should be ensured that the supply voltage is available and is present at the infeed.

On this subject, also note the information in Chapter Switching on a drive object X_INF using a VECTOR drive object (Page 647)[1)].

CAUTION
Automatic restart functions in the vector and servo modes - 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 re-established. 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, there is a high signal at binector input p1208[1], or in the case of an infeed drive object (X_INF[1)]), F06200 has occurred. If additional faults are present, then these faults are also acknowledged and when successfully acknowledged, the starting attempt is continued. The failure of the CU's 24 V supply will be interpreted 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 deactivated 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. P1210 = 1 prevents a restart. 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 drive object VECTOR and X_INF[1)]
   - 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 important parameters (see SINAMICS S120/S150 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

[1)] X_INF stands for all drive objects "Infeed"; i.e.: A_INF, B_INF, S_INF

6.10 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, chassis)
  - Internal voltage protection (booksize, chassis)

Note

The "Internal voltage protection" (IVP) function can only be used for the following modules with an IVP support (r0192.10=1):

- Motor Modules in booksize format, order numbers 6SLxxxx-xxxx-xxx3
- Motor Modules Booksize Compact
- Motor Modules (booksize, chassis)

- For induction motors
  - Control of a DC brake (booksize, chassis)
- Configuration via parameter (p1231)
- Status message using a parameter (r1239)

Preconditions

The preconditions for the "Armature short-circuit brake" function are provided in Chapter "Internal voltage protection".

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. It is preferably 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 Off etc. or if an infeed unit is used that is not capable of energy recovery. 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 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 functions with Motor Modules in the booksize and chassis formats.

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), the fault F07906 "Armature short-circuit / DC brake parameterization error" is generated.

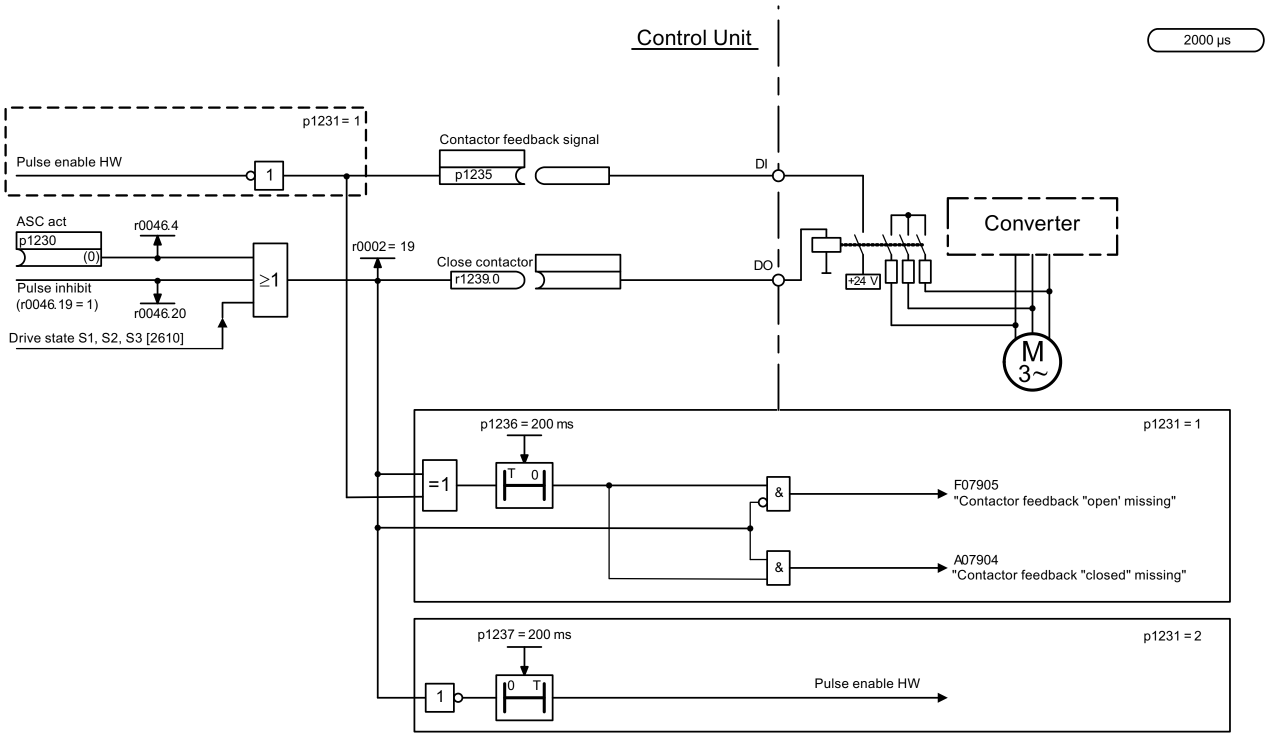


Figure 6-3 External armature short-circuit braking with/without contactor feedback signal

Internal voltage protection (booksize, chassis)

You can find detailed information on internal voltage protection in Chapter "Internal voltage protection" (Page 249).

Internal armature short-circuit braking (booksize, chassis)/DC braking

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 function 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 message F7906 is generated):

- Permanent magnet synchronous motor (internal armature short-circuit)
  The firmware of the Motor Module supports the internal armature short-circuit (r0192.9=1). If the Motor Module firmware does not support the internal armature short-circuit, then when an attempt is made to activate it, fault F01303 (DRIVE-CLiQ component does not support the requested function) is output with fault value 101. (The Motor Module does not support an 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 preconditions are also checked, which may result in the cancelation of all messages whose parameters have been changed (p2100 / p2101) and which have this function as a response. In parameter p0491 ("Motor encoder fault response"), the factory setting OFF2 is entered again as response if the "Encoder fault results in internal armature short-circuit brake / DC brake" response was previously entered there.
Alternatively, all encoder faults 3yxxx, y=1,2,3 as well as F07412 (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 encocer.

The user can use the parameters p2100 and p2101 to set this function as a fault response for individual messages.

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 message 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.

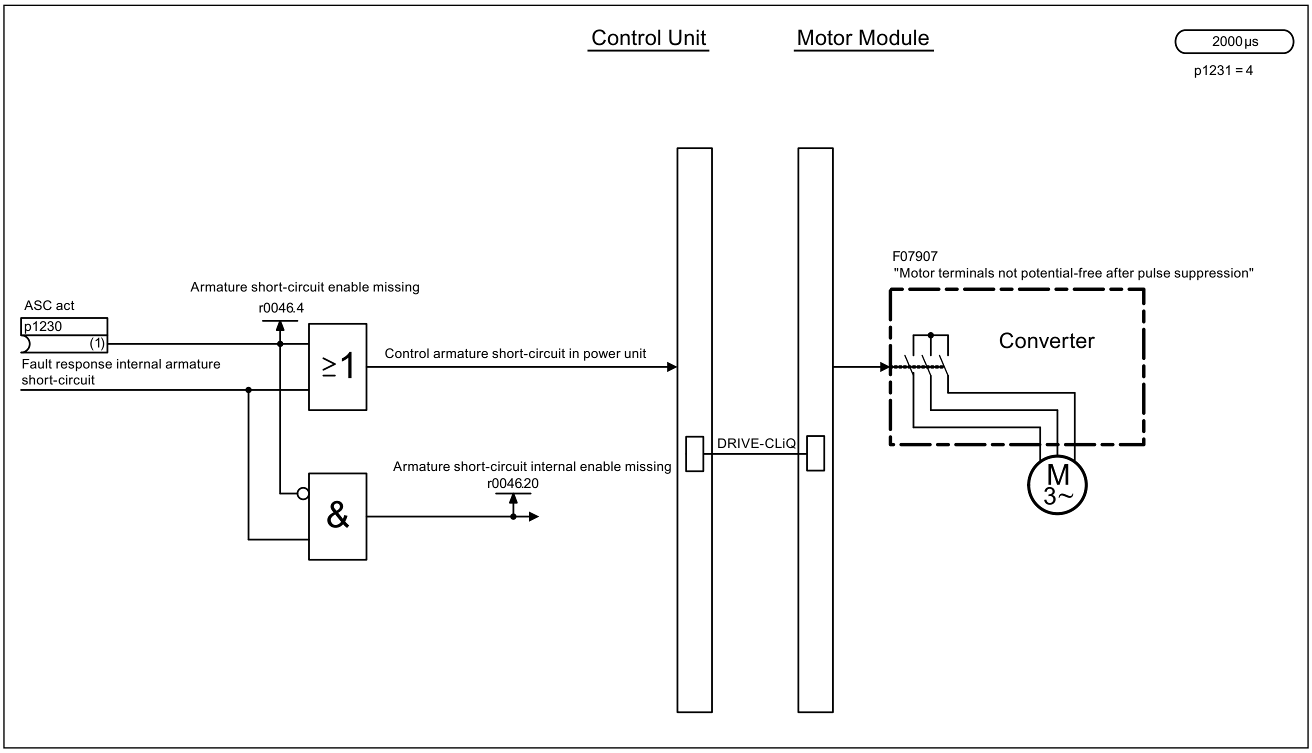


Figure 6-4 Internal armature short-circuit

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.

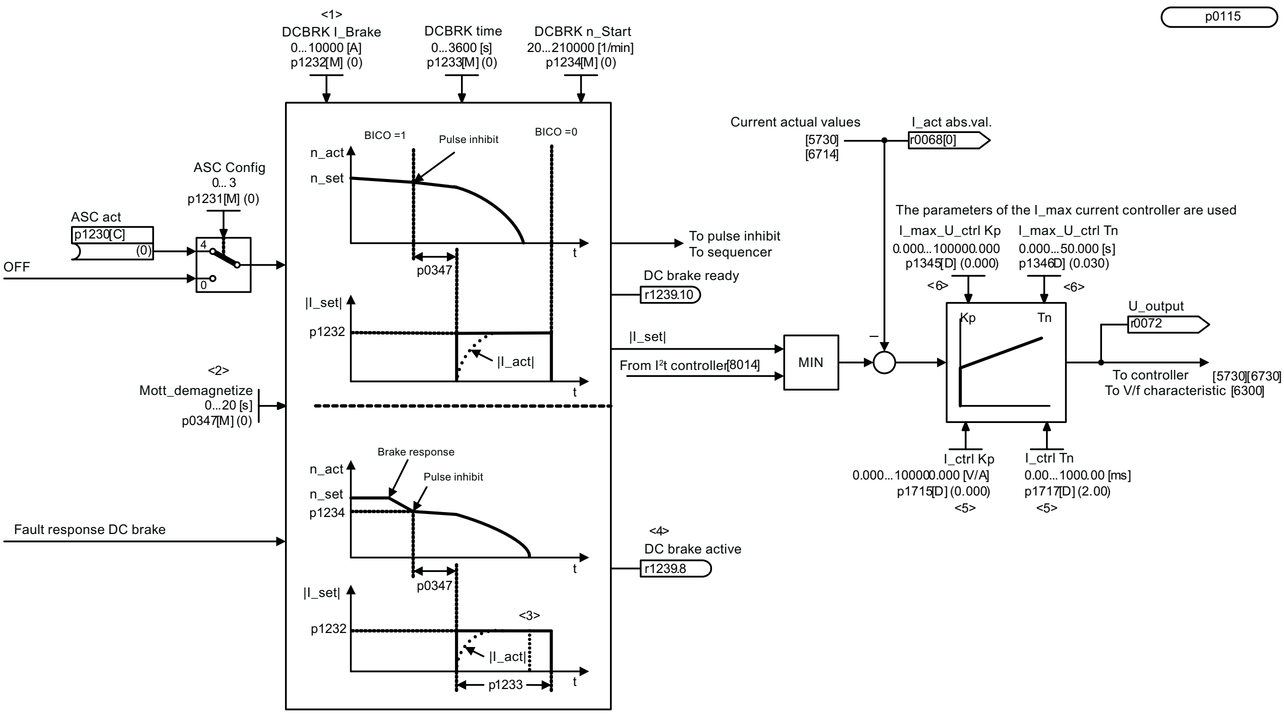
If the DC brake is removed, the drive returns to its selected operating mode.

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 an overcurrent fault.
- In V/f mode:
  With the "flying restart" function activated, the converter frequency is synhronized 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 brake as a 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 S120/S150 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 important parameters (see SINAMICS S120/S150 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 brake, braking current
- p1233[0...n] DC braking time
- p1234[0...n] DC brake starting speed
- 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

6.11 Integrated voltage protection

Description

The speed range of permanent-field synchronous motors (e.g. 1FE1 spindles) can be greatly extended by means of field weakening.
If faults that hinder controlled operation occur in this operating status, the EMF (electromotive force) can result in high terminal voltages. These overvoltages must not be applied to the Motor Module because otherwise this could damage all the components connected to the DC link.

The DC link group can be protected by feeding the motor energy back to the supply system and tripping the Internal Voltage Protection (IVP) in the Motor Module. If a ground fault occurs, a Braking Module with a suitable braking resistor can prevent the DC link voltage from rising until the pre-charging relay of the infeed module is open. The internal voltage protection mechanism in the Motor Module is then applied.

Internal voltage protection is implemented by shorting the motor cables in the power unit (Motor Module) (internal armature short-circuit).

This eliminates the need for a VPM (Voltage Protection Module) for 1FE motors (e.g. VPM 120 or VPM 200).

The internal armature short-circuit is configured and activated with p1231 = 3 and activated when a device-specific DC link voltage threshold is reached. It is initiated when the pulses are canceled.

If the internal voltage protection is activated (r0192.10 = 1), the Motor Module decides on the basis of the DC link voltage whether or not the internal armature short-circuit is applied. In this case, the voltage protection remains operative even if the DRIVE-CLiQ connection between the Control Unit and the Motor Module is interrupted. To ensure continued operation of the components in the drive line-up after a line supply failure, the 24 V is supplied from the DC link via a Control Supply Module (CSM).

The IVP (Internal Voltage Protection) mechanism ensures a stable 24 V supply.

The DC link voltage is monitored independently in the Motor Module.

If the DC link voltage exceeds the maximum voltage limit of the Motor Module (e.g. booksize: 800 V, chassis: dependent on the voltage class), then the internal armature short-circuit is activated.

If the DC link voltage falls below the minimum voltage limit of the Motor Module (e.g. booksize: 450 V, chassis: dependent on the voltage class), the internal armature short-circuit is deactivated again. This ensures that the necessary input voltage for the Control Supply Module is maintained.

Note

The "Internal voltage protection" (IVP) function can only be used for the following modules that support IVP (r0192.10 = 1):

- Motor Module in the booksize format with order numbers 6SLxxxx-xxxx-xxx3
- Motor Module Booksize Compact
- Motor Module (booksize, chassis)

Preconditions

Preconditions for the use of integrated voltage protection IVP and for the "Armature short-circuit brake" function are:

- Short-circuit-proof motors (p0320 < p0323)
- The short-circuit current of the motor must not be higher than the specified S6 current of the Motor Module (see "Technical data" for the Motor Module).
- One of the permanent-magnet motor types specified below is used:
  - Rotating permanent-magnet synchronous motor booksize (p0300 = 2xx)
  - Linear permanent-magnet synchronous motor booksize (p0300 = 4xx)
- The max. power unit current (r0209.0) must be at least 1.8 x the motor short-circuit current (r0331).
- Infeed modules with regenerative feedback capability
  Active Line Module 16 kW to 120 kW or Smart Line Module 16 kW to 36 kW.
  The regenerative feedback power rating of the infeed module must be higher or equal to the rated power of the PE spindle(s).
- Two independent 24 V supplies as redundant standard supply (e.g. SITOP) or CSM for Control Unit and Line Modules. DC link-buffered supply (CSM) for the Motor Modules, which are operated on the PE spindles.
- Braking Module with connected braking resistor
  The short-time power of the braking resistor must be adjusted to the rated power of the spindle(s) operating on a permanent-magnet motor. The following formula can be used to determine the maximum resistance of the braking resistor:

$$R_{Brake} \leq \frac{765\ V * 2\pi * Zp * \frac{n_{max}}{60\ s/min} * L_A}{\sqrt{\frac{2}{3}\left(\frac{k_E * n_{max}}{1000 min^{-1}}\right)^2 - \frac{(765\ V)^2}{3}}}$$

Formula symbol	Parameter	Description
k_E	p0317	Voltage constant
n_{max}	p0322	Maximum rotational speed
Z_P	p0314	Number of pole pairs
L_A	p0356	Armature inductance

Calculation example:

K_E = 145 V_{eff} n_{max} = 10.000 min^{-1}, Z_P = 2, L_A = $15.7*10^{-3}$ H

Result in formula above: R_{Brake} = 22.9 Ω

The resistance of the braking resistor must not exceed 22.9 Ω This means that a 17 Ω braking resistor (P_{max} = 25kW) is sufficient here.

- The EMF of the PE spindle motor must not exceed 1.4 kVeff.
- Correct parameterization of the drive line-up:
  In cases where the "Internal voltage protection" function is not activated with the appropriate parameter setting p1231 = 3, the maximum motor speed is automatically limited to a non-critical value. An alarm message is also output.

Configuration example

An example of a configuration recommended to achieve perfect operation of the internal voltage protection function can be seen below.

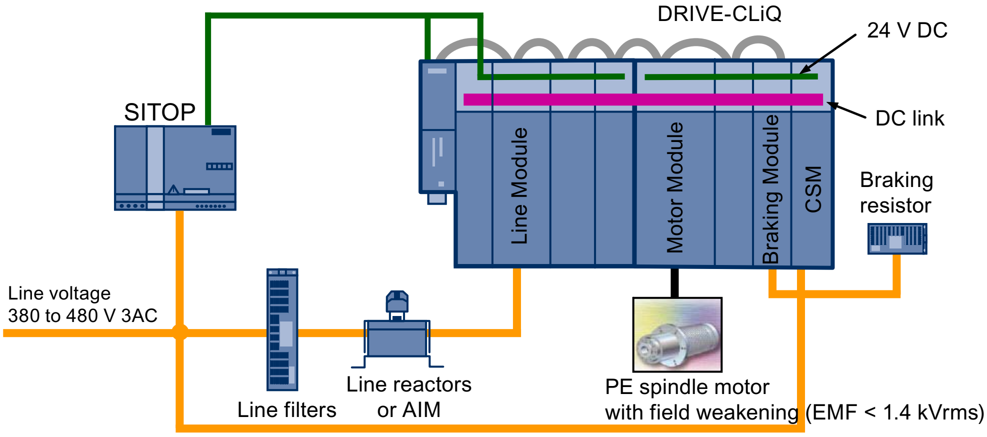


Figure 6-6 Example of a configuration recommended for application of internal voltage protection

Safety information

⚠ DANGER
The internal voltage protection function is deactivated at DC link voltages lower than 450 V. Kinetic energy is converted to heat loss in the drive system and motor. If the power loss is too high or this operation takes too long, the drive may be subject to thermal overload.

⚠ CAUTION
The kinetic motor energy is initially only absorbed by the braking resistor connected to the Braking Module. The internal voltage protection mechanism is activated when the Braking Module reaches the I²t shutdown limit, that is, when 80% of the maximum ON time of the braking resistor is reached. At this point, the Braking Module is no longer available for braking other motors.

CAUTION

Motors

Use only short-circuit proof motors. The Power Module/Motor Module must be designed to handle 1.8 times the short-circuit current of the motor.

The internal voltage protection function cannot be interrupted by a fault response. If an overcurrent occurs while internal voltage protection is active, this can destroy the Power Module/Motor Module and/or the motor.

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).

DANGER

When the internal voltage protection mechanism is active (p1231 = 3), all the motor terminals are at half the DC link potential once the pulses have been suppressed (without the internal voltage protection mechanism, the motor terminals are floating).

CAUTION

The internal voltage protection function cannot be interrupted by a fault response. If an overcurrent occurs while internal voltage protection is active, the Motor Module and/or the motor might sustain irreparable damage!

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).

Note

An activated internal voltage protection mechanism extends the speed range by raising the speed limits (p1082, ...) - also for EMF values > 800V. The original settings are not buffered.

WARNING

Maximum EMF

Motors whose EMF can exceed a phase-to-phase DC-link voltage > 2 kV (EMF ≥ 1.4 $kV_{rms(terminal-terminal)}$) must not be operated on a Motor Module: The insulation voltage could be exceeded, resulting in personal injury or damage to the equipment due to electric shock or overvoltage.

Under fault conditions, voltages of up to 2 kV can occur at cables that are cut or damaged. Depending on the speed of the motors, the motor terminal voltage of the 1FE1 motors can attain values as high as 2 kV.

Note

The internal voltage protection can be disabled at any time. Switchover is effective only after POWER ON.

Troubleshooting

- If a fault occurs, the main objective is to feed the energy produced by the motor back to the supply system.
  Examples of faults: CSM failure, interrupted DRIVE-CLiQ communication, defective motor encoder, defective Motor Module hardware, defective Braking Module
- If, in the case of a fault, the motor energy cannot be fed back to the line supply in sufficient quantity - or not at all - then the internal armature short-circuit function in the Motor Module is activated for DC link voltages > 800 V, thus preventing the DC link voltage from increasing any further.
  Examples: Line supply failure, defective 24 V supply, defective hardware in the Active Line Module or Control Unit, interrupted DRIVE-CLiQ communication.
- Special case: A ground fault develops in the motor during field-weakening operation.
  In this case, the Line Module disconnects the drive from the line supply. The Braking Module limits the ground fault current to acceptable values until the Line Module disconnects from the supply.

Parameters (see SINAMICS S120/S150 List Manual)

- p0300[0...n] Motor type selection
- p1231[0..n] Armature short-circuit/DC braking configuration

6.12 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.

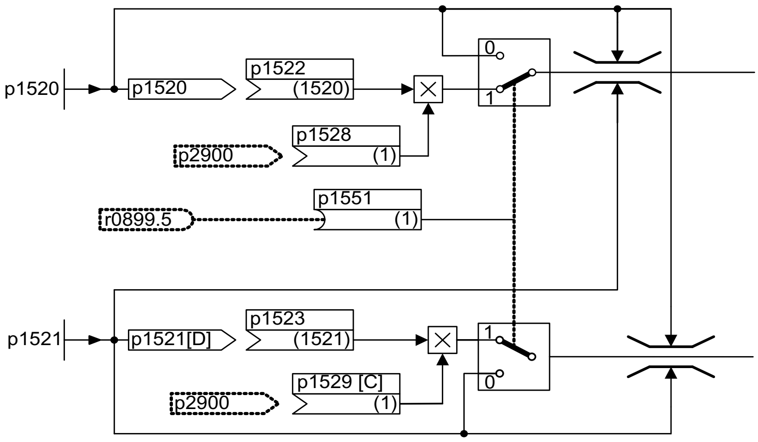


Figure 6-7 Torque limits OFF3

Function diagrams (see SINAMICS S120/S150 List Manual)

- 5620 Motor/generator torque limits
- 5630 Upper/lower torque limit
- 6630 Upper/lower torque limit

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1520 Torque limit, upper/motoring
- p1521 Torque limit, lower/regenerative

6.13 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 S120/S150 List Manual)

- 5610 Torque limiting/reduction/interpolator
- 6710 Current setpoint filters
- 7010 Friction characteristic curve

Overview of important parameters (see SINAMICS S120/S150 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 first 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 Off 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".

6.14 Simple brake control

Features

- Automatic activation by means of sequence control
- Standstill (zero-speed) monitoring
- Forced brake release (p0855, p1215)
- Application of brake for a 1 signal "unconditionally close holding brake" (p0858)
- Application of brake after "Enable speed controller" signal has been canceled (p0856)

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 sequence control is shown in the SINAMICS S120/S150 List Manual (function diagram 2701 and 2704). The operating principle of the holding brake can be configured via parameter p1215.

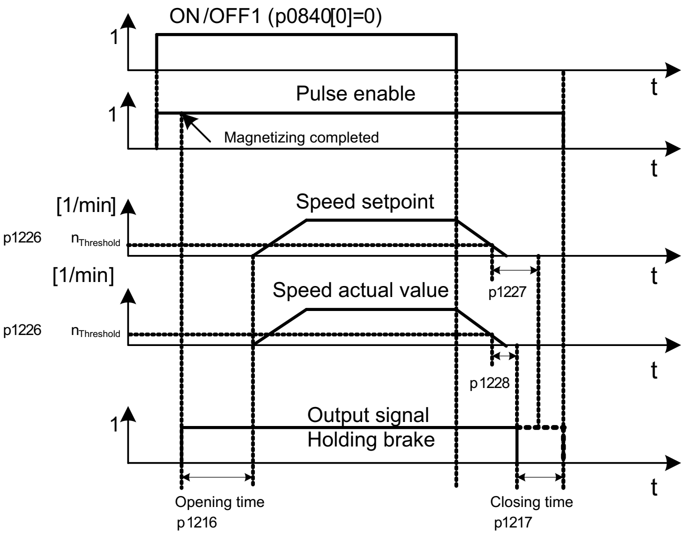


Figure 6-8 Sequence diagram, simple brake control

The start of the closing time for the brake depends on the expiration of the shorter of the two times p1227 (standstill detection monitoring time) and p1228 (pulse cancellation delay 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.

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. This can destroy the brake.

CAUTION
Brake control monitoring may only be activated for booksize power units and blocksize power units with Safe Brake Relay (p1278 = 0).

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2701 Simple brake control (r0108.14 = 0)
- 2704 Extended brake control (r0108.14 = 1)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0056.4 Magnetizing complete
- r0060 CO: Speed setpoint before the setpoint filter
- r0063 CO: Actual speed value after actual-value smoothing (servo)
- r0063[0...2] CO: Speed actual value
- r0108.14 Extended brake control
- p0855[C] BI: Unconditionally release holding brake
- p0856 BI: Speed controller enabled
- p0858 BI: Unconditionally close 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 Brake control diagnostics evaluation

6.15 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.

If p0651 is at 0, the counter is deactivated.

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 changeover 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.

6.16 Energy-saving display

Introduction

Through the tailored, speed-controlled operation, a drive can consume significantly less energy than with a conventional closed-loop process control. This is especially true for continuous-flow machines with parabolic load characteristics, such as centrifugal pumps and fans. Using the SINAMICS S120 system enables control of the flow rate or the pressure by changing the speed of the continuous-flow machine. As a consequence, the plant or system is controlled close to its maximum efficiency over the complete operating range.

When compared to continuous-flow machines, machines with a linear or constant load characteristic, such as conveyor drives or reciprocating pumps, have a lower energy-saving potential.

This function is optimized for fluid-flow machines.

Situation

In a conventionally controlled plant or system, the flow rate of the medium is controlled using valves or throttles. In this case, the drive motor operates at a constant rated speed defined by the particular operation. The system efficiency decreases significantly if the flow rate is reduced by means of valves or throttles. The pressure in the system increases. The motor also consumes energy when the valves/throttles are completely closed, i.e. with a flow rate of Q = 0. In addition, undesirable process-related situations can occur; for example, cavitation in the continuous-flow machine or increased heating of the continuous-flow machine and the medium.

Solution to optimize the system

When using a speed controller, the process-specific flow rate of the continuous-flow machine is controlled by varying the speed. The flow rate changes proportionally with the speed of the continuous-flow machine. Any throttles or valves remain completely open. The entire plant/system characteristic is shifted by the speed controller to achieve the required flow rate. As a consequence, the complete system operates close to the optimum efficiency – and especially in the partial load range, uses significantly less energy than when using a throttle or valve to control the flow rate.

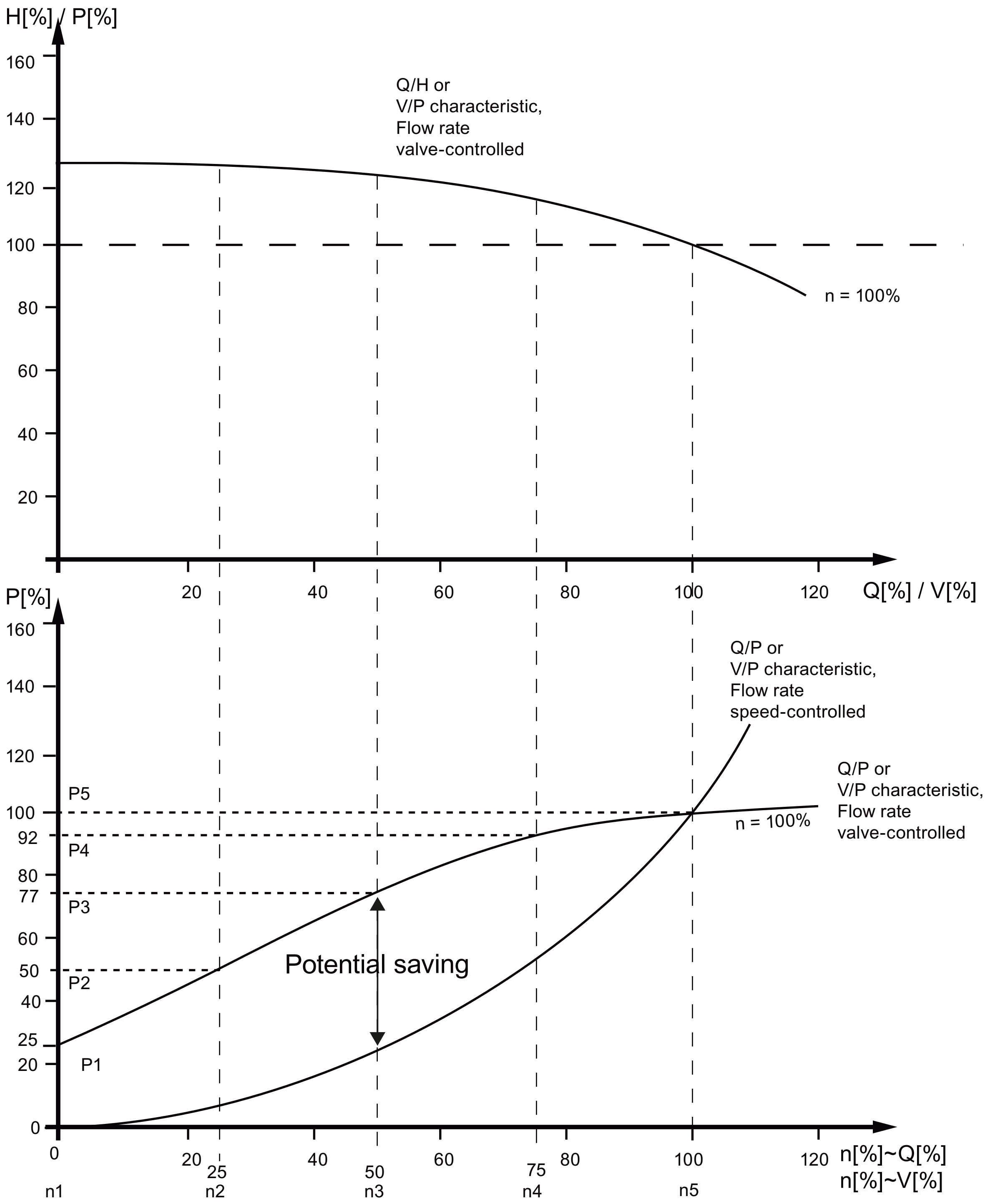


Figure 6-9 Energy-saving potential

Legend for top characteristic:
H[%]=Flow level, P[%]=Flow pressure, Q[%]=Flow rate, V[%]=Volumetric flow
Legend for bottom characteristic:
P[%]=Capacity of flow machine, n[%]=Speed of flow machine
Interpolation points p3320 to p3329 for plant/system curve with n=100%:
P(1...5) = Capacity of flow machine, n(1...5) = Speed in accordance with speed-controlled machine

Energy-saving function

This function determines the amount of energy used and compares it with the interpolated energy required for a plant or system equipped with a conventional throttle control. The amount of energy saved is calculated over the last 100 operating hours and is displayed in kW. For an operating time of less than 100 hours, the potential energy-saving is interpolated up to 100 operating hours. To do this, you must manually enter the plant/system characteristic with the conventional throttle control.

Note

Plant/system characteristic

The factory setting is used as basis for the calculation if you do not enter the interpolation points for your plant/system characteristic. The values of the factory setting can deviate from your plant/system characteristic and result in an inaccurate calculation.

This calculation is configurable individually for each individual axis.

Activation of the function

This function is enabled only for vector mode.

- Activate the function with parameter p0898.3 = 1
- Enter 5 interpolation points for the load characteristic in parameters p3320 to p3329:

Table 6- 7 Plant/system interpolation points

Interpolation point	Parameter	Factory setting: P - power in % Q - flow rate in %	
1	p3320	P1 = 0.00	
	p3321	n1 = 25.00	
2	p3322	P2 = 25.00	
	p3323	n2 = 50.00	
3	p3324	P3 = 50.00	
	p3325	n3 = 77.00	
4	p3326	P4 = 75.00	
	p3327	n4 = 92.00	

Interpolation point	Parameter	Factory setting: P - power in % Q - flow rate in %	
5	p3328	P5 = 100.00	
	p3329	n5 = 100.00	

Reading-off the energy-saving

You can read the energy saved in parameter r0041. Set p0040 = 1 to reset the value of parameter r0041 to 0. Parameter p0040 is then automatically set to 0.

6.17 Parking axis and parking encoder

The parking function is used in two ways:

- "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 encoder"
  – Monitoring of a certain encoder is suppressed.
  – The encoder is prepared for the "removed" state.

Parking an axis

When an axis is parked, the power unit and all the encoders 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).

Parking an encoder

When an encoder is parked, the encoder being addressed is switched to inactive (r0146 = 0).

- Control is carried out via the encoder 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).

Note

Removing/replacing parked components

Once parked components have been disconnected/connected, they can only be unparked once they have been successfully integrated in the actual topology. (See r7853)

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 STW1.0 (OFF1). All components assigned to the motor control (e.g. power unit and motor encoder) are shut down.

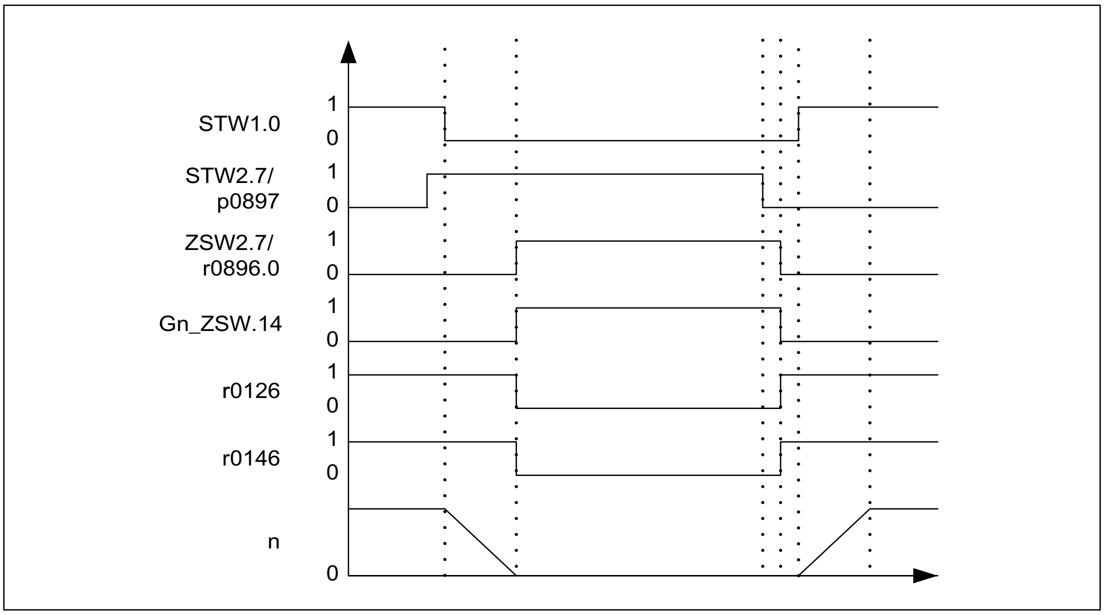


Figure 6-10 Function chart: parking axis

Example: parking encoder

In the following example, a motor encoder is parked. To activate motor encoder parking, the drive must be stopped (e.g. via STW1.0 (OFF1).

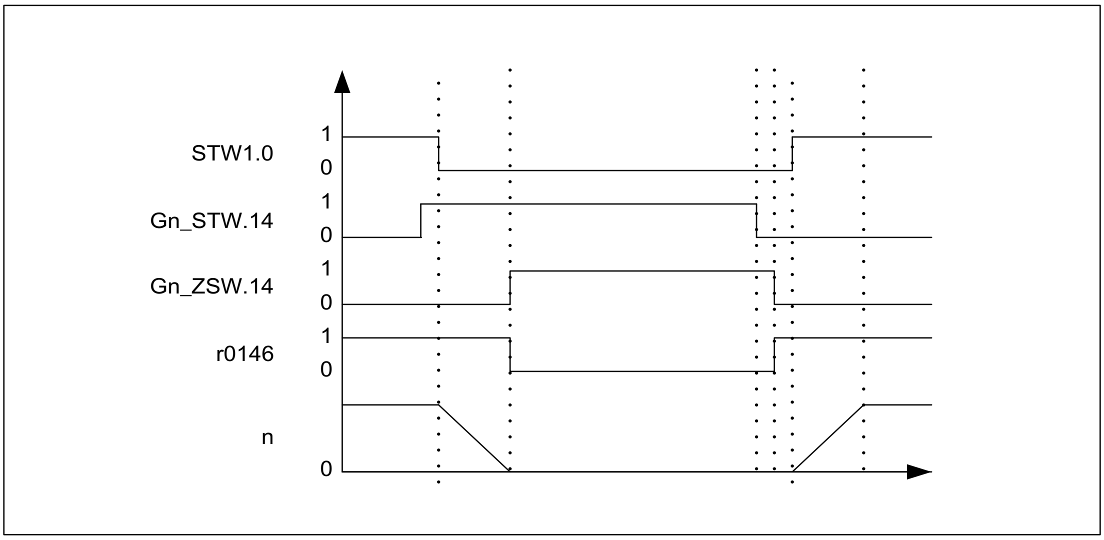


Figure 6-11 Function chart: parking encoder

Overview of important parameters (see SINAMICS S120/S150 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

6.18 Position tracking

6.18.1 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.

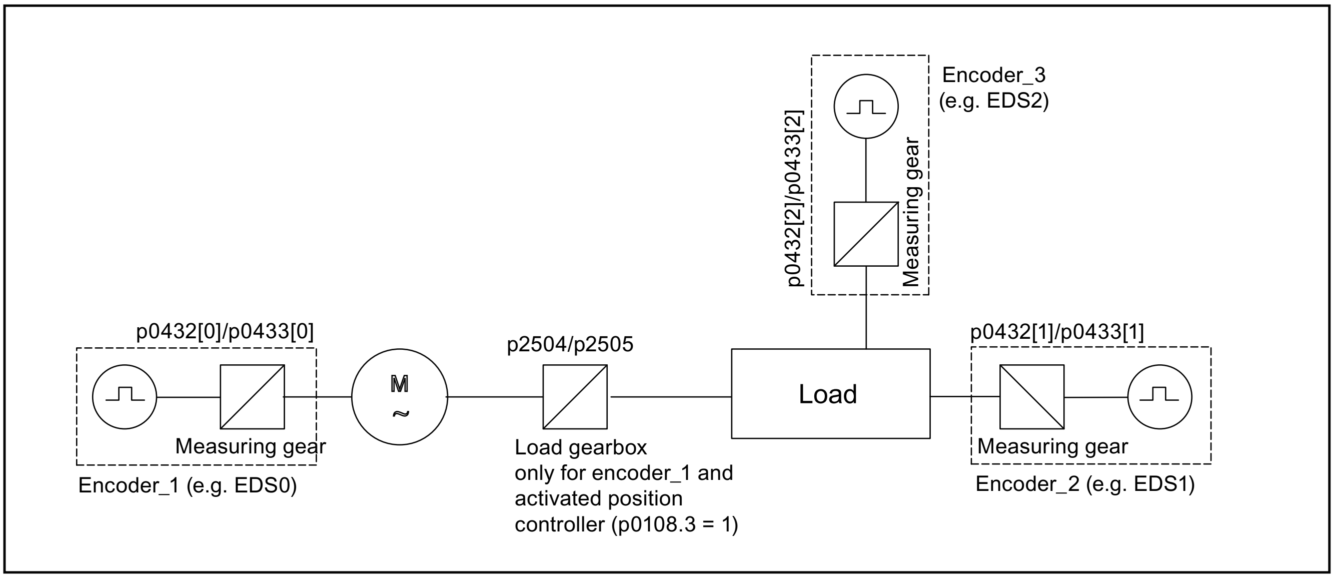


Figure 6-12 Overview of gears and encoders

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)

6.18.2 Measuring gear

Features

- Configuration via p0411
- Virtual multiturn via p0412
- Tolerance window for monitoring the position at power ON p0413
- Input of the measuring gear via p0432 and p0433
- Display via r0483

Description

If a mechanical gear (measuring gear) 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 gear ratio) between the zero position of the encoder and the motor/load whenever encoder overflow occurs.

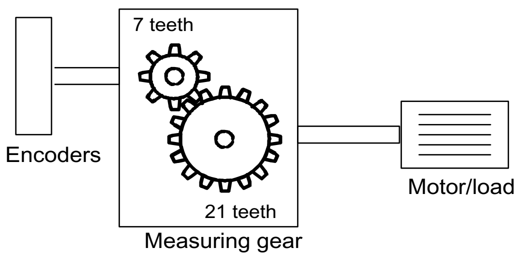


Figure 6-13 Measuring gear

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).

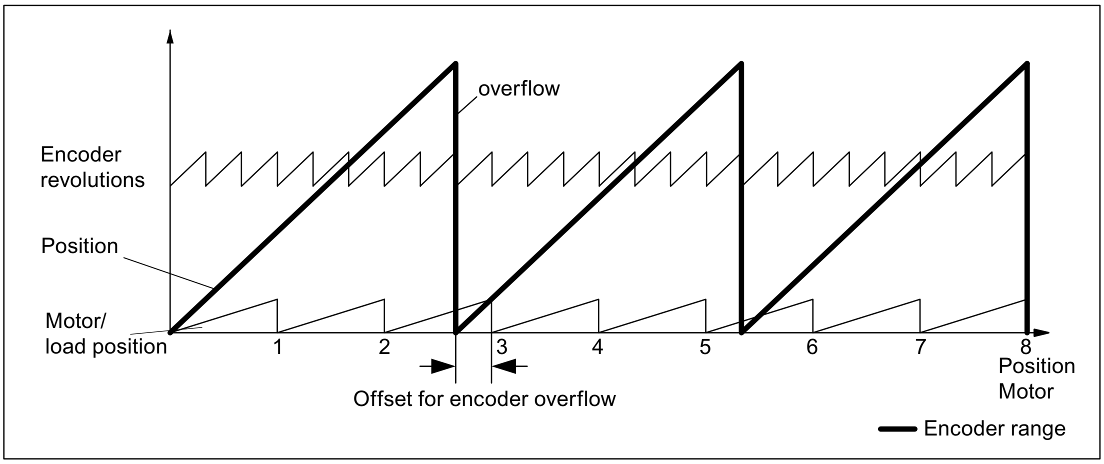


Figure 6-14 Drive with odd-numbered gears without position tracking

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).

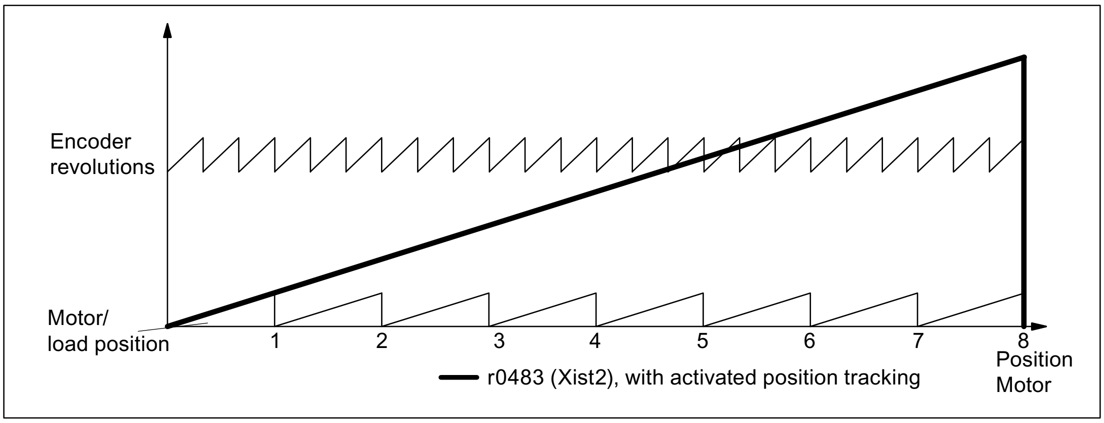


Figure 6-15 Odd-numbered gears with position tracking (p0412 = 8)

Measuring gear 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 actual encoder value.

Difference outside the tolerance window → message F07449 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 gear rating 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 gear teeth must be requested from the gear manufacturer.

Note regarding using synchronous motors with a measuring gear

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 geares: 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 gear 4.25, ratio = 4).

Commissioning

The position tracking of the measuring gear 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 p0412 (Measuring gear, rotary absolute encoder, revolutions, virtual) and p0413 (Measuring gear, position tracking tolerance window) can only be set via the expert list.

Prerequisite

- Absolute encoder

Function diagrams (see SINAMICS S120/S150 List Manual)

- 4704 Position and temperature sensing, encoders 1 ... 3

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0402 Gear type selection
- p0411 Measuring gear configuration
- p0412 Measuring gear absolute encoder rotary revolutions virtual
- p0413 Measuring gear position tracking, tolerance window

- p0421 Absolute encoder rotary multiturn resolution
- p0432 Gear factor encoder revolutions
- p0433 Gear factor motor/load revolutions
- r0477 CO: Measuring gear, position difference
- r0485 CO: Measuring gear, raw encoder value, incremental
- r0486 CO: Measuring gear, raw encoder value, absolute

6.19 ENCODER drive object

Encoders can be linked in as autonomous drive objects (abbreviated, "DOs") and evaluated. An ENCODER drive object can be addressed as an encoder via PROFIBUS/PROFINET as an independent unit, i.e. the previous forced coupling to a drive DO no longer applies.

Using an ENCODER drive object allows an encoder of an upstream machine to be directly connected via an SMC without having to take an indirect route via the 2nd encoder of an axis. In this case, the encoder is connected via an encoder interface SMx or - for a dedicated DRIVE-CLiQ interface - directly to a free DRIVE-CLiQ socket. The ENCODER drive object makes it easier to implement modular concepts.

This means that the number of possible ENCODER drive objects is restricted so that a total maximum of 24 drive objects can be connected to one Control Unit.

6.19.1 Preconditions for creating an ENCODER drive object using STARTER

This chapter describes how ENCODER drive objects can be created using the STARTER tool and configured using a wizard and screen forms.

Requirements

- STARTER V4.1.5 or higher
- Project with one CU320-2

The project can also be created OFFLINE. A description of this can be found in the SINAMICS S120 Commissioning Manual in Chapter "Commissioning".

Connection conditions for ENCODER drive objects

- All encoders that can be assigned to a drive can be used.
- ENCODER drive objects may be connected to all DRIVE-CLiQ ports.
- Up to 4 DRIVE-CLiQ HUBs (DMC20 or DME20) can be used to establish a star-shaped wiring of the ENCODER drive objects. This means that a maximum of 19 possible ENCODER drive objects can be connected to one Control Unit.
- The DRIVE-CLiQ HUBs must be directly connected to a Control Unit.

6.19.2 Creating an ENCODER drive object with STARTER, offline

Creating an ENCODER drive object is described using a CU320-2 as an example. The project is created OFFLINE using the STARTER tool.

1. In the navigator, you can find the selection of the ENCODER drive objects between **Input/output components** and **Drives**.

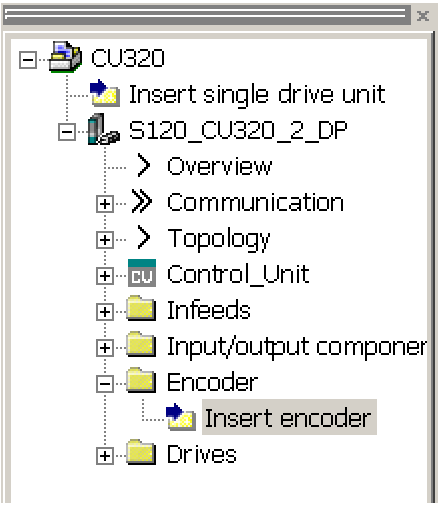


Figure 6-16 Navigator, creating an encoder DO

2. Double-click on **Insert encoder** to enter the basic encoder data in the dialog box **Insert encoder** ; make sure that you define the drive object number of the encoder under the tab **Drive Object No.** .
3. Click on **OK** and then follow the configuration wizard to set-up the encoder.

The encoder has been inserted in the topology and is now available.

6.20 Terminal Module 41 (TM41)

6.20.1 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. They can, for example, be used to enter an analog speed setpoint and transfer control and status signals, such as OFF1/ON, ready or fault.

General features

- Pulse encoder emulation, TTL signals (RS422)
- 1 analog input
- 4 digital inputs
- 4 bidirectional digital inputs/outputs

6.20.2 Description of SIMOTION mode

The SIMOTION mode is set using parameter p4400 = 0. The incremental encoder emulation is produced with the 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) is entered into parameter p4426 and enabled with p4401.0 = 1.

Note

To be able to signal encoder emulation faults from the TM41 to a higher-level external control, parameter r2139.0...8 CO/BO: Status word faults/alarms 1 must be interconnected via a BICO with a digital output (TM41 or CU) which can be read by the external control system.

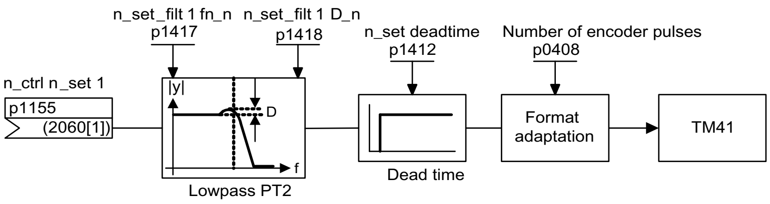


Figure 6-17 Function diagram for encoder emulation

Special features

- PROFIdrive telegram 3
- Own control word (r0898)
- Own status word (r0899)
- Sequence control (refer to function diagram 9682)
- Settable zero mark position (p4426)
- Operating display (r0002)

6.20.3 Description of SINAMICS mode

The SINAMICS mode is set using parameter p4400 = 1. The incremental encoder emulation is produced with the encoder position actual value of a drive DO.

The position actual values of the leading encoder (r0479) are connected to the TM41 via a connector input (p4420). This means that the position actual values at the TM41 are available as pulse encoder emulation - including the zero mark. The signals of the pulse encoder emulation appear just like the signals of a TTL encoder - and can be read in from a control. This means that the position controller can be implemented in a higher-level control system without PROFIBUS. The speed setpoint is transferred to the drive at the analog input of the TM41 via the analog output of the control system (see example, TM41).

Note

Connector input p4420 should preferably be interconnected with signal source r0479 (diagnostics encoder position actual value Gn_XIST1). Parameter r0482 must not be used as signal source.

The TM41 supports a step-up/step-down ratio between the output signal of the leading encoder and the output signal of the TM41. Set the number of encoder pulses per revolution of the leading encoder using p4408 and the fine interpolation using p4418. Set the pulse number of the encoder emulation of the TM41 with p0408. Set the fine resolution of the TM41 using p0418.

The runtime of the encoder position actual value up to the pulse encoder emulation can be compensated using the deadtime compensation with parameter p4421.

If p4422 = 1, input signal p4420 is inverted.

The zero mark signal for the TM41 is generated from the zero position of the leading encoder. Parameters p0493, p0494 and p0495 apply to the generation of the zero position of the leading encoder.

Special features

- PROFIdrive telegram 3
- Deadtime compensation (p4421)
- A step-up/step-down of the pulse number between the encoder to be emulated and the associated TM41 is supported.
- Only one Encoder Data Set (EDS) can be interconnected to precisely one TM41.
- If the same EDS is interconnected to a further TM41, only the position actual value but not the zero mark position can be emulated.
- A TM41 cannot emulate the zero mark position or the position actual value of another TM41.
- A TM41 cannot use external zero marks for the encoders to be emulated.
- Using p4401[1] = 1, the zero position is synchronized with the zero mark of the absolute encoder. If you have to remain compatible with older firmware versions, for example for use in an existing control system, set parameter p4401[1] = 0.

6.20.4 Limit frequencies for TM41

- Adjustable pulse number (p0408): 32 to 16384 pulses/revolution (factory setting = 2048)
- The limit frequencies specified in the tables below must not be exceeded.

Table 6- 8 Maximum output frequencies for TM41

Sampling time p4099[3]		125 μs	250 μs	500 μs
Resolution		31.25 Hz	15.625 Hz	7.8125 Hz
SINAMICS mode p4400 = 1	Output frequency f_{max} for p0408<17bits	512 kHz	512 kHz	256 kHz
	Output frequency f_{max} for p0408=17bits	512 kHz	256 kHz	128 kHz
	Output frequency f_{max} for p0408=18bits	256 kHz	128 kHz	64 kHz
SIMOTION mode p4400 = 0	Output frequency f_{max}	512 kHz	512 kHz	256 kHz

6.20.5 Example in SINAMICS mode

The signals of the leading encoder should be adapted using the TM41 and transferred to the SERVO drive object.

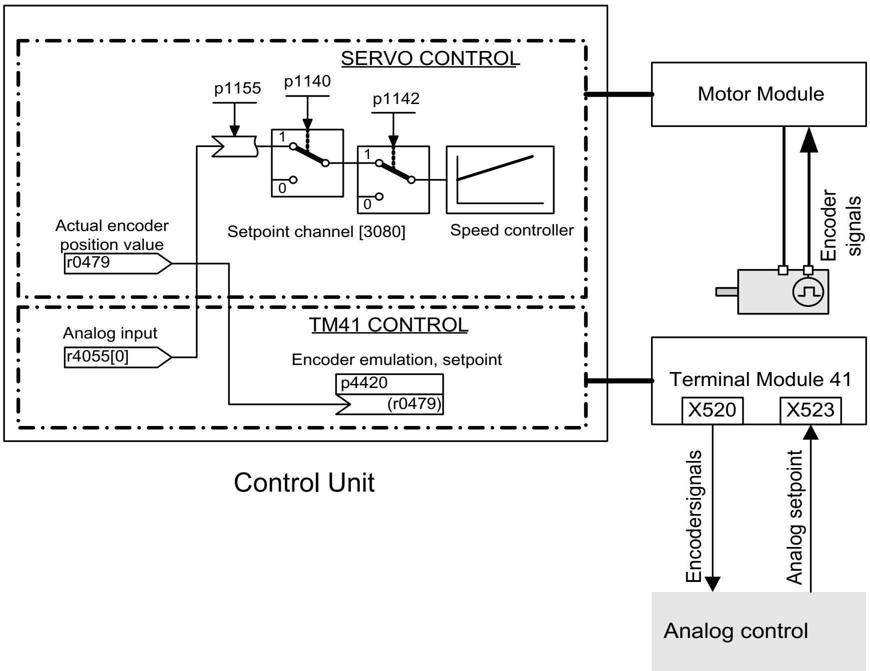


Figure 6-18 Example_TM41

Commissioning the example

Input of parameter values via STARTER screen form:

- p4400 = 1 (encoder emulation by means of encoder position actual value)
- p4420 = r0479[n] (SERVO or VECTOR), n = 0...2
- p4408 = sets the gear ratio pulse number (this must correspond to the pulse number of the leading encoder)
- p4418 = sets the fine resolution of the signal source (this must correspond to the fine resolution of the leading encoder)
- p0408 = sets the pulse number of the encoder emulation
- p0418 = sets the fine resolution of the encoder emulation

Note

To be able to signal encoder emulation faults from the TM41 to a higher-level external control, parameter r2139.0...8 CO/BO: Status word faults/alarms 1 must be interconnected via a BICO with a digital output (TM41 or CU) which can be read by the external control system.

6.20.6 Integration

Function diagrams (see SINAMICS S120/S150 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 important parameters (see SINAMICS S120/S150 List Manual)

General

- r0002 TM41 operating display
- p0408 Rotary encoder pulse number
- p0418 Fine resolution Gx_XIST1 (in bits)
- p4099 TM41 inputs/outputs, sampling time
- p4400 TM41 incremental encoder emulation operating mode
- p4401 TM41 incremental encoder emulation mode
- p4402 CO/BO: TM41 incremental encoder emulation status

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 the encoder actual position (p4400 = 1)

- p4408 TM41 encoder emulation pulse number signal source
- p4418 TM41 encoder emulation fine resolution signal source
- p4420 CI: TM41 incremental encoder emulation encoder actual position
- p4421 TM41 incremental encoder emulation deadtime compensation
- p4422 TM41 position actual value inversion
- p4426 TM41 encoder emulation pulses for the zero mark

6.21 Upgrade the firmware and project

The software must be upgraded if extended functions are made available in a more recent firmware and these functions are to be used.

The firmware for the SINAMICS drive system is distributed in the system. Firmware is installed on each individual DRIVE-CLiQ component and the Control Unit.

When it powers up, the Control Unit automatically takes its firmware from the memory card. As a consequence, it does not have to be specifically upgraded. The memory card only needs to be replaced with a card containing the more recent firmware version.

When upgraded, the firmware is saved (non-volatile) in the DRIVE-CLiQ components. The firmware of the DRIVE-CLiQ components is also provided on the memory card of the Control Unit. With the factory setting p7826 = 1, it is automatically transferred from the memory card to the DRIVE-CLiQ components when commissioned for the first time.

Once the project has been downloaded or automatic configuration has been carried out, the firmware is upgraded on all the connected DRIVE-CLiQ components. This upgrades all DRIVE-CLiQ components to the firmware release that matches the memory card.

This operation can take several minutes. This is indicated by the RDY-LED on the corresponding components flashing green/red and the Control Unit RDY-LED flashing orange at 0.5 Hz.

Parameter p7827 indicates the progress.

Once the upgrades of all components have been completed, the RDY LED on the Control Unit flashes orange at 2 Hz and the corresponding RDY LED on the components flashes green/red at 2 Hz. A POWER ON must be performed for the components in order to activate the new firmware.

For individual components, STARTER screens (Drive Unit → Overview → Version Overview) can be used to read the firmware version or start a firmware upgrade manually for specific components.

Note

The versions of the DRIVE-CLiQ components and that of the Control Unit can differ. A version overview is available in the STARTER under **<Drive Unit> → Overview → Version Overview**.

Note

DRIVE-CLiQ components with higher firmware are downwards compatible and also interoperate with DRIVE-CLiQ components that have lower firmware versions.

6.21.1 Firmware/project upgrade using the STARTER

Prerequisites are:

- a functioning drive project,
- a memory card with the latest firmware,
- the STARTER commissioning tool on a programming device (PG/PC),
- PG/PC connected with the Control Unit (target device).

Converting an existing project to the latest firmware

1. Does the project exist in the STARTER commissioning tool? If yes: then continue with point 3.
2. Open the project using STARTER:
   - Connect with target system (go online)
   - Load the project to the PG/PC
3. Convert the project to the current firmware version:
   - In the project navigator, right-click on <Drive unit > -> Target device -> Device version / Upgrade device type
   - e.g. select version "SINAMICS S120 firmware version 4.x" -> Change version

Upgrading firmware to the latest version and downloading the converted project to the target device

1. Insert the memory card containing the new firmware version:
   - Disconnect the Control Unit from the power supply,
   - Remove the memory card containing the old firmware version,
   - Insert the memory card containing the new firmware version,
   - Power-up the Control Unit again.
2. Go online and download the project to the target device, then execute the "RAM to ROM" command.
3. Upgrading the firmware for the DRIVE-CLiQ components takes place automatically.
4. Carry out a POWER ON for the drive unit (Control Unit and all DRIVE-CLiQ components). After switching on, wait until the Control Unit has completed power up and transfer of the new firmware. The signals on the diagnostic LEDs indicate this. Only then is the new firmware version active in the DRIVE-CLiQ components - and this is also displayed in the version overview.

6.21.2 Downgrade disable

Description

The downgrade disable prevents the firmware from being downgraded from updated releases which were designed to debug firmware programs.

The table below classifies the interlock levels for individual modules, which differ depending on the firmware in question.

Note

Upgrading higher firmware versions is not harmful

A higher firmware version is fully compatible with lower versions. Following a firmware upgrade, a component will also interoperate without restrictions with components that have a lower firmware version.

Table legend:

* Digit = interlock level
  When the levels are identical, the firmware may be upgraded and downgraded.
  Otherwise:
  It is not generally possible to downgrade from a higher to a lower interlock level. Downgrades are permissible where interlock levels are identical. Firmware can be upgraded only to a higher or identical interlock level.
* -- = no downgrade disable.

Table 6- 9 Downgrade disable

Module		Firmware version				
Designation	Order numbers	4.3	4.3.1	4.3.2	4.4	4.4.1
Motor Module booksize 1-axis	6SL312y[3]-a[1]TExx-x[2]AA0/-x[2]AA1	--	--	--	--	--
Motor Module booksize 1-axis	6SL312y[3]-1TExx-x[2]AA3	5	5	5	5	5
Double Motor Module booksize (2-axis)	6SL312y[3]-2TExx-x[2]AA3	4	4	4	4	4
Motor Module chassis 1-axis	6SL332y[3]-1Tu[4]xx-x[2]	--	--	--	--	--
Motor Module chassis 1-axis	6SL3320-1Txxx-x[2]Ax[2]3	2	2	2	2	2
CUA31 small memory	6SL3040-0PA00-0AA0	1	1	1	1	1
CUA31 large memory	6SL3040-0PA00-0AA1	1	1	1	1	1
CUA32	6SL3040-0PA01-0AA0	1	1	1	1	1
CU310-2DP	6SL3040-0LA00-0AA1	1	1	1	1	1
CU310-2PN	6SL3040-0LA01-0AA1	1	1	1	1	1
SMX	--	--	--	--	--	--
SMC10	6SL3055-0AA00-5AA3	0	0	0	0	0
SMC20	6SL3055-0AA00-5BA2	n	n	n	n	n
SMC20	6SL3055-0AA00-5BA3	n	n	n	n	n
SMC30	6SL3055-0AA00-5CA2	2	2	2	2	2
SME20	6SL3055-0AA00-5EA3	3	3	3	3	3
SME25	6SL3055-0AA00-5HA3	3	3	3	3	3
SME120	6SL3055-0AA00-5JA3	n	n	n	n	n
SME125	6SL3055-0AA00-5KA3	n	n	n	n	n
TMX	--	--	--	--	--	--
TM15	6SL3055-0AA00-3FA0	n	n	n	n	n
TM17	6SL3055-0AA00-3HA0	n	n	n	n	n
TM31	6SL3055-0AA00-3AA1	0	0	0	0	0
TM41	6SL3055-0AA00-3PA1	0	0	0	0	0
TM54F	6SL3055-0AA00-3BA0	1	1	1	1	1
TM120	6SL3055-0AA00-3KA0	0	0	0	0	0
DMC20	6SL3055-0AA00-6AA3	0	0	0	0	0
DME20	6SL3055-0AA00-6AB0	0	0	0	0	0
VSM10	6SL3053-0AA00-3AA1	n	n	n	n	n

[1] "a" number of axes, [2] "x" current ratings, [3] "y" cooling type, [4] "u" DC link voltage

6.21.3 Project transfer from CU320 to CU320-2

A drive project was developed for SINAMICS S120 devices (CU320) with firmware version 2.6.2 or lower. This drive project should be used on the new SINAMICS S120 CU320-2, firmware version 4.4. To do this, the project must be converted from firmware version 2.6 into the new firmware version 4.4. This conversion is demonstrated using the following example:

Example:

The following preconditions must be met:

- A programming device (PG/PC) with the STARTER commissioning tool, version 4.2 or higher
- Communication connection between the drive and PG/PC, e.g. via PROFIBUS
- A drive project with firmware 2.6.2 or lower.

Note

During the conversion, data can only be exported/imported offline.

---

1. Loading the drive project into the PG/PC:
   - Call the STARTER commissioning tool on the PG/PC.
   - Connect to target system.
   - Load the project into STARTER with "Load to PG/PC".
2. Exporting and saving the project data:
   - Disconnect from target system.
   - The export is initiated under the context menu "Expert → Save project and export object".

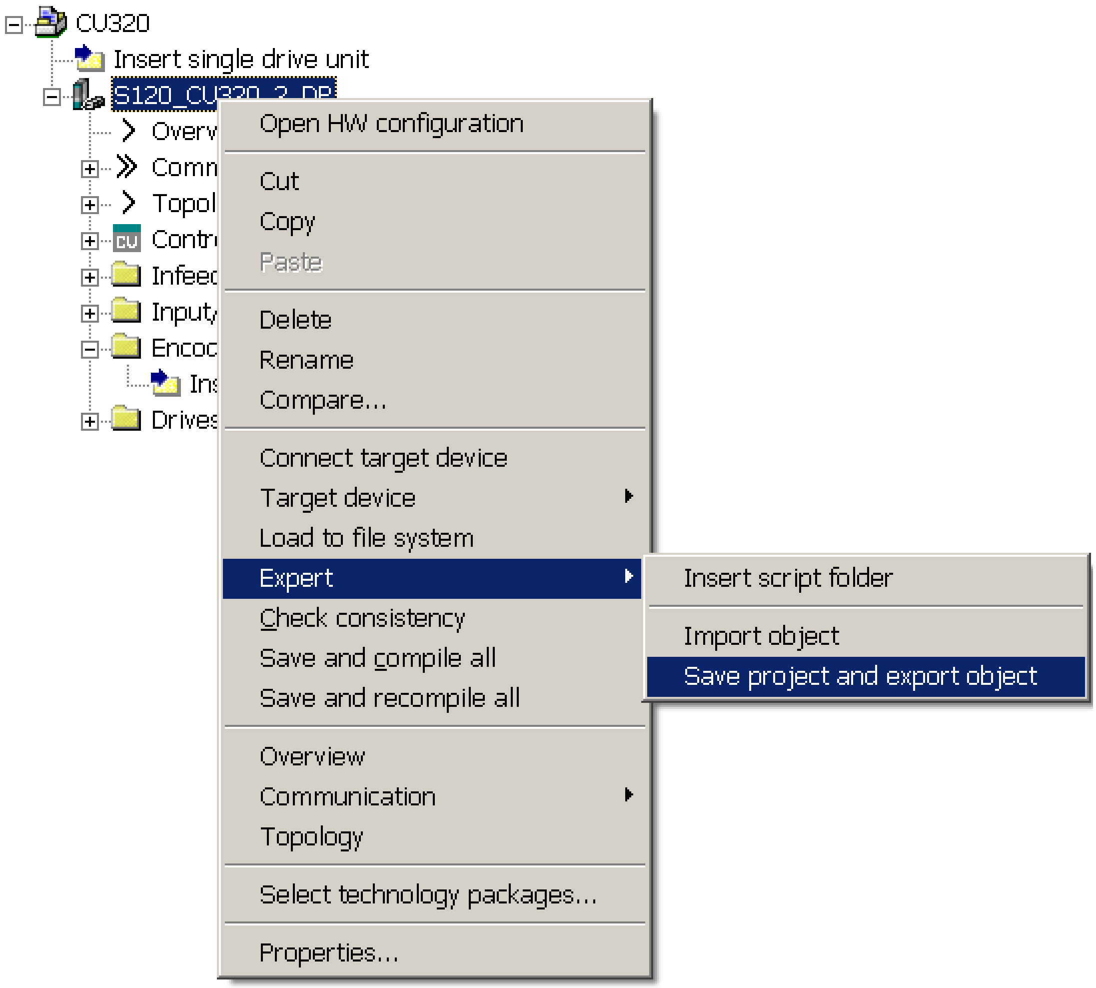


Figure 6-19 Exporting and saving a project

– The storage location for the exported drive object can be freely selected in the window "Export device" under "Browse", in the example, this is folder "Object7".

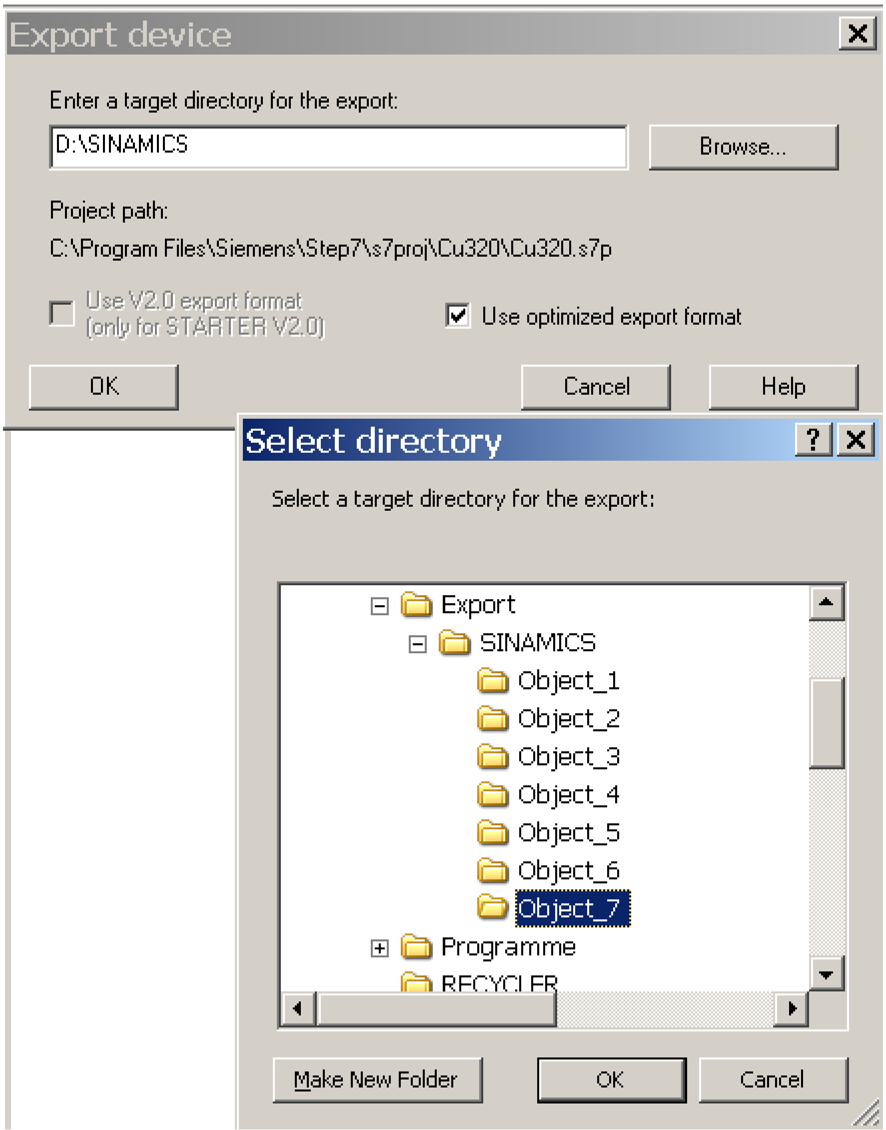


Figure 6-20 Selecting from existing projects

A window follows with a report about the project export, which you can close.

3. Importing the project data with conversion and transfer to the CU320-2:
   - Creating a new drive project in STARTER.
   - Insert a CU320-2, firmware version 4.4 using "Insert individual devices".

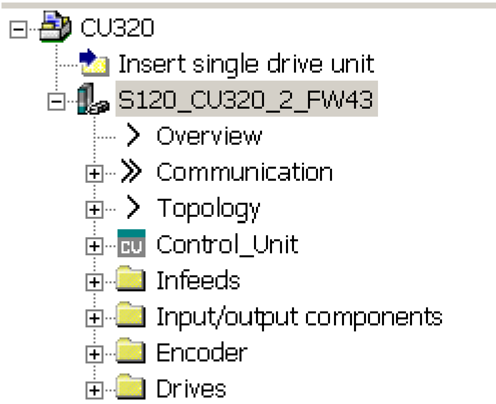


Figure 6-21 Navigation window with new hardware: S120_CU320_2_FW4.4

4. Call the new drive project (CU320-2) "Expert → Import object" using the context menu.

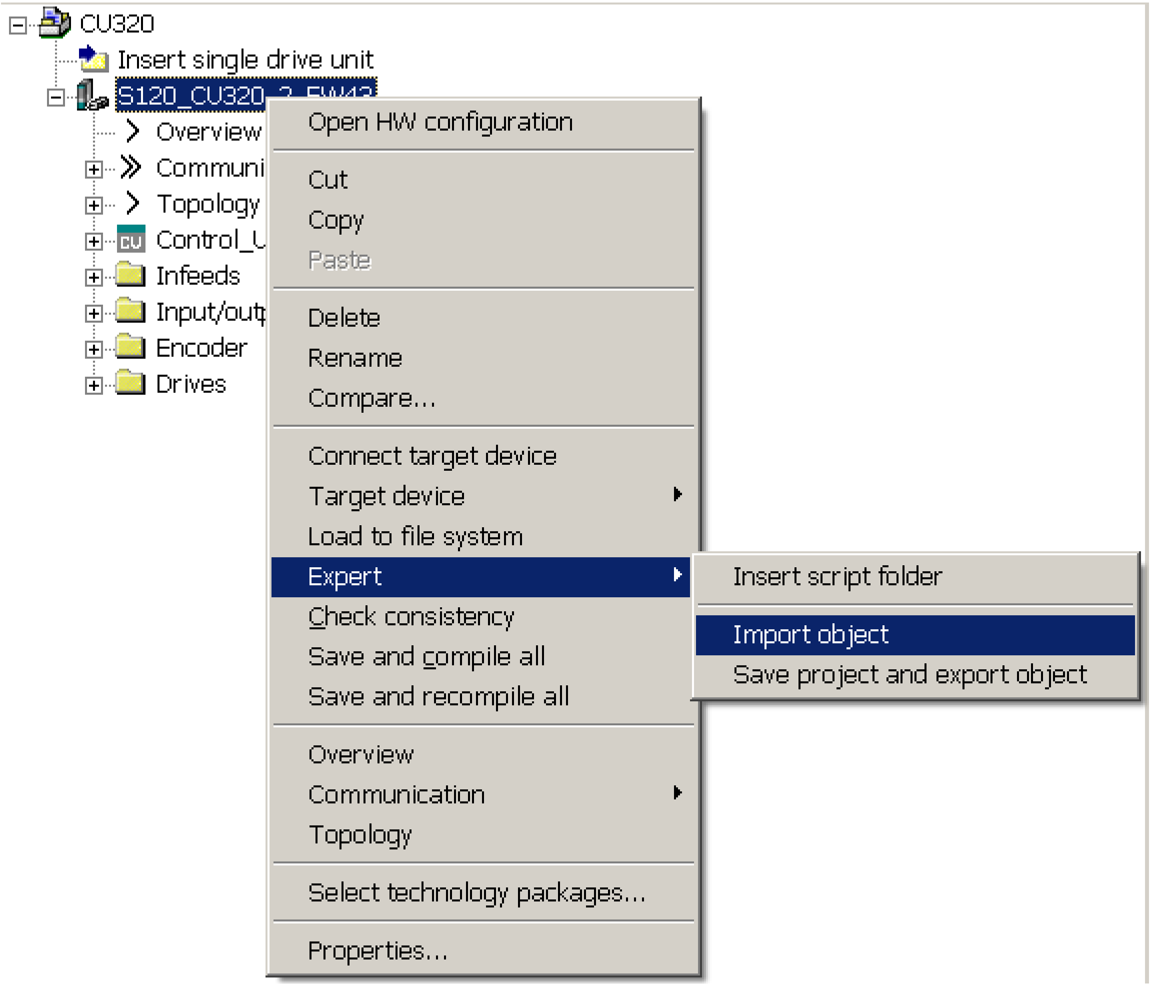


Figure 6-22 Calling a drive project

5. In the window **Import device** under **Browse**, select the required drive object, in our example, this is in folder Object7.
   – Open the *.xml file of the drive project

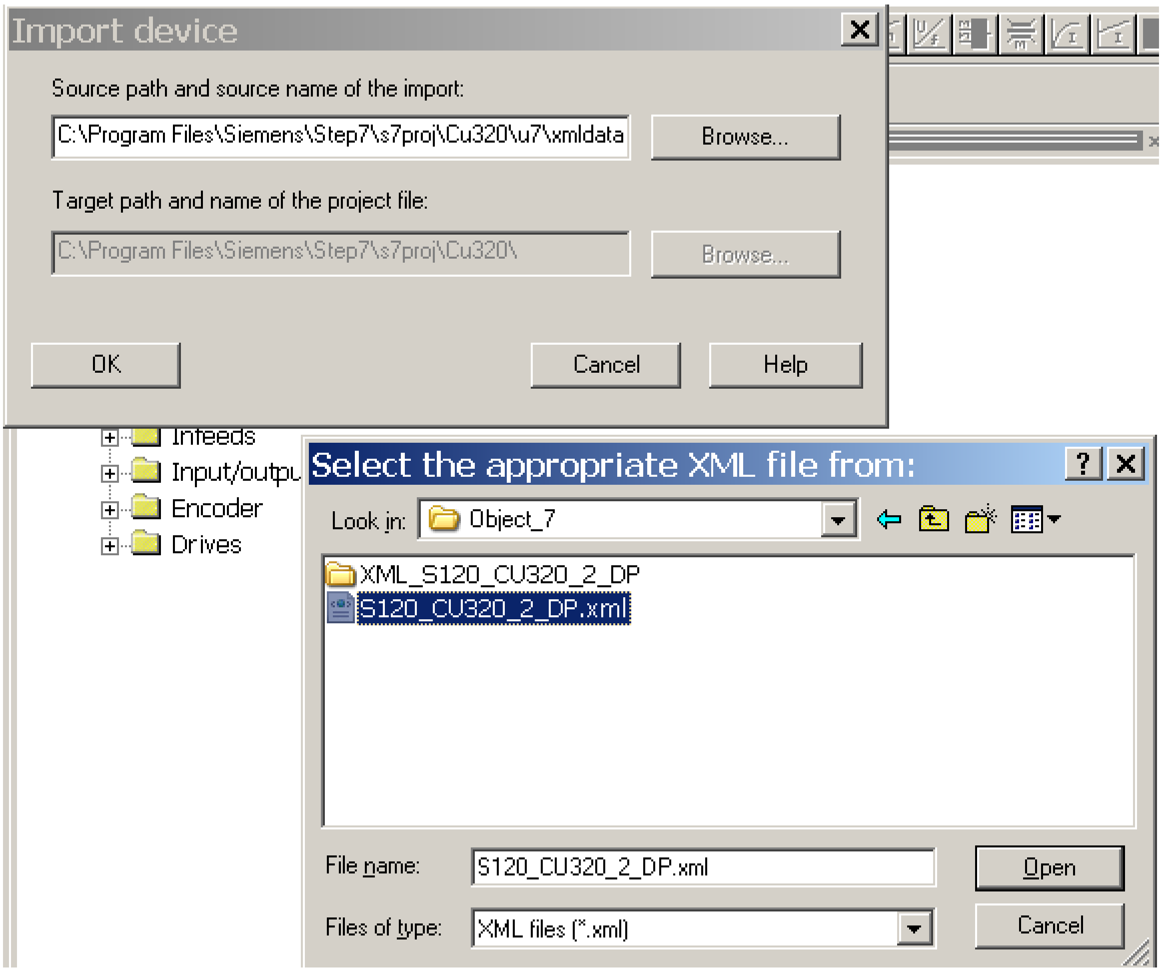


Figure 6-23 Select the xml file of the drive object

   – In the import window, confirm with **OK**, and
   – Also confirm the following queries with **OK**.

   The import starts. The status of the import is then displayed:

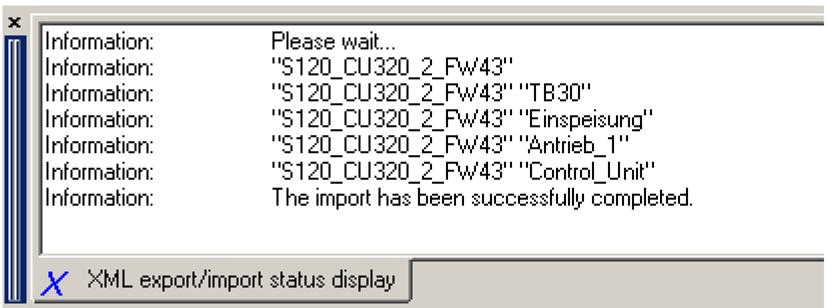


Figure 6-24 Import status

6. When importing, the existing project is converted into the new firmware version 4.4. The converted drive project is then displayed in the navigation window.

   The conversion process has been completed.

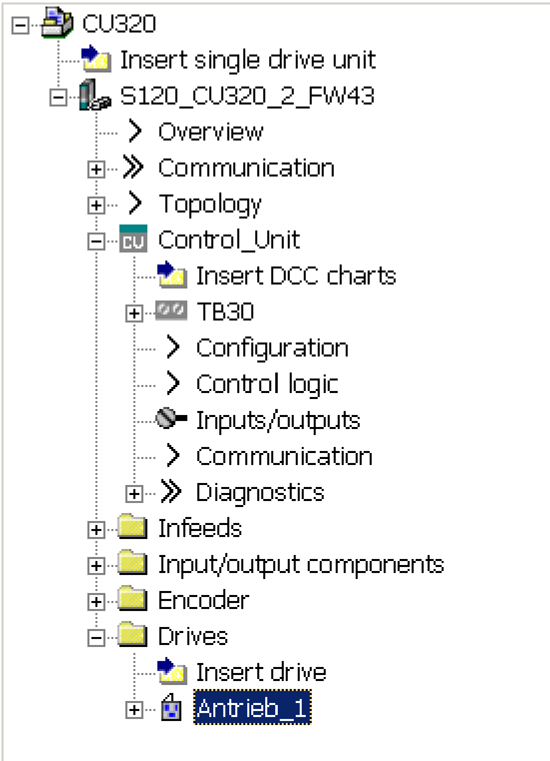


Figure 6-25 Navigation window with converted existing project

7. Transferring into the new hardware
   - Connecting the new hardware with the PG/PC, in our example using PROFIBUS.
   - Connect to target system.
   - Perform a **Download to target device**.

This completes the transfer of the drive project "Object 7" from the CU320 into the CU320-2.

Note

If a higher-level control, e.g. a SIMATIC S7, is involved as master at the drive project, then its previous settings to the CU320 must be transferred to the new CU320-2 using HW Config. To do this, you must manually note the data of the old drive project (IO addresses, telegrams, times, ...), create a new drive project and there, manually enter the data of the old drive project.

Note

When exporting/importing, DCC diagrams are completely transferred into the new drive project.

6.21.4 Project transfer from CU310 to CU310-2 PN

Migrating a project from a CU310 to a CU310-2 PN is essentially the same as described in the procedure for transferring from a CU320 to a CU320-2 DP (see Project transfer from CU320 to CU320-2 (Page 284)).

⚠ CAUTION
PROFINET configuration The PROFINET configuration when transferring a project from a CU310 to a CU310-2 PN is lost. You must note the PROFINET parameters before the migration (see PROFINET: Address parameters (Page 617)) and after the transfer has been completed, enter them again.

6.22 Pulse/direction interface

Thanks to the pulse/direction interface, in the SERVO and VECTOR control modes, SINAMICS S120 can be used for simple positioning tasks on a controller.

- The encoder interface of the SMC30 (connector X521) is used to connect the controller to the CU320-2.
- The internal encoder interface at connector X23 is used to connect the controller to the CU310-2.

The controller enters the setpoints for the pulse/direction signals to the drive via the encoder interface.

The speed actual value r0061 thus entered can then be connected as speed setpoint to the fixed setpoint p1155 via BICO

Note

- More information on the Control Unit CU320-2 and the SMC30 is provided in
  Reference: SINAMICS S120 Control Units Manual
- More information on the Control Unit CU310-2 is provided in
  Reference: SINAMICS S120 AC Drive Manual

Application: Speed-controlled drive

The drive is subject to speed control when operating on the controller. The clock frequency stipulates the speed setpoint. The pulse number is entered in p0408. This is calculated from the clock frequency of the controller and the preferred maximum motor speed. The following formula applies:

Pulse number = (max. clock frequency • 60)/max. speed

Example: If the controller has a maximum clock frequency of 100 kHz and the motor being used is to run at its maximum rated speed of 3000 rpm, the resulting pulse number will be 2000.

Wiring the SMC30 input signals

The input signals for the pulse/direction interface are wired via connector X521 of the SMC30:

Table 6- 10 Wiring the SMC30

Pin	Signal name	Technical specifications
1	Pulse	–
2	M	Ground
3	Direction of rotation	–
4	M	Ground
5 ... 8	Not relevant	–

Wiring the CU310-2 input signals

The input signals for the pulse/direction interface are wired via connector X23 of the CU310-2:

Table 6- 11 Wiring the CU310-2

Pin	Signal name	Technical specifications
1 ... 11	Not relevant	–
12	M	Ground
13	Direction of rotation	–
14	M	Ground
15	Pulse	–

Settings in the configuration wizard

Make the settings for the pulse/direction interface (rotary, 24 V, terminal, no track monitoring, no zero mark, ...) in the configuration wizard of STARTER in the dialog **Encoder data**.

Note

The pulse/direction interface is activated using p0405.5 = 1 (e.g. via the Expert list of STARTER).

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0010 Drive commissioning parameter filter
- r0061 CO: Actual speed value unsmoothed
- p0400[0...n] Encoder type selection
- p0404[0...n] Encoder configuration active
- p0405[0...n] Rectangular signal encoder track A/B
- p0408[0...n] Rotary encoder pulse number
- r0722 CO/BO: CU digital inputs, status
- p0738 BI: CU signal source for terminal DI/DO 8
- p0739 BI: CU signal source for terminal DI/DO 9
- p2530 CI: LR position setpoint
- p2550 BI: LR enable 2

Function modules 7

7.1 Function modules - Definition and commissioning

Description

A function module is a functional expansion of a drive project that can be activated during commissioning.

Examples of function modules:

- Technology controller
- Setpoint channel
- Extended brake control

A function module generally has separate parameters and, in some cases, separate faults and alarms 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 STARTER commissioning screens, you can activate the function modules directly (e.g. technology controller) or indirectly (activating the basic positioner automatically activates position control, for example).

Commissioning via parameter (only with BOP20)

The function modules can be activated/deactivated using parameter p0108 of the Control Unit (CU). The READY LED on the main component of the drive object can be made to flash by means of parameter p0124 (CU).

Overview of important parameters (see SINAMICS S120 List Manual)

- p0108[0..23] drive objects function module
- p0124[0...23] main component detection via LED

7.2 Technology controller

Features

Simple control functions can be implemented with the technology controller, e.g.:

- Fill level control
- Temperature control
- Dancer position control
- Pressure control
- Flow control
- Simple closed-loop controls without higher-level controller
- Tension control

The technology controller features:

- Two scalable setpoints
- Scalable output signal
- Separate fixed values
- Integrated motorized potentiometer
- The output limits can be activated and deactivated via the ramp-function generator.
- The D component can be switched into the control deviation or actual value channel.
- The motorized potentiometer of the technology controller is only active when the drive pulses are enabled.

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.

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.

Application example: 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, a Terminal Board 30 (TB30) is used.

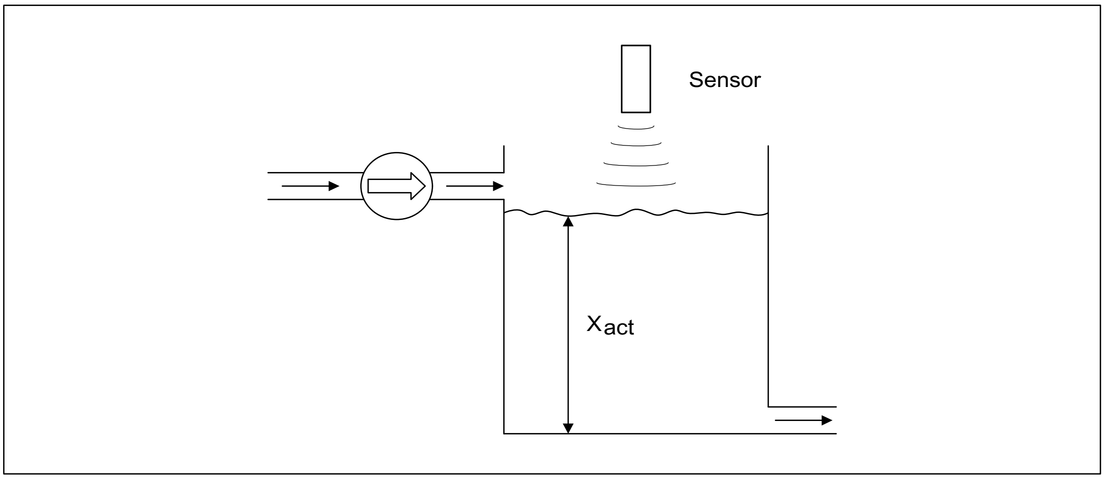


Figure 7-1 Fill level control: Application

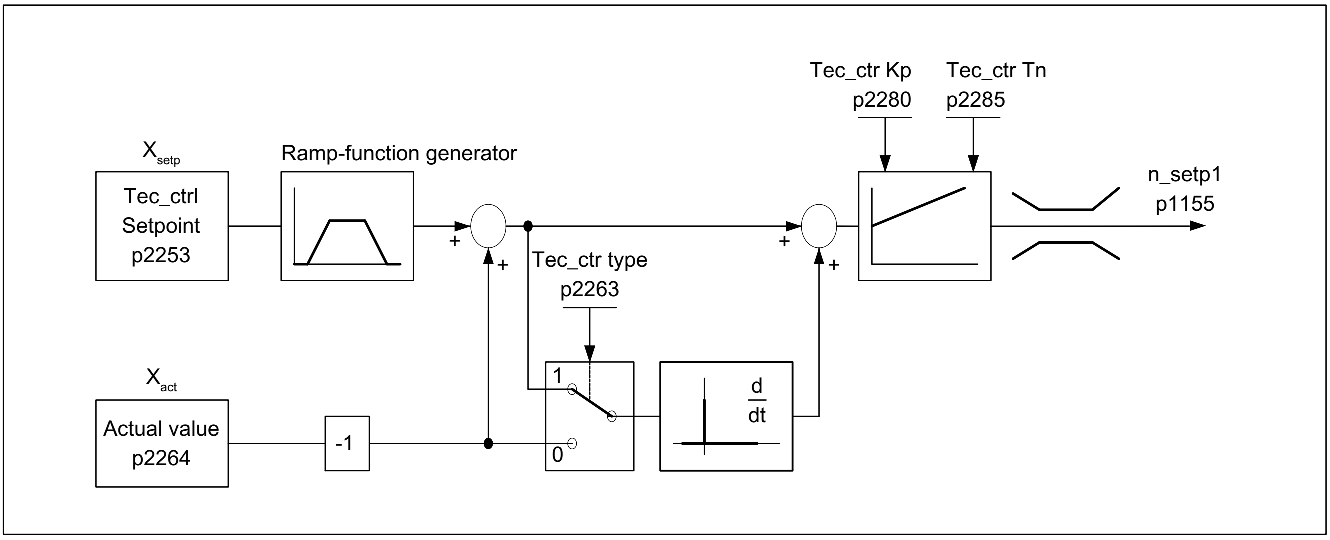


Figure 7-2 Fill level control: Controller structure

Table 7- 1 Important parameters for the level control

Parameter	Designation	Example
p1155	n_setp1 downstream of RFG	p1155 = r2294 Tec_ctrl output_sig [3080]
p2200	BI: Technology controller enable	p2200 = 1 Technology controller enabled
p2253	CI: Technology controller setpoint 1	p2253 = r2224 Fixed setpoint active [7950]
p2263	Technology controller type	p2263 = 1 D component in fault signal [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

Function diagrams (see SINAMICS S120/S150 List Manual)

- 7950 Fixed values, binary selection (r0108.16 = 1 and p2216 = 2)
- 7951 Fixed values, direct selection (p2216 = 1)
- 7954 Motorized potentiometer (r0108.16 = 1)
- 7958 Closed-loop control (r0108.16 = 1)
- 7960 Controller DC-link voltage (r0108.16 = 1)

Overview of important parameters (see SINAMICS S120/S150 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, setpoint, raise
- p2236[0...n] BI: Technology controller motorized potentiometer, setpoint, lower
- 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

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 actual 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 messages caused by brief transitional states.

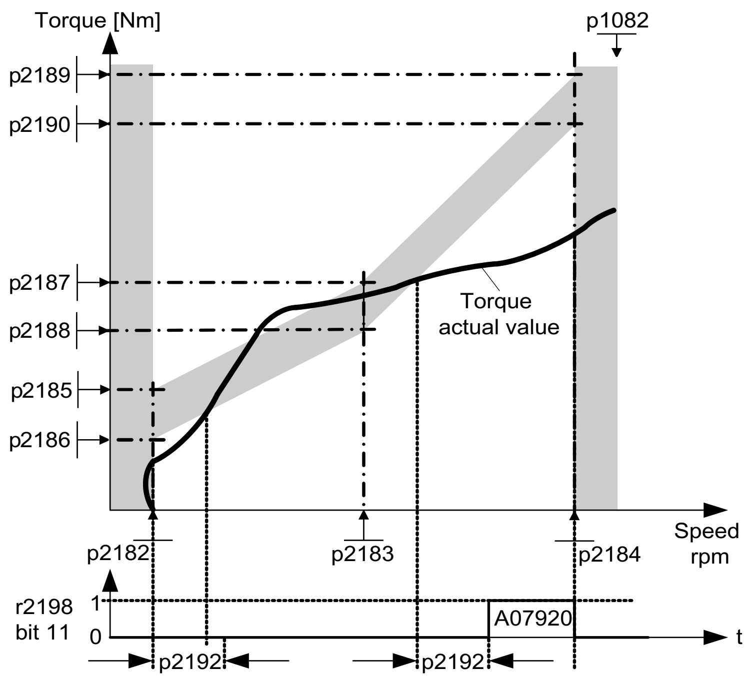


Figure 7-3 Load monitoring

Commissioning

The extended monitoring functions are activated while the commissioning wizard is running. Parameter r0108.17 indicates whether it has been activated.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8010 Speed messages 1
- 8011 Speed messages 2
- 8013 Load monitoring

Overview of important parameters (see SINAMICS S120/S150 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

Features

The "extended brake control" function has the following features:

- Forced brake release (p0855, p1215)
- Application of 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, r1229.11)
- 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 canceled (p0856)

Description

The "Extended brake control" function allows complex braking control for e.g. 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.

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).

In the case of brakes with a feedback signal (p1222), the inverted signal must be connected to the BICO input for the second (p1223) feedback signal. The brake closing and opening times 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. This can destroy the brake.

CAUTION
Brake control monitoring may only be activated for booksize power units and blocksize power units with Safe Brake Relay (p1278 = 0).

Examples

Start-up with brake applied

When the motor is switched on, the setpoint is enabled immediately (providing the required enabling signals have been issued) even if the brake has not yet been released (p1152 = 1). The factory setting p1152 = r0899.15 must be disconnected. The drive starts to generate torque against the applied brake. The brake is not released until the motor torque or current (p1220) has exceeded braking threshold 1 (p1221). Depending on the type and version of the brake, it may take some time for it to be fully released. Note that once the braking threshold torque has been exceeded, the operation enabling signal (p0899.2) is interrupted while the brake is being released (p1216) to ensure that the motor current does not exceed the permissible limit values during this period and/or the motor torque generated does not damage the brake. Interval p1216 must be set on the basis of the time the brake actually requires to release.

Emergency brake

If emergency braking is required, the brake must be applied both electrically and mechanically. This can be achieved by using OFF3 as a tripping signal for emergency braking:
p1219[0] = r0898.2 and p1275.00 = 1 (OFF3 to "Apply Brake Immediately" and invert signal).

To ensure that frequency converter does not operate against the brake, the OFF3 ramp (p1135) should be set to 0 seconds. Regenerative energy can be generated, which must be either fed back to the supply system or dissipated by means of a braking resistor.

Operating brake for crane drives

For hoisting gear with a manual control, it is important that the drive immediately responds when the control lever is moved (master switch). The drive is switched on with an ON command (p0840) (the pulses are enabled). Speed setpoint (p1142) and speed controller (p0856) are inhibited. The motor is magnetized. The magnetization time required for three-phase motors (1-2 seconds), therefore, no longer applies.

The only delay now between actuation of the master switch and movement of the motor is the brake release time. If the master switch is moved (deflected), then there is a "setpoint enable from the control" (bit interconnected with p1142, r1229.3, p1224.0). The speed controller is enabled immediately. Once the brake release time has elapsed (p1216), the speed setpoint is enabled. When the master switch is in the zero position, the speed setpoint is inhibited - the drive brakes along the deceleration ramp of the ramp-function generator. The brake closes when the speed drops below the standstill limit (p1226). After the brake closing time (p1217), the speed controller is inhibited (no motor force!). Uses extended brake control.

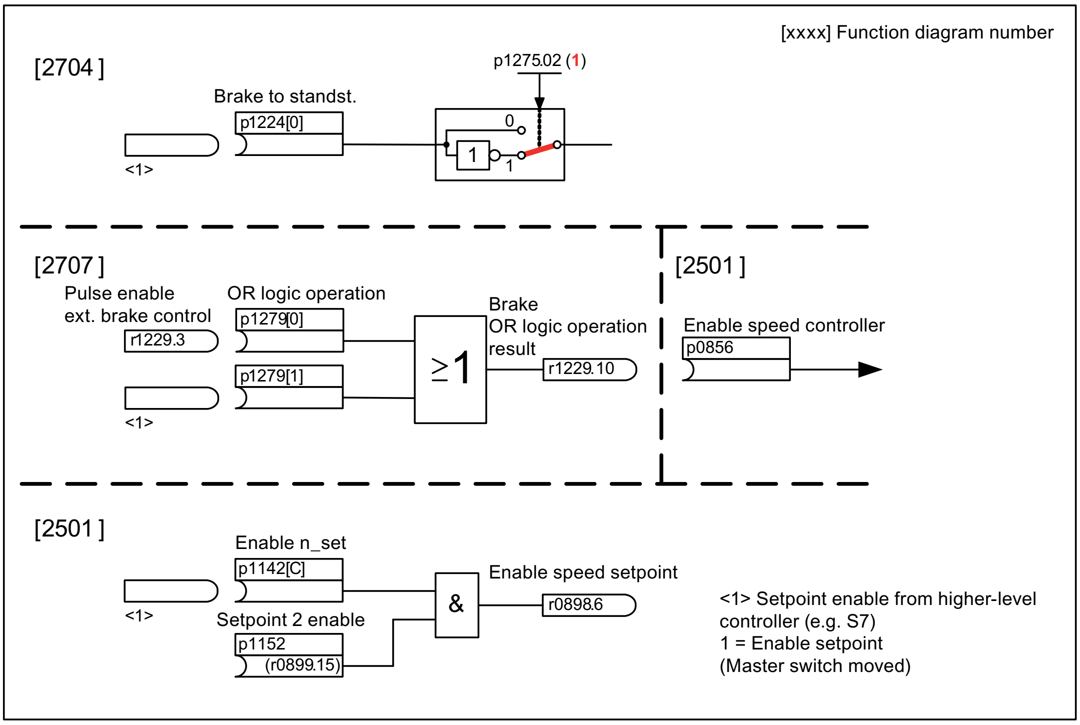


Figure 7-4 Example, operating brake for a crane drive

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 holding brake	p0858 BI: Unconditionally close holding brake	STWA.14

Table 7- 3 Status message extended brake control

Signal name	Parameter	Brake status word
Command, open brake (continuous signal)	r1229.1	B_ZSW.1
Pulse enable, extended 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
Value below brake threshold	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

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2704 Zero speed detection (r0108.14 = 1)
- 2707 Release and apply brake (r0108.14 = 1)
- 2711 Signal outputs (r0108.14 = 1)

Overview of important parameters (see SINAMICS S120/S150 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 value after actual-value smoothing (servo)
- r0063[0...2] CO: Actual speed value (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 and apply the brake

- p0855 BI: Unconditionally release holding brake
- p0858 BI: Unconditionally close 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 Open motor holding brake threshold
- p1277 Motor holding brake delay braking threshold exceeded

Free blocks

- 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

7.5 Braking Module

Features

- Braking the motor without any possibility of regenerating into the line supply (e.g. power failure)
- Fast DC link discharge (booksize format)
- The Braking Module terminals are controlled via the drive object infeed (booksize and chassis format)
- Controlling up to 8 Braking Modules in a parallel connection.
- 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.

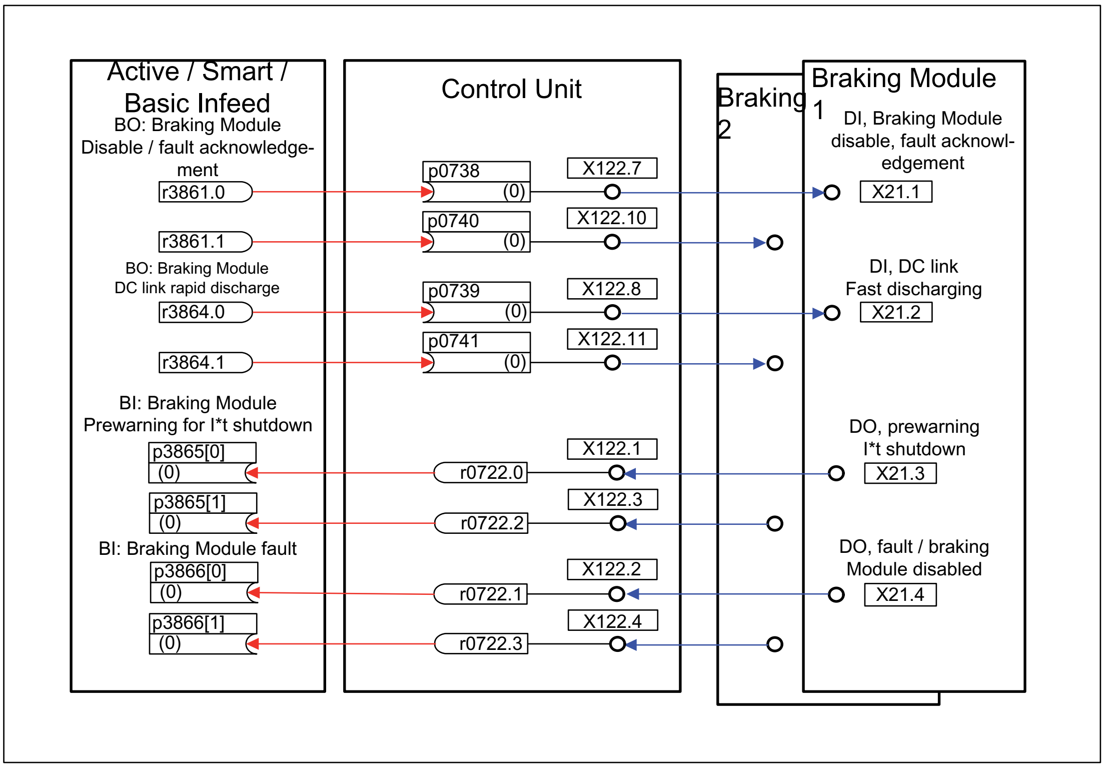


Figure 7-5 Example of controlling two booksize Braking Modules

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 X21.3 chassis every 10 ms. Alarm A06900 is output simultaneously.

Fast DC link discharge (booksize)

It is only possible to quickly discharge the DC link via the Braking Module for the booksize format. 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
A fast DC link discharge requires the use of a line contactor with feedback signal (p0860) that is controlled via r0863.1.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0108.26 Drive object function module - Braking Module external
- p3860 Braking Module number of modules connected in parallel
- r3861.0...7 BO: Braking Module inhibit/acknowledgement
- p3862 Braking Module DC link fast discharge delay time
- p3863 BI: Braking Module activate DC link fast discharge
- p3864.0...7 BO: Braking Module DC link fast discharge
- p3865[0...7] BI: Braking Module pre-alarm I*t shutdown
- p3866[0...7] BI: Braking Module fault

7.6 Motor Module as a Braking Module

7.6.1 Introduction

This function uses a Motor Module as a Braking Module. To do this, three resistors are connected to the Motor Module instead of a motor.

Requirements for operation as a Braking Module:

- CU320-2 PN or CU320-2 DP firmware 4.4 or higher
- STARTER version 4.2 or higher
- Only Motor Modules in chassis format
- Three identical braking resistors in a star (see table below) or delta connection
- At least 10 m cable length to the resistors
- Configuration in STARTER
  - VECTOR drive object
  - Control U/f

7.6.2 Features

- Permissible for Motor Modules in chassis format
- Three identical resistors required
- Parallel connection of Motor Modules possible
- Integrated protective equipment for monitoring the resistors

7.6.3 Configuring the resistors

1. The values for peak braking power must not fall below the ohmages listed in this table!
2. The resistance values stated apply to a single cold resistor in a star connection.
3. The braking power listed must be divided by 3 for a single resistor.
4. For delta connections, the resistance value must be multiplied by 3.
5. The tables apply for all chassis designs (liquid-cooled/convection-cooled, with old or new control electronics).
6. The cable lengths to the resistors must be at least 10 m.

The resistance can be entered via p1360 in a star connection. The default setting of the resistance values is calculated from:

p1362[0] / (sqrt(6) * r0207[0])

p1362[0] = chopper thresholds from the table below,

r0207[0...4] = Rated current of Infeed Module.

Table 7- 4 Resistance table 380 - 480 V supply voltage

Motor module frame size	Rated voltage	Rated current	Braking current	$U_{DC\ link}$ chopper threshold	Continuous braking power	Peak braking power	Resistance Continuous braking power	Resistance Peak braking power
	[V]	[A]	[A]	[V]	[kW]	[kW]	[ohm]	[ohm]
F	400	210	210	667	172	257	1.297	0.864
	480	210	210	774	199	299	1.505	1.003
F	400	260	255	667	206	312	1.068	0.712
	480	260	255	774	242	363	1.239	0.826
G	400	310	290	667	237	355	0.939	0.626
	480	310	290	774	275	412	1.090	0.726
G	400	380	340	667	278	417	0.801	0.534
	480	380	340	774	322	483	0.929	0.620
G	400	490	450	667	368	551	0.605	0.403
	480	490	450	774	427	640	0.702	0.466
H	400	605	545	667	445	668	0.500	0.333
	480	605	545	774	517	775	0.580	0.387
H	400	745	680	667	555	833	0.400	0.267
	480	745	680	774	645	967	0.465	0.310
H	400	840	800	667	654	980	0.340	0.277
	480	840	800	774	758	1138	0.395	0.263
J	400	985	900	667	735	1103	0.303	0.202
	480	985	900	774	853	1280	0.351	0.234
J	400	1260	1215	667	93	1489	0.224	0.149
	480	1260	1215	774	1152	1728	0260	0.173
J	400	1405	1365	667	1115	1673	0.199	0.133
	480	1405	1365	774	1294	1941	0.231	0.154

Table 7- 5 Resistance table 500 - 690 V supply voltage

Motor module frame size	Rated voltage	Rated current	Braking current	$U_{DC\ link}$ chopper threshold	Continuous braking power	Peak braking power	Resistance Continuous braking power	Resistance Peak braking power
	[V]	[A]	[A]	[V]	[kW]	[kW]	[ohm]	[ohm]
F	500	85	85	841	87.6	131.3	4.039	2.693
	600	85	85	967	100.7	151.0	4.644	3.096
	660	85	85	1070	111.4	167.1	5.139	3.426
	690	85	85	1158	120.6	180.8	5.562	3.708
F	500	100	100	841	103.0	154.5	3.433	2.289
	600	100	100	967	118.4	177.6	3.948	2.632
	660	100	100	1070	131.0	196.6	4.368	2.912
	690	100	100	1158	141.8	212.7	4.728	3.152
F	500	120	115	841	118.5	177.7	2.986	1.990
	600	120	115	967	136.2	204.3	3.433	2.289
	660	120	115	1070	150.7	226.1	3.798	2.532
	690	120	115	1158	163.1	244.6	4.111	2.741
F	500	150	144	841	148.3	222.5	2.384	1.590
	600	150	144	967	170.5	255.8	2.742	1.828
	660	150	144	1070	188.7	283.1	3.034	2.022
	690	150	144	1158	204.2	306.3	3.283	2.189
G	500	175	175	841	180.3	270.4	1.962	1.308
	600	175	175	967	207.3	310.9	2.256	1.504
	660	175	175	1070	229.3	344.0	2.496	1.664
	690	175	175	1158	248.2	372.3	2.701	1.801
G	500	215	215	841	221.5	332.2	1.597	1.065
	600	215	215	967	254.6	381.9	1.836	1.224
	660	215	215	1070	281.8	422.6	2.032	1.354
	690	215	215	1158	304.9	457.4	2.199	1.466
G	500	260	255	841	262.7	394.0	1.346	0.898
	600	260	255	967	302.0	453.0	1.548	1.032
	660	260	255	1070	334.2	501.3	1.713	1.142
	690	260	255	1158	361.7	542.5	1.854	1.236
G	500	330	290	841	298.7	448.1	1.184	0.789
	600	330	290	967	343.5	515.2	1.361	0.908
	660	330	290	1070	380.0	570.1	1.506	1.004
	690	330	290	1158	441.3	616.9	1.630	1.087
H	500	410	400	841	412.0	618.0	0.858	0.572
	600	410	400	967	473.7	710.6	0.987	0.658
	660	410	400	1070	524.2	786.3	1.092	0.728
	690	410	400	1158	567.3	851.0	1.182	0.788

Motor module frame size	Rated voltage	Rated current	Braking current	$U_{DC\ link}$ chopper threshold	Continuous braking power	Peak braking power	Resistance Continuous braking power	Resistance Peak braking power
	[V]	[A]	[A]	[V]	[kW]	[kW]	[ohm]	[ohm]
H	500	465	450	841	463.5	695.3	0.763	0.509
	600	465	450	967	532.9	799.4	0.877	0.585
	660	465	450	1070	589.7	884.6	0.971	0.647
	690	465	450	1158	638.2	957.3	1.051	0.700
H	500	575	515	841	530.5	795.7	0.667	0.444
	600	575	515	967	609.9	914.9	0.767	0.511
	660	575	515	1070	674.9	1012.3	0.848	0.565
	690	575	515	1158	730.4	1095.6	0.918	0.612
J	500	735	680	841	700.4	1050.6	0.505	0.337
	600	735	680	967	805.3	1208.0	0.581	0.387
	660	735	680	1070	891.1	1336.7	0.642	0.428
	690	735	680	1158	964.4	1446.6	0.695	0.463
J	500	810	805	841	829.2	1243.7	0.427	0.284
	600	810	805	967	953.4	1430.1	0.490	0.327
	660	810	805	1070	1054.9	1582.4	0.543	0.362
	690	810	805	1158	1141.7	1712.5	0.587	0.392
J	500	910	905	841	932.2	1398.2	0.379	0.253
	600	910	905	967	1071.8	1607.7	0.436	0.291
	660	910	905	1070	1186.0	1779.0	0.483	0.322
	690	910	905	1158	1283.5	1925.3	0.522	0.348
J	500	1025	1020	841	1050.6	1575.9	0.337	0.224
	600	1025	1020	967	1280.0	1812.0	0.387	0.258
	660	1025	1020	1070	1336.7	2005.0	0.428	0.286
	690	1025	1020	1158	1446.6	2169.9	0.463	0.309
J	500	1270	1230	841	1266.9	1900.4	0.279	0.186
	600	1270	1230	967	1456.7	2185.1	0.321	0.214
	660	1270	1230	1070	1611.9	2417.8	0.355	0.237
	690	1270	1230	1158	1744.5	2616.7	0.384	0.256

Connection of the braking resistors

The braking resistors should preferably be wired in a star connection.

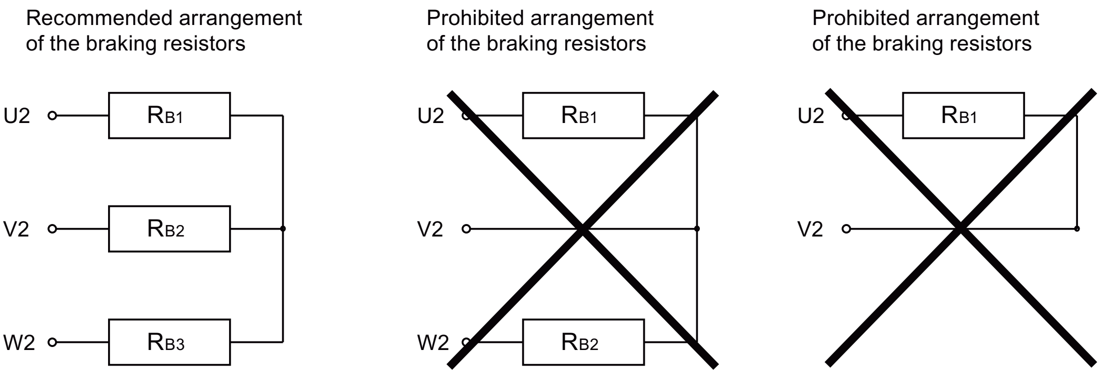


Figure 7-6 Braking resistors

Setting the chopper threshold

The previous chopper thresholds are taken from the Basic Line Module (table below).

The chopper threshold p1362[0] and hysteresis p1362[1] are adjustable. Depending on the type of voltage and the factory setting for p0210, the parameters are assigned default values.

The cold resistance values of the braking resistors for p0340 = 1 during STARTER commissioning are measured and calculated automatically.

Table 7- 6 Chopper threshold

Line voltage	V	380 - 480	500 - 600	660 - 690
Tolerance	%	+/-10%, -15%(60s)	+/-10%, -15%(60s)	+/-10%, -15%(60s)
Ud_{max} p0210	V	820	1022	1220
Chopper threshold p1360	V_{min}	759	948	1137
	V_{rated}	774	967	1159
	V_{max}	789	986	1179
Ud_{max} controller threshold p1362[0]	V_{min}	759	948	1137
	V_{rated}	774	967	1159
	V_{max}	789	986	1179
HW shutdown threshold	V_{min}	803	1003	1198
	V_{rated}	819	1022	1220
	V_{max}	835	1041	1244
AFE max. operating voltage	V_{max}	750	940	1030
AFE briefly t ≤ 60s	V	785	980	1130

7.6.4 Activating the function

You have opened the STARTER commissioning tool and created a new project.

1. Configure the Control Unit and the infeed module as usual (see SINAMICS S120 Commissioning Manual).
2. Select the type "VECTOR" as drive objects.
3. "U/f control" should be selected as controller structure.
4. Under "Control mode", select "(15) Operation with braking resistor".
5. Select the connection voltage in the Configuration window.
6. Select "Cabinet Module" as type of construction in the Configuration window.
7. Select the required power unit in the Configuration window.
8. Close the Configuration window for the Motor Module and the resistors.
9. Follow the wizard from "Continue >" up to "Complete".

The Motor Module is displayed with the component number in the topology. The Motor Module recognizes the values of the resistors and automatically sets the current limits. The resistance can be read in parameter p1360.

Note

Commissioning with AOP

When commissioning with an AOP, it is possible to skip step 4 and operate the Motor Module in speed-control mode (no U/f control).

Parallel connection

The Motor Modules can be operated in parallel as Braking Modules. The setting is made in the STARTER as follows during configuration:

- After point 7 in the list above, the "Configuration window Power unit Additional data" appears.
- Activate the checkbox for "Parallel connection" in this screen. The pull-down menu for the "Number of parallel modules" appears.
- Select the desired number of Motor Modules.
- Click on "Continue" until you reach "Complete". You have now completed the wizard for the configuration of the Motor Modules.

You can check the number of Motor Modules you have set in the topology.

The braking resistors must be dimensioned for each Motor Module according to the table of resistances above.

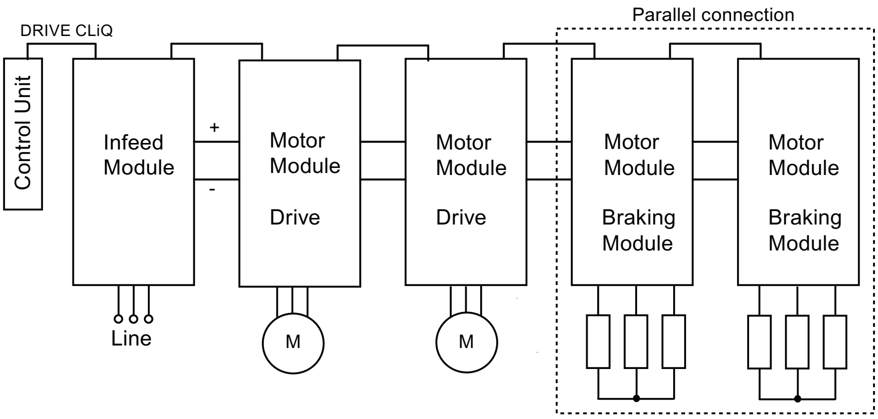


Figure 7-7 Parallel connection of Motor Modules as Braking Modules

To carry out further checks, double-click on ".../Drives/Drive_1 > Configuration" in the navigation list. A dialog opens allowing you to check the current configuration. The "Current power unit operating values" button lists the Motor Modules according to component number. During operation, they show the current electrical values.

Master/slave

Motor Modules connected in parallel can also be operated in master/slave mode. To do this, use parameter p1330 to enter the input of the U/f characteristic for the next power unit. The slaves only receive the voltage setpoint for the U/f characteristic.

7.6.5 Protective equipment

The protective functions are described in detail in the section "Thermal motor monitoring".

- Ground fault

  Monitoring of sum of all phase currents.

- Cable break

  An unbalanced load of 20% and more produces a non-symmetrical current and is detected by the I*T monitoring.

  - Alarm A6921 is output if phase non-symmetry is detected.
  - The errors are located in parameter r0949:
    Parameter r0949 = 11 Wire break phase U
    Parameter r0949 = 12 Wire break phase V
    Parameter r0949 = 13 Wire break phase W
  - Fault F6922 is output if a phase failure is detected.

- Overcurrent

  The Imax controller is active. The setpoint is stored in parameter p0067.
- Overtemperature of the resistors

  The temperature is monitored by means of bimetal termperature switches installed at the resistors.
  - Switch the temperature evaluation contacts of all 3 resistors in series.
  - Connect the temperature evaluation contacts to the temperature sensor evaluation of the Motor Module (terminals X41.3 and X41.4).
  - Parameterize the temperature sensor evaluation of the Motor Module as "external fault" of the converter.
  - Set parameter p0600 = 11 and p0601 = 4.

7.6.6 Integration

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0108[0…23] Drive objects function module
- r0207[0…4] Power unit rated current
- r0949[0...63] Fault value
- p1300[0...n] Open-loop/closed-loop control operating mode
- p1330[0...n] CI: U/f control independent of voltage setpoint
- p1360 Braking Module braking resistance, cold
- p1362[0…1] Braking Module switch-on threshold
- p1363 CO: Braking Module output voltage
- p1364 Braking Module non-symmetrical resistance

7.7 Cooling unit

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 deionized 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).

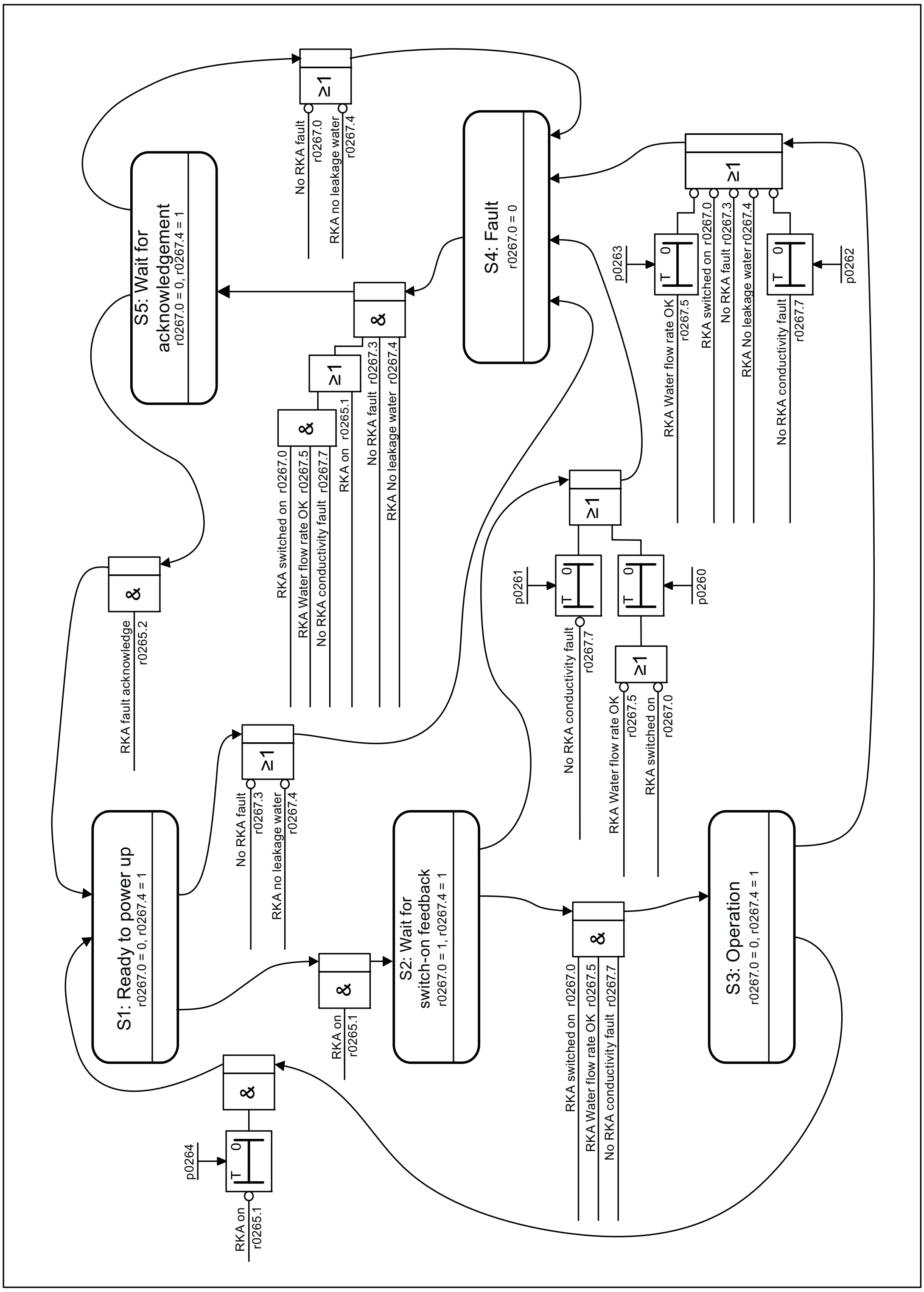


Figure 7-8 Sequence control cooling unit

Commissioning

You activate the "cooling unit" function module by setting Control Unit parameter p0108[x].28 = 1. "x" stands for the number of the particular drive object (power unit).

Parameter r0108.28 of the particular drive object (power unit) can be used to check the activation.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 9794 Cooling unit, control and feedback signals
- 9795 Cooling unit sequence control

Overview of important parameters (see SINAMICS S120/S150 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

7.8 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 offline via: Right-click the drive > Properties > Function Modules. It must then be downloaded to the target system.

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 S120/S150 List Manual)

- 7008 kT estimator

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0108.1 drive objects function module - extended torque control
- 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

7.9 Closed-loop position control

7.9.1 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)
- Position tracking of the load gear (motor encoder), using absolute encoders for rotary axes (modulo) as for linear axes.

7.9.2 Position actual value conditioning

7.9.2.1 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)

7.9.2.2 Description

The position actual value conditioning converts the actual position value into a neutral distance 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).

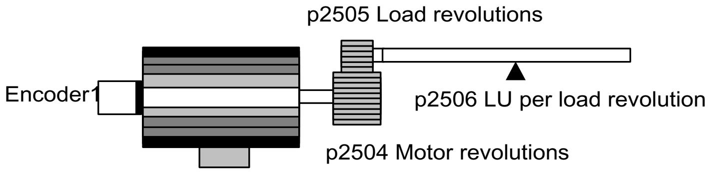
The position actual value is conditioned, regardless of whether the position controller is enabled immediately after the system has booted, as soon as valid values are received via the encoder interface.

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]

p2502 = 1, position control at motor encoder 1



p2502 = 2, position control at external encoder 2

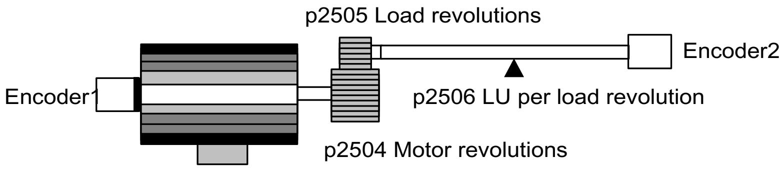


Figure 7-9 Position actual value sensing with rotary encoders

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).

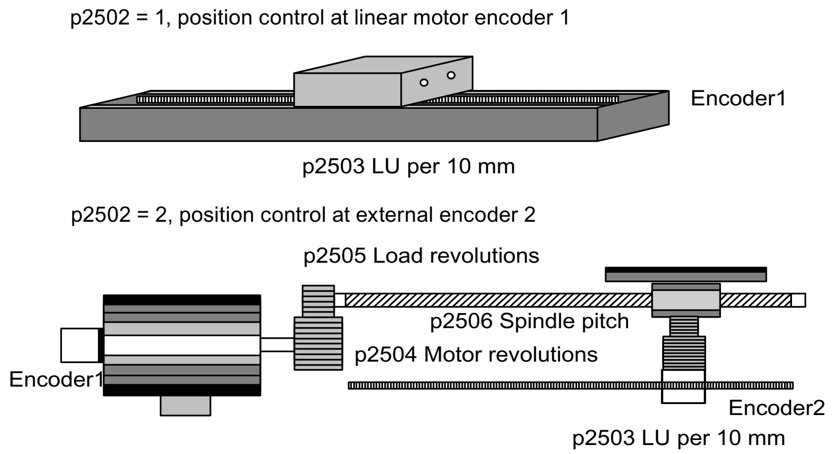


Figure 7-10 Position actual value sensing with linear encoders

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

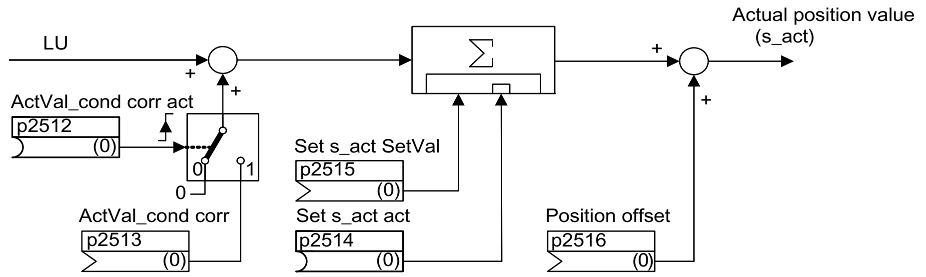


Figure 7-11 Position actual value conditioning

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.

7.9.2.3 Indexed actual value acquisition

Features

- Encoder assignment (p2502[D])
- Absolute encoder adjustment (p2507[E])
- Activate measuring probe evaluation (p2509[0...3])
- Measuring probe evaluation selection (p2510[0..3])
- Measuring probe edge (p2511[0..3])
- Activate position actual value conditioning, correction value (p2512[0...3])
- Position actual value conditioning, correction 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[E])
- 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 conditioning

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 wird for encoder x (Geber 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.

7.9.2.4 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

Preconditions

- Absolute encoder

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.

Position tracking for load gear functions in the same way as position tracking for the measuring gear (see "Position tracking/Measuring gear"). Position tracking is activated via 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.

Position tracking for the load gear can only be activated once for each motor data set MDS.

The load position actual value in r2723 (must be requested via Gn_STW.13, see chapter "Control and status words for encoders") comprises the following 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 gear ratio (p0433/p0432), if p0411.0 = 1

> **Note**
>
> The sum of p0408, p0419 and p2721 is limited to 32 bits.

Note

Load gear problems and solutions, see example in chapter Position tracking -> Measuring gear.

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).

The following diagram illustrates an absolute encoder that can represent 8 encoder revolutions (p421 = 8).

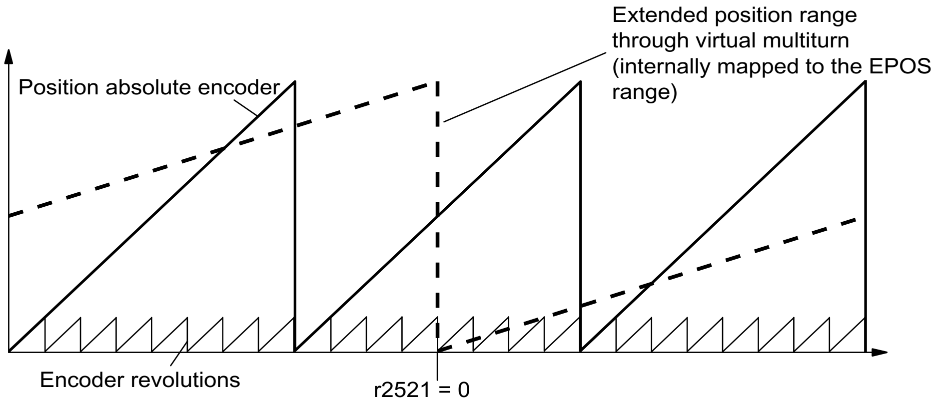


Figure 7-12 Position tracking (p2721 = 24), setting p2504 = p2505 =1 (gear factor = 1)

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 gear) 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
  The position values stored in non-volatile memory are reset in response to the following events:
  - When encoder replacement is detected.
  - When the configuration of the encoder data set (EDS) is modified.
  - When the absolute encoder is adjusted again.

Note

If position tracking of the load gear is activated with parameter p2720[0] = 1 (position gear load tracking) after the encoder is adjusted (p2507 = 3), the adjustment will be reset.

If the encoder is adjusted again when load position tracking is active, the load gear position will be reset (overflows).

The permissible position tracking range is mapped onto the reproducible encoder range of EPOS.

It is possible to activate position tracking for several DDS.

Virtual multiturn encoder (p2721)

The number of resolvable load rotations for a rotary absolute encoder with active position tracking
can be set by means of the virtual multiturn resolution.
It is only editable for rotary axes.

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.

NOTICE
If the gear factor is not equal to 1, then p2721 always refers to the load side. The virtual resolution, which is required for the load, is then set here.

In the case of rotary axes, the virtual multiturn resolution (p2721) is preset to the multiturn resolution value of the encoder (p0421) and can be altered.
Example: Singleturn encoder
Parameter p0421 is preset to p0421 = 1. However, parameter p2721 can be altered subsequently, e.g. the user can program p2721 = 5. As a result, the encoder evaluation initiates 5 load rotations before the same absolute value is achieved again.

In the case of linear axes, the virtual multiturn resolution (p2721) is preset to the multiturn resolution value of the encoder (p0421), which is extended by 6 bits, (max. 32 positive/negative overflows).
The setting for p2721 cannot be edited again afterwards.
Example: Multiturn encoder:
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.

If, as a result of extension of the multiturn information, the displayable area of r2723 (32 bits) 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, 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 gear rating 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.

Multiple drive data sets

Position tracking of the load gear can be activated in multiple drive data sets.

- The load gear is DDS-dependent.
- Load gear position tracking is computed only for the active drive data set and is EDS-dependent.
- The position tracking memory is only available once for each EDS.
- For position tracking to be continued in different drive data sets under the same mechanical conditions and with the same encoder data sets, it must be activated explicitly in all the relevant drive data sets. Possible applications of drive data set changeover with continuation of position tracking:
  – Star/delta changeover
  – Different ramp-up times / controller settings
- When the changeover between drive data sets involves a change in gear unit, the position tracking function starts from the beginning again, i.e. it behaves on changeover as if a POWER ON had occurred.
- With identical mechanical conditions and encoder data set, a DDS changeover does not affect the status of the encoder adjustment or reference point.

Restrictions

- Position tracking cannot be activated for an encoder data set which is used in different drive data sets as encoder1 for different gears. If an attempt is still made to activate position tracking, fault "F07555 (Drive encoder: Configuration position tracking" will be displayed with fault value 03 hex.
  A check is generally performed to determine whether the load gear is the same in all DDS in which the relevant encoder data set is used.
  In this case, the settings in each of the load gear parameters p2504[D], p2505[D], p2720[D], p2721[D] and p2722[D] must be identical.
- If an encoder data set is used in one DDS as a motor encoder with position tracking and in another DDS as an external encoder, the position tracking starts from the beginning again, i.e. it behaves in the same way as it would do after a POWER ON.
- If position tracking is reset in one drive data set, it is also reset in all other drive data sets which contain the relevant encoder data set.
- An axis in an inactive drive data set may move by a maximum of half an encoder range (see p2722: tolerance window).

The following table describes what happens on changeover from one DDS to another. A DDS changeover always starts from DDS0.

An overview of DDS changeover without position tracking load gear can be found in section "Instructions for data set changeover" in chapter "EPOS - referencing".

Table 7- 7 DDS changeover with load gear position tracking

DDS	p0186 (MDS)	p0187 (encoder_1)	p0188 (encoder_2)	p0189 (encoder_3)	Encoder for position control p2502	Mechanical conditions p2504/ p2505/ p2506 or p2503	Load gear position tracking	Changeover response
0	0	EDS0	EDS1	EDS2	encoder_1	xxx	activated	---
1	0	EDS0	EDS1	EDS2	encoder_1	xxx	activated	Changeover during pulse inhibit or operation has no effect
2	0	EDS0	EDS1	EDS2	encoder_1	yyy	deactivated	Pulse inhibit/operation: Encoder adjustment and referencing bit are reset. Position tracking for EDS0 is no longer calculated and must be re-adjusted when switching back to DDS0.
3	0	EDS0	EDS1	EDS2	encoder_2	xxx	activated	Pulse inhibit/operation: Position tracking for EDS0 is continued and the referencing bit is reset.1)
4	0	EDS0	EDS3	EDS2	encoder_2	xxx	activated	Pulse inhibit/operation: Position tracking for EDS0 is continued and the referencing bit is reset.1)
5	1	EDS4	EDS1	EDS2	encoder_1	xxx	activated	Pulse inhibit/operation: Position tracking for EDS4 is newly initiated and the referencing bit is reset.1) When switching back to DDS0, the same applies for EDS0.
6	2	EDS5	EDS6	EDS7	encoder_1	zzz	activated	Pulse inhibit/operation: Position tracking for EDS5 is newly initiated and the referencing bit is reset.1) When switching back to DDS0, the same applies for EDS0.
7	3	EDS0	EDS1	EDS2	encoder_1	xxx	activated	MDS changeover alone during pulse inhibit or operation has no effect.

8	0	EDS0	EDS1	EDS2	encoder_1	xxx	deactivated	Pulse inhibit/operation: The referencing bit is reset.1) Position tracking for EDS0 is no longer calculated and, as a consequence, the position actual value also changes (the offset correction of the position tracking is canceled). When switching back to DDS0, the position tracking for EDS0 is newly set and the referencing bit is reset.1) It only makes sense to switch back to DDS0 without a new adjustment in DDS0 if the user did not make a new adjustment in DDS8 and the permissible tolerance window (p2722) was not exited.
9	4	EDS6	EDS0	EDS2	encoder_1	www	activated	Pulse inhibit/operation: Position tracking for EDS6 is newly initiated and the referencing bit is reset.1) When switching back to DDS0, the same applies for EDS0.

1) The referencing bit (r2684.11) is reset for a DDS changeover. If, in the new DDS, the EDS already has an adjusted encoder, then the referencing bit is set again.

Definitions:

- *Position tracking is continued*
  The behavior of the position tracking during the changeover is the same as it would be if the data set had not even been changed.
- *Position tracking is newly initiated* (The position actual value can change when the changeover is made!)
  The behavior during changeover is the same as the behavior after a POWER ON. The position value read by the absolute encoder is compared to the stored value. If the position difference is within the tolerance window (p2722), the position is corrected correspondingly; if it is outside the range, a corresponding fault message is generated.
- *Position tracking is reset* (The position actual value can change when the changeover is made!)
  The stored absolute value is rejected and the overflow counter is reset to zero.
- *Position tracking is not calculated* (The position actual value changes when the changeover is made!)
  The saved absolute value of the position tracking - including the offset correction from the dissolved DDS - is not used.
- www, xxx, yyy, zzz: Different mechanical conditions.
- Additional information: The position tracking memory is only available once for each EDS.

7.9.2.5 Commissioning position tracking load gear using STARTER

The position tracking function can be configured in the "Mechanical system" screen for "Position control" in STARTER.
The "Mechanical system" screen for "Position control" is not made accessible unless the function module "Basic positioner" is activated (r0108.4 = 1) which means that the function module "Position control" (r0108.3 = 1) is automatically activated as well.

The "Basic positioner" function module can be activated via the commissioning wizard or the drive configuration (configure DDS) (configuration "Closed-loop control structure" - checkbox "Basic positioner").

Configuring the position tracking load gear function

The "Position tracking load gear" function can be configured in the following STARTER screens:

1. In the "Mechanical system configuration" screen in the commissioning wizard.
2. In the project navigator under Drive → "Technology" → "Position control" in the "Mechanical system" screen.

7.9.2.6 Integration

Function diagrams (see SINAMICS S120/S150 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 important parameters (see SINAMICS S120/S150 List Manual)

- p2502[0...n] LR encoder assignment
- p2503[0...n] LR length unit LU per 10 mm
- p2504[0...n] LR motor/load motor revolutions
- p2505[0...n] LR motor/load load revolutions
- p2506[0...n] LR length unit LU per load revolution
- r2520[0...n] CO: LR position actual value conditioning encoder control word
- r2521[0...n] CO: LR actual position value
- r2522[0...n] CO: LR actual velocity value
- r2523[0...n] CO: LR measured value
- r2524[0...n] CO: LR LU/revolutions
- r2525[0...n] CO: LR encoder adjustment offset
- r2526[0...n] CO/BO: LR status word
- p2720[0...n] Load gear configuration
- p2721[0...n] Load gear absolute encoder rotary revolutions virtual
- p2722[0...n] Load gear position tracking tolerance window
- r2723[0...n] CO: Load gea absolute value
- r2724[0...n] CO: Load gear position difference

7.9.3 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 S120/S150 List Manual)

- 4015 Position controller

Overview of important parameters (see SINAMICS S120/S150 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

7.9.4 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

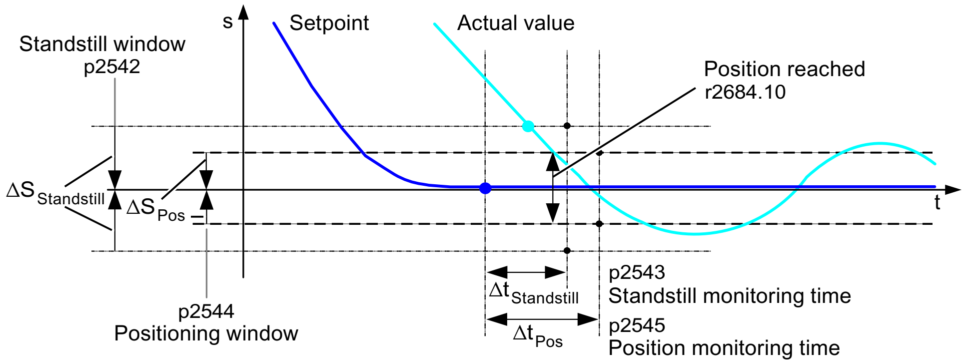


Figure 7-13 Zero-speed monitoring, positioning window

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).

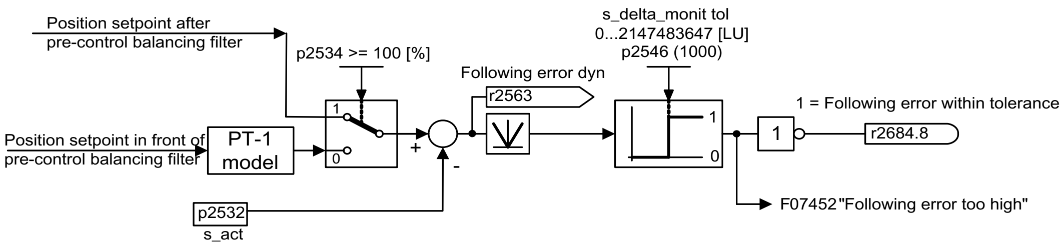


Figure 7-14 Following error monitoring

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.

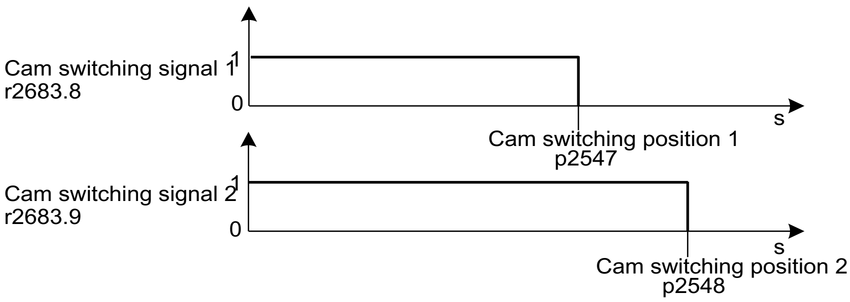


Figure 7-15 Cam controllers

The position controller has two cam controllers. If cam position p2547 or p2548 is passed in the positive direction (r2521 > p2547 or p2548), then cam signals r2683.8 and r2683.9 are reset.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 4020 Zero-speed / positioning monitoring
- 4025 Dynamic following error monitoring, cam controllers

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p2530 CI: LR position setpoint
- 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

7.9.5 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 (also see Chapter Control and status words for encoder (Page 542)).

Function diagrams (see SINAMICS S120/S150 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 important parameters (see SINAMICS S120/S150 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

7.9.6 Integration

The "positon control" function module is integrated in the system as follows:

Commissioning

The configuration screen for "Position control" in STARTER is not made accessible unless the function module "Basic positioner" is activated (r0108.4 = 1) which means that the function module "Position control" (r0108.3 = 1) is automatically activated as well.

The "basic positioner" function module can be activated via the commissioning wizard or the drive configuration (configure DDS) (configuration "Closed-loop control structure" - checkbox "Basic positioner").

To ensure correct, error-free operation of the basic positioner, it is absolutely essential that the "Position control" function module is activated and the position control correctly configured.

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 S120/S150 List Manual)

- 4010 Position actual value conditioning
- 4015 Position controller
- 4020 Zero-speed / positioning monitoring
- 4025 Dynamic following error monitoring, cam controllers

7.10 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 operating mode
  - 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 via PROFIdrive telegrams 7 and 110
  (for additional information, see Chapter Cyclic communication (Page 493) and SINAMICS S120/S150 List Manual)

7.10.1 Mechanical system

Features

- Backlash compensation (p2583)
- Modulo offset (p2577)

Description

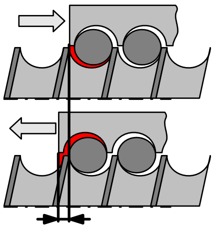


Figure 7-16 Backlash compensation

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- 8 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

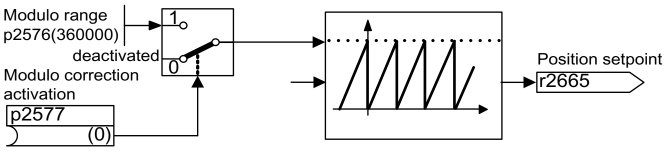


Figure 7-17 Modulo offset

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 gear:

  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 gear:

  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 gear:

  v = p0412 * p2506 / p2576

With position tracking it is recommended to change p0412 or p2721.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 3635 Interpolator
- 4010 Position actual value conditioning

Overview of important parameters (see SINAMICS S120/S150 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.

7.10.2 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

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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 current motion is stopped with OFF3 and the appropriate status bit r2684.13 (STOP cam minus active) or r2684.14 (STOP cam plus active) is set.

When an axis has approached a STOP cam, only motion that allows the axis to move away from the 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 which 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.

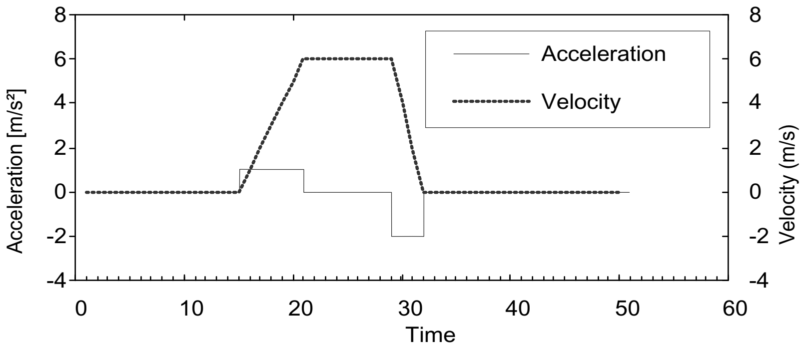

Figure 7-18 Without jerk limitation

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.

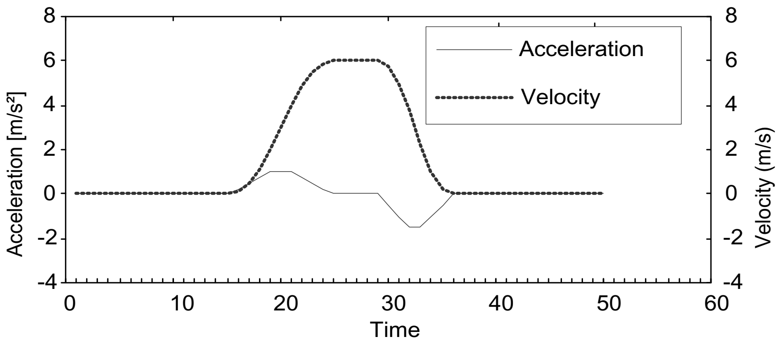

Figure 7-19 Activated jerk limitation

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 messages are generated with stop responses OFF1 / OFF2 / OFF3.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 3630 Traversing range limits

Overview of important parameters (see SINAMICS S120/S150 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

Jerk limitation

- p2574 EPOS jerk limitation
- p2575 BI: EPOS jerk limitation activation

7.10.3 EPOS and Safely-Limited Speed

If safe speed monitoring (SLS) is also to be used at the same time as the EPOS positioning function , EPOS must be informed of the activated speed monitoring limit. Otherwise the speed monitoring limit can be violated by the EPOS setpoint input. Through the SLS monitoring, this violation leads to the drive being stopped and so abandoning the planned movement sequences. Here the relevant safety faults are output first of all and only then the sequential faults created by EPOS.

With its parameter r9733, the SLS function provides a setpoint limit value which, when taken into account, prevents the SLS limit value from being violated.

This means that the setpoint limit value in r9733 must therefore be transferred to the input for the maximum setpoint speed/velocity of EPOS (p2594), to prevent an SLS limit value violation as a result of the EPOS setpoint input. You need to set the delay time for SLS/SOS (p9551/p9351) so that the SLS only becomes active after the maximum required time for the speed to be reduced below the SLS limit. This required braking time is determined by the current speed, the jerk limit in p2574 and the maximum delay in p2573.

7.10.4 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 or p0494 = 0)*)
  - External zero mark (p0495 ≠ 0 or p0494 ≠ 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, an adjustable parameter for this quantity is also required. As standard, this adjustable 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 and the actual position value is valid (p2658 = 1 signal).
A reference point can also be set for an intermediate stop.

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 adjustable 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 for an already adjusted axis, the axis will remain unadjusted even after a POWER ON of the drive unit. 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 → Position actual 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.

Referencing with DRIVE-CLiQ encoders

The DRIVE-CLiQ encoder is available as either a "multiturn" or "singleturn" absolute encoder. If the "referencing" function is selected via the PROFIdrive encoder interface and if a DRIVE-CLiQ encoder or other type of absolute encoder is connected via the DRIVE-CLiQ interface, the zero crossing of the singleturn position is used as the reference point.

Further information on commissioning DRIVE-CLiQ encoders is provided in the SINAMICS S120 Commissioning Manual.

Reference point approach for incremental measurement systems

With 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.

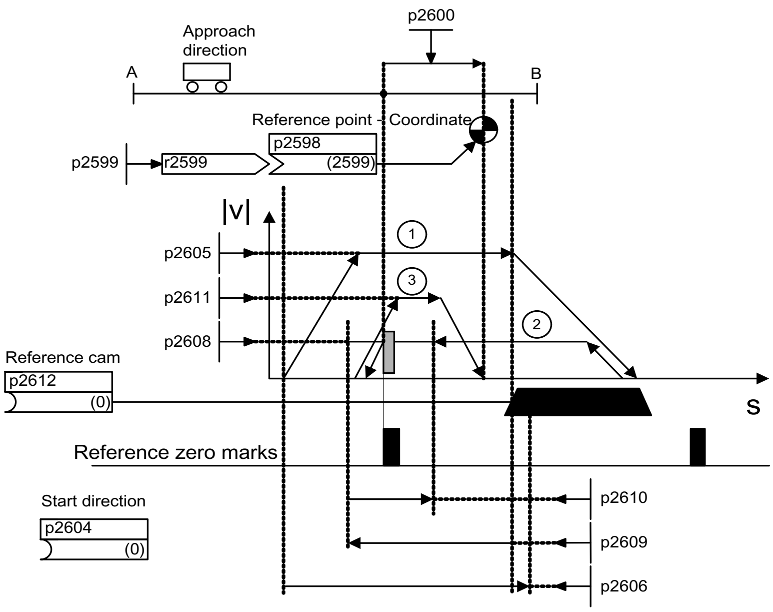

Figure 7-20 Example: reference point approach with reference cam

The signal on binector input p2595 (start referencing) 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 (referencing type selection). The signal in binector input p2595 (start referencing) 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 referencing 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 referencing 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 referencing 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 reference point approach, the search direction is reversed.

If the minus reversing cam is approached in the positive direction of travel or the plus reversing cam in the negative direction of travel, fault message F07499 "EPOS: Reversing cam approached from the wrong direction" is generated. In this case, the reversing cam connections must be checked (BI: p2613, BI: p2614) or the direction of approach to the reversing cam.

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 the behavior 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 (p0494 = 0 or p0495 = 0) *), no reference cams (p2607 = 0):

Synchronization to the reference zero mark begins as soon as the signal at binector input p2595 (start referencing) 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 available (p0494 ≠ 0 or p0495 ≠ 0) *), no reference cams (p2607 = 0):

Synchronization to an external zero mark begins as soon as the signal at binector input p2595 (start referencing) 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 (p0494 or 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 and the corresponding digital input selected using parameters p0494 or p0495 *) (equivalent zero mark input terminal). 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 adjustable 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.

Flying referencing

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 (jog, 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.

With "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 referencing) 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), alarm 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 data set changeover

Using drive data set changeover (DDS), motor data sets (p0186) and encoder data sets (p0187 to p0189) can be changed over. 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, a fault message (F07494) is also generated.

The following table contains a few examples for data set changeover. The initial data set is always DDS0.

Table 7- 9 DDS changeover without load gear position tracking

DDS	p186 (MDS)	p187 (encoder_1)	p188 (encoder_2)	p189 (encoder_3)	Encoder for position control p2502	Mechanical conditions [4] p2504/ p2505/ p2506 or p2503	Load gear position tracking	Changeover response
0	0	EDS0	EDS1	EDS2	encoder_1	xxx	deactivated	---
1	0	EDS0	EDS1	EDS2	encoder_1	xxx	deactivated	Changeover during pulse inhibit or operation has no effect
2	0	EDS0	EDS1	EDS2	encoder_1	yyy	deactivated	Pulse inhibit: Position actual value conditioning is newly initiated [1] and reference bit [2] is reset. Operation: Fault message is generated. Position actual value conditioning is newly initiated [1] and reference bit [2] is reset.
3	0	EDS0	EDS1	EDS2	encoder_2	xxx	deactivated	Pulse inhibit: Position actual value conditioning is newly initiated [1] and reference bit [3] is reset. Operation: Fault message is generated. Position actual value preprocessing is newly initiated [1] and reference bit [3] is reset.
4	0	EDS0	EDS3	EDS2	encoder_2	xxx	deactivated	
5	1	EDS4	EDS1	EDS2	encoder_1	xxx	deactivated	
6	2	EDS5	EDS6	EDS7	encoder_1	zzz	deactivated	
7	3	EDS0	EDS1	EDS2	encoder_1	xxx	deactivated	MDS changeover alone during pulse inhibit or operation has no effect

1) Is newly initiated means: For absolute encoders, the absolute value is read out anew and for incremental encoders a restart is performed just like after a POWER ON.

2) For incremental encoders r2684.11 ("Reference point set") is reset, and additionally for absolute encoders the status of adjustment (p2507).

3) For incremental encoders r2684.11 ("Reference point set") is reset, and for absolute encoders the status of adjustment (p2507) is not reset in addition, because the encoder data set is different from the original.

4) xxx, yyy, zzz: different mechanical conditions

Function diagrams (see SINAMICS S120/S150 List Manual)

- 3612 Referencing
- 3614 Flying referencing

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0494[0...n] equivalent zero mark input terminal*)
- p0495 equivalent zero mark input terminal*)
- p2596 BI: EPOS set reference point
- p2597 BI: EPOS referencing 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

*) Parameter p0494 corresponds to parameter p0495 regarding its significance. In addition, parameter p0494 is dependent on an encoder data set; for example which can be used for the data set switchover for interchangeable machining heads.

7.10.5 Referencing with several zero marks per revolution

The drive detects several zero marks per revolution when using reduction gears or measuring gears. In this cases, an additional BERO signal allows the correct zero mark to be selected.

Example with a reduction gear

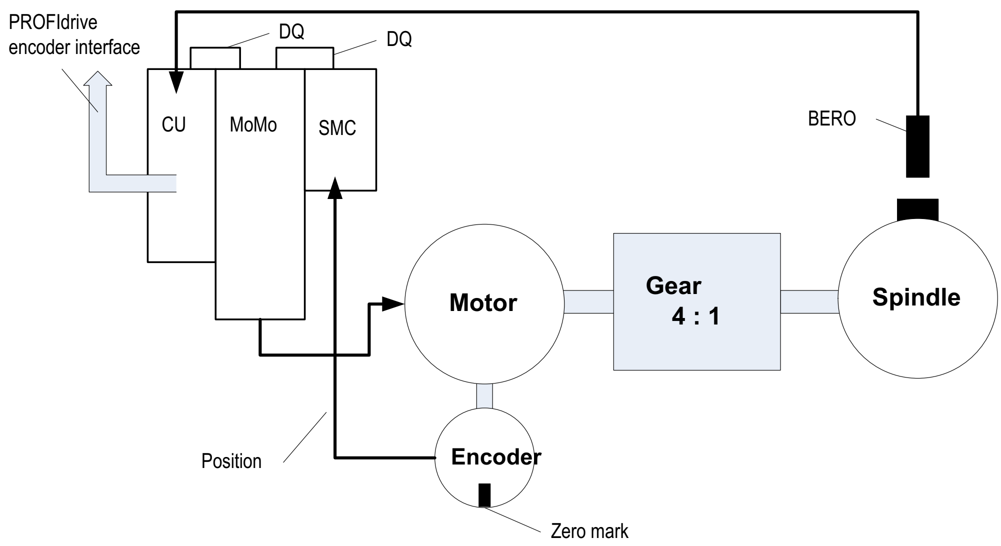

Figure 7-21 Design with a gear between the motor and spindle

The diagram shows an application example for referencing with several zero marks per revolution and selecting the correct zero mark using a BERO signal.

By using a reduction gear between the motor and the load (spindle), the drive detects several revolutions of the motor per mechanical revolution of the load - and therefore also several encoder zero marks.

The higher-level control/position control when referencing requires a unique reference between the encoder zero mark and the machine axis (load/spindle). This is the reason that the "correct" zero mark is selected using a BERO signal.

Example with a measuring gear

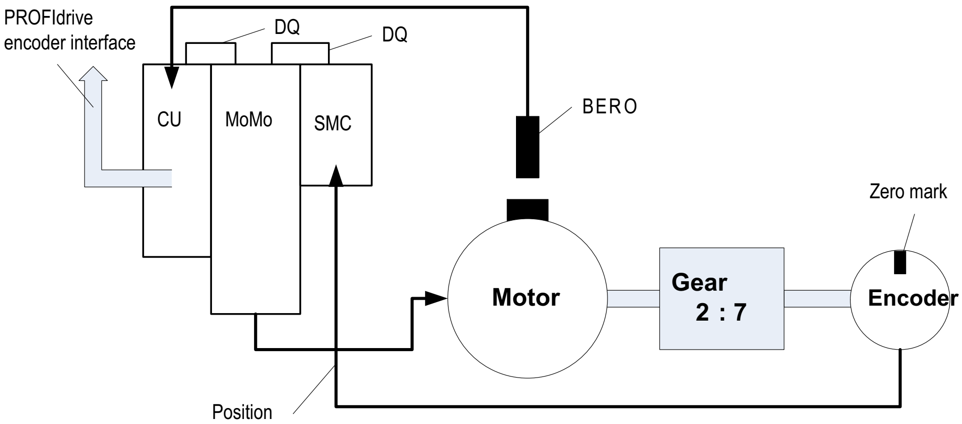

Figure 7-22 Measuring gear between the motor and encoder

The diagram shows an application example for using referencing with several zero marks per revolution with a measuring gear located between the motor/load and encoder.

As a result of the measuring gear, several encoder zero marks appear within one motor/load revolution. Using the BERO signal, also here, the correct zero mark for referencing can be selected from the several encoder zero marks.

Requirements

- The position of the zero mark that has the shortest distance to the position when the BERO signal switches is to be determined.
- The appropriate mechanical preconditions must be fulfilled when mounting the BERO.
- The preferred mechanical configuration is that the BERO signal covers the zero mark as, in this case, the zero mark selection is independent of the direction of rotation.
- In order to be able to precisely determine the position of the BERO (in relation to the reference position of the encoder) even at higher speeds, this must be connected to a fast Control Unit input.

Evaluating the BERO signal

You have the option of either evaluating the positive or negative signal edge of the BERO signal:

- Positive edge (factory setting)

  For referencing with a positive evaluation of the BERO signal, the encoder interface supplies the position of the reference mark, which is directly detected after the positive edge of the BERO signal. If, mechanically, the BERO is sized in such a way that the BERO signal covers the entire width of the encoder zero mark, the required encoder zero mark will be reliably detected in both traversing directions.

- Negative edge

  For referencing with a negative edge evaluation of the BERO signal, synchronization is realized to the next reference mark after leaving the BERO signal.

Proceed as follows to parameterize referencing with several zero marks:

- Using parameter p0493, define the fast digital input to which the BERO is connected.
- Set the corresponding bit of parameter p0490 to 1: The signal inversion means that the evaluation uses the negative edge of the BERO signal.

Referencing then proceeds as follows:

- Via the PROFIdrive encoder interface, SINAMICS S receives the request for a reference mark search.
- Using the parameterization, SINAMICS S determines the zero mark depending on the BERO signal.
- SINAMICS S provides the (possibly corrected) zero mark position as reference mark via the PROFIdrive encoder interface.

Note

At high speeds or if the distance between the BERO signal and the following zero mark is too low, then it is possible that the required, next zero mark is not detected, but instead, a subsequent one due to the computation time. Due to the known zero mark distance, in this particular case, the determined position is correspondingly corrected.

When using a measuring gear, the zero mark position depends on the motor revolution. In this case, a correction is also performed and for each motor revolution a reverse calculation is made back to the position of the zero mark with the shortest distance BERO signal ↔ zero mark.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0488 Probe 1 input terminal
- p0489 Probe 2 input terminal
- p0493 Zero mark selection input terminal
- p0495 External zero mark input terminal
- p0580 Probe input terminal
- p0680 Central probe input terminal
- p2517 LR direct probe 1
- p2518 LR direct probe 2

7.10.6 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: Identifiers
    000x → hide/show block (x = 0: show, x = 1: hide)
    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 triggered via the binector input p2633 when p2632 = 1 or via the measuring probe input p2661, which is connected to parameter r2526.2 of the "position control" function module, when 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 a fault with a stop response so that block processing can be canceled 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 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".

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 [0.01 Nm] with rotary motors or clamping force in [0.01 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 fault message 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 S120/S150 List Manual)

- 3616 Traversing blocks operating mode

Overview of important parameters (see SINAMICS S120/S150 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

7.10.7 Travel to fixed stop

Description

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 travek to fixed stop prevents the drive from traveling beyond the window if the fixed stop should break away.

In positioning mode, travel to 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. travel 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 "Travel to fixed stop active" status bit r2683.14 is active.

Fixed stop is 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 following error exceeds the value set in parameter p2634 (fixed stop: maximum following error) (p2637 = r2526.4)
- external, status set via the signal at binector input p2637 (fixed stop reached) (for p2637 ≠ r2526.4)

In travel 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 / linear motor). 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 set to 100% when fixed stop is not active. During active fixed stop, r2686[0] (torque limit upper) or r2686[1] (torque limit lower) are evaluated as a percentage of p1522/p1523 in such a way that the specified clamping torque or clamping force is limited.

When the fixed stop is acknowledged (p2637), the "Speed setpoint total" (p2562) is frozen, as long as the binector input p2553 (fixed stop reached message) is set. The speed control holds the setpoint torque due to the applied speed setpoint. The setpoint torque is output for diagnosis via the connector output r2687 (torque setpoint).

If the parameterized clamping torque is reached at the fixed stop, the status bit r2683.13 "Fixed stop clamping torque reached" is set.

Once the "Fixed stop reached" status has been detected, the traversing task "Travel to fixed stop" is ended. The program advances to the next block depending on the task 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 must remain at the fixed stop until a step enabling signal is applied externally.

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 0, and fault 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 such that it will only be triggered if the axis breaks away from the fixed stop.

Fixed stop is not reached

If the brake application point is reached without the "fixed stop reached" status being detected, then the fault F07485 "Fixed stop is not reached" is output with fault reaction OFF1, the torque limit is canceled and the drive cancels the traversing block.

Note

- The fault can be changed into an alarm (see chapter: "Message configuration" in the Commissioning Manual IH1), which means that the drive program will advance to the next specified block.
- The target point must be sufficiently far inside the workpiece.

Interruption to "Travel to fixed stop"

The "travel to fixed stop" traversing task can be interrupted and continued using the "intermediate stop" signal at the binector input p2640. The block is canceled 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. Measures are taken to prevent any risk of damage if the block is canceled when an axis has almost reached the fixed stop (setpoint already beyond the fixed stop, but still within the threshold for fixed stop detection). For this purpose, the position setpoint is made to follow the actual position value after standstill. As soon as the fixed stop is reached, the drive remains in fixed stop even after cancelation. It can be moved away from the fixed stop using jog or by selecting a new traversing task.

Note

The fixed stop monitoring window (p2635) is only activated when the drive is at the fixed stop and remains active until the fixed stop is exited.

Vertical axis

Note

In servo mode, a torque limit offset (p1532) can be entered for vertical axes (see also chapter: Servo control -> Vertical axis).

With asymmetrical torque limits p1522 and p1523, the net weight is taken into account for travel to fixed stop in parameters r2686 and r2687.

If, for example, with a suspended load, p1522 is set to +1000 Nm and p1523 to -200 Nm, then a net weight of 400 Nm (p1522 - p1523) is assumed. If the clamping torque is now configured as 400 Nm, then r2686[0] is preset to 80%, r2686[1] to 0% and r2687 to 800 Nm when travel to fixed stop is activated.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 3616 Traversing blocks mode (r0108.4 = 1)
- 3617 Travel to fixed stop (r0108.4 = 1)
- 4025 Dynamic following error monitoring, cam controllers (r0108.3 = 1)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p1528 CI: Torque limit, upper/motoring, scaling
- p1529 CI: Torque limit, lower/regenerative scaling
- p1545 BI: Activate 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

7.10.8 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

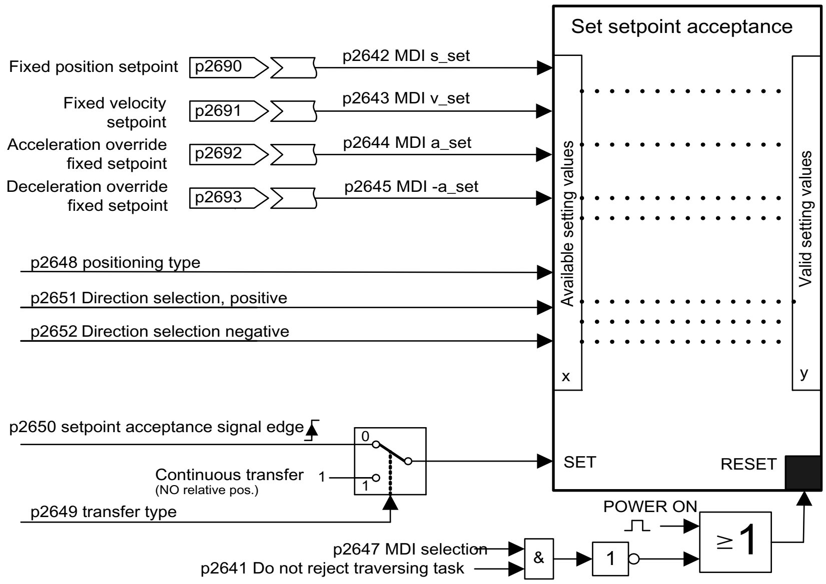

Figure 7-23 Setpoint transfer

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 reject traversing task

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 S120/S150 List Manual)

- 3618 EPOS - direct setpoint input mode/MDI, dynamic values
- 3620 EPOS - direct setpoint input mode/MDI

Overview of important parameters (see SINAMICS S120/S150 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

7.10.9 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.

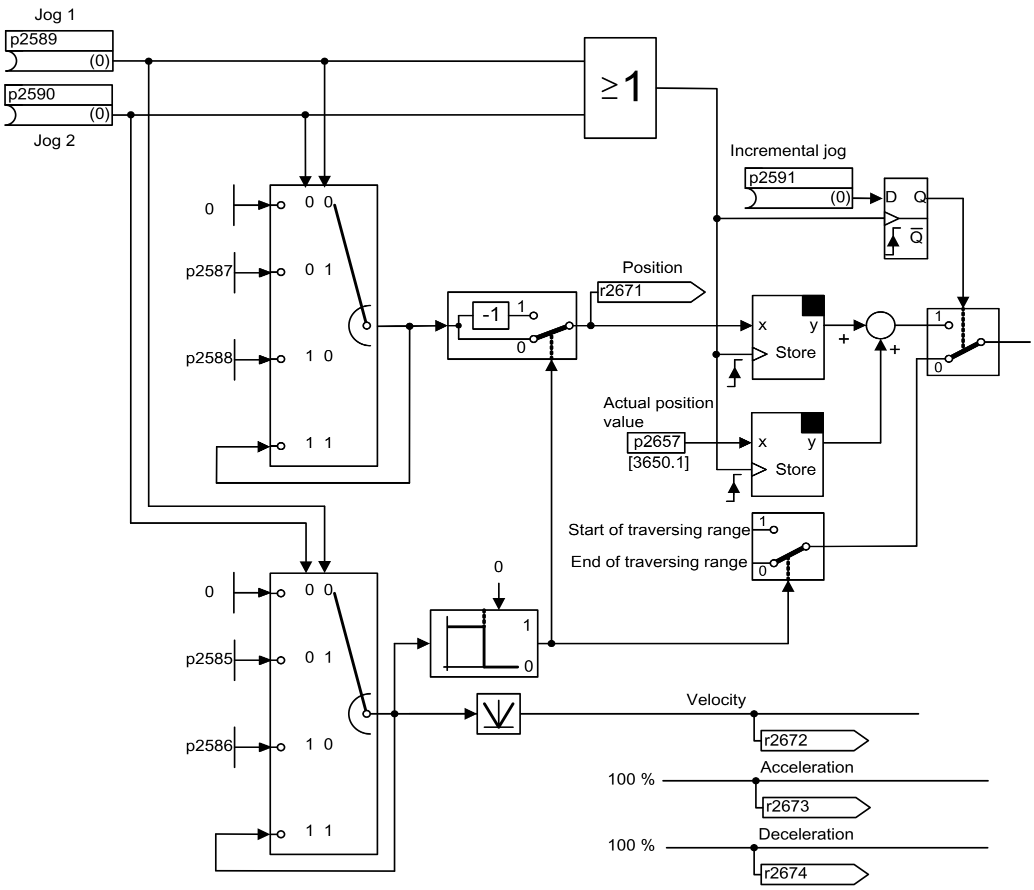

Figure 7-24 Jog mode

Function diagrams (see SINAMICS S120/S150 List Manual)

- 3610 EPOS - jog mode

Overview of important parameters (see SINAMICS S120/S150 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

7.10.10 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 has been 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.

7.11 Master/slave for Active Infeed

7.11.1 Operating principle

Description

This function allows drives to be operated with a redundant infeed. Redundancy can be implemented only in the components specified below, such as LT, CM and VSM. The function can be applied for the following applications:

- Hoisting gear that is to continue functioning in emergency mode (e.g. so that the load can still be placed down)
  .
- Paper and steel works that require a line drive to continue operation at a reduced line velocity.
- Oil production platforms that must continue normal production even if one infeed fails (full redundancy).
- Expansion of output range for plants with infeeds of different dimensions
- Infeed from mains supplies/transformers with phase displacement and/or voltage difference to a common DC link.

This function requires each infeed to be served by a separate Control Unit. It also requires either a higher-level control system (e.g. SIMATIC S7) to transfer current setpoints using the PROFIBUS slave-to-slave communication capability or TM31 modules which transmit current setpoints in the form of analog signals. If the infeeds are appropriately configured, operation can continue even if an infeed has failed. The master is selected by the controller and operated under V_{dc} voltage control (parameter p3513 = 0) with current control. The slaves receive their setpoint directly from the master and are only operated under current control (parameter p3513 = 1).

The infeeds must be isolated from the mains, for example, by means of an isolating transformer. Electrical isolation from the line with isolating transformers is necessary to prevent equalizing currents.

The infeed can be decoupled from the DC link by means of a DC breaker.

7.11.2 Basic structure

Description

DRIVE-CLiQ can be used to connect an Active Line Module (ALM) to a Control Unit (CU) and Voltage Sensing Module (VSM) to create an infeed train. A Motor Module can be combined with a Sensor Module Cabinet (SMC) or Sensor Module External (SME) and a Control Unit to create a drive train. If one of the modules develops a fault, only the affected train will fail. This failure can be signaled, e.g. via read parameter r0863.0, as a fault message to the higher-level controller. The fault is evaluated in the user program of the higher-level controller, which sends corresponding signals to the other infeeds. If a higher-level controller is not used, the fault can be evaluated by means of DCC charts in the Active Line Modules.

All the other trains remain fully functional, which means that they can continue operating normally.

Features

- The "master/slave" function only works in conjunction with Active Line Modules.
- One Active Line Module is the master and up to three others are slaves.
- If the master fails, a slave ALM takes on the role of the master.
- The redundant infeeds can continue functioning normally even if one infeed train has failed.
- Electrical isolation between the infeed trains is needed on the line side to prevent circulating currents caused by non-synchronous pulsing patterns.
- The entire infeed system supplies a joint DC busbar (DC link).
- Since the Active Line Module cannot detect whether the DC link is disconnected or a DC link fuse has blown, an additional circuit to monitor these states must be installed (DC breaker checkback function and fuse signaling contacts).
- The higher-level controller communicates with the CUs and Active Line Modules via PROFIBUS/PROFINET or analog data. If a higher-level controller is not to be used, the control signals must be hard-wired (e.g. via TM31).
- Infeed trains with different outputs can be combined.

Topology

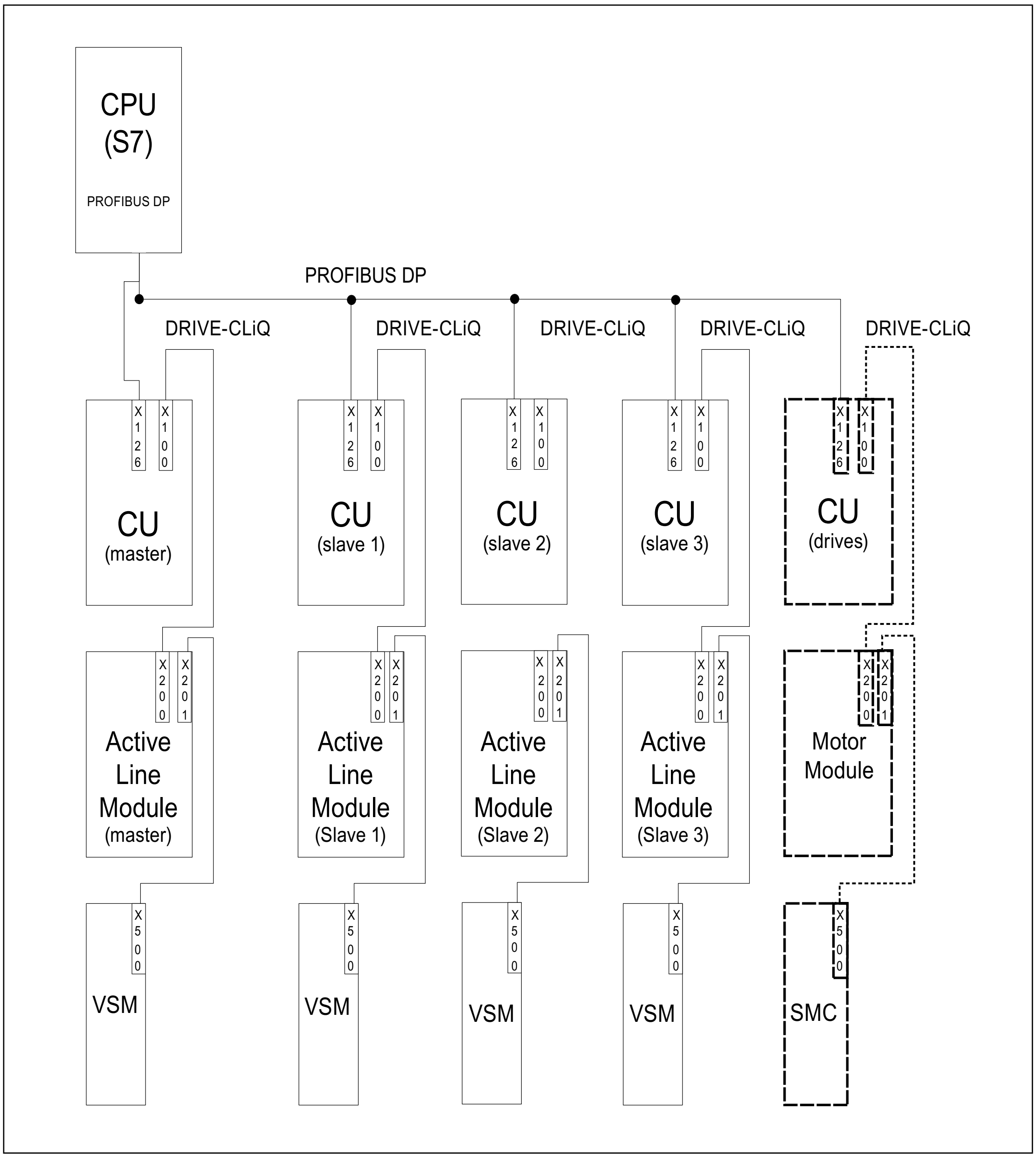

Figure 7-25 Topology structure and communications network based on PROFIBUS for master/slave operation with redundant infeeds (4 infeed trains)

Master/slave operation can be implemented for a maximum of 4 Active Line Modules.

Electrical isolation of infeeds

To successfully implement the structure, a means of electrically isolating the infeeds from the mains supply is required in addition to the SINAMICS components. This is to prevent circulating currents from developing if the pulse patterns of the Active Line Modules are not synchronized.

One of two possible methods of electrical isolation can be chosen:

- Using an isolating transformer for each slave infeed train. The primary side of the transformer is to be connected to the grounded or ungrounded mains transformer. The secondary side must never be grounded.
- Using a three-winding transformer for the master and slave infeeds. In this case, only the neutral point of one winding may be grounded to prevent further electrical coupling via ground.

Whichever solution is chosen, it must be noted that a separate transformer must be used for each Active Line Module (slaves 1 to 3).

DC breaker

Note

When an infeed develops a fault, it is disconnected on the line side by the line contactor as well as at the DC link end, for example, by a DC breaker. Infeeds must not be switched in to a charged DC link. The DC link must be discharged before another infeed train can be switched in.

An infeed may only be connected to a charged DC link if a DC breaker with pre-charging branch is installed.

7.11.3 Types of communication

Description

To implement master/slave operation, the CUs must be able to communicate with one another. The master passes the active current setpoint to the slaves. To optimize V_{dc} voltage control (DC link voltage), the dead times during communication must be kept to a minimum.

PROFIBUS slave-to-slave communication

The data is exchanged directly between the CUs without passing via the DP master. A PROFIBUS master (higher-level controller) is required to act as a "clock generator" (e.g. an S7-CPU). The minimum PROFIBUS cycle time that can be set depends on the Profibus master specifications.

Isochronous mode must be set for PROFIBUS. The PROFIBUS cycle time must not exceed 2 ms otherwise the closed-loop control may start to oscillate.

In order to ensure that other infeeds do not switch to fault status when one CU fails, the fault message F01946 "Link to Publisher disconnected" must be deactivated.

The number "1946" can be set in one of the parameters p2101[0..19] and p2101[x] set to "0" in order to block fault message F01946. This means that the drive will not shut down when one slave-to-slave communication node fails.

In a master/slave infeed, a common current controller cycle is essential, particularly when infeeds with different outputs are used. If the number of PROFIBUS nodes or drives increases, this can affect the bus cycle or current controller sampling time.

Communication using an analog setpoint

The analog setpoint between the CUs with Terminal Module 31 (TM31) can also be used as an alternative to bus communication. The factory setting for the sampling time of analog inputs and/or outputs is 4 ms (TM31 inputs/outputs sampling time p4099[1/2]). The sampling times must be an integer multiple of the basic sampling times (r0110). The lowest common denominator of the current controller clock cycle for the integrated infeeds must be selected to implement the "master/slave" function. The sampling time of the analog inputs/outputs should be the set to the same value as the current controller cycle (e.g. 250 µs). The slave can then use the analog setpoint every second current controller cycle. with the dead time corresponding to one clock cycle.

The advantages of this variant is that the communication system can be configured to be independent of bus and master.

Disadvantages are the additional hardware wiring and the necessity to use one TM31 per CU. This communication method is also more susceptible to EMC-related problems. It is not absolutely essential to use a higher-level control (e.g. SIMATIC S7) for this system. Control functions can also be implemented using DCC charts in individual CUs.

7.11.4 Description of functions

The "Mmaster/slave" function module is not implemented in the higher-level control, but directly in the firmware of the CUs and infeeds. It is signaled by r0108.19 = 1 (option "Master/slave" for infeeds selected in STARTER).
The V_{dc} closed-loop control band and current setpoint via multiplexers of the Active Line Module control are implemented in the function module.

All infeeds must be parameterized in such a way that they are fully functional as both a master and slave. The infeeds can be switched between master and slave role during operation. Switchover is handled by a higher-level control according to the setting in parameter p3513. A master is configured to operate with V_{dc} control (p3513 = 0) and current control, while the slaves operate only with current control (p3513 = 1). The Iactive(setp) setpoint of the active current is transferred from the master to the slaves via the communication links between the Control Units.

If the Active Line Module is used for reactive power compensation with external reactive current setpoint, then the reactive current setpoint must also be wired for the slave. The master-to-slave setpoint specifies only the active current.

When Active Line Modules have been deactivated, make sure that the maximum DC link capacitance C_{ZK} for the remaining Active Line Modules is not exceeded during the switch-on procedure (danger of overloading the pre-charging resistors).

Parameter p3422 ($C_{DC\ link}$capacitance) can be changed in operation. For a master/slave change, the closed-loop control can be directly adapted using this parameter instead of by changing V_{dc} controller (p3560, proportional gain V_{dc} controller). When parameter p3422 changes, parameter p3560 is recomputed automatically by the firmware.

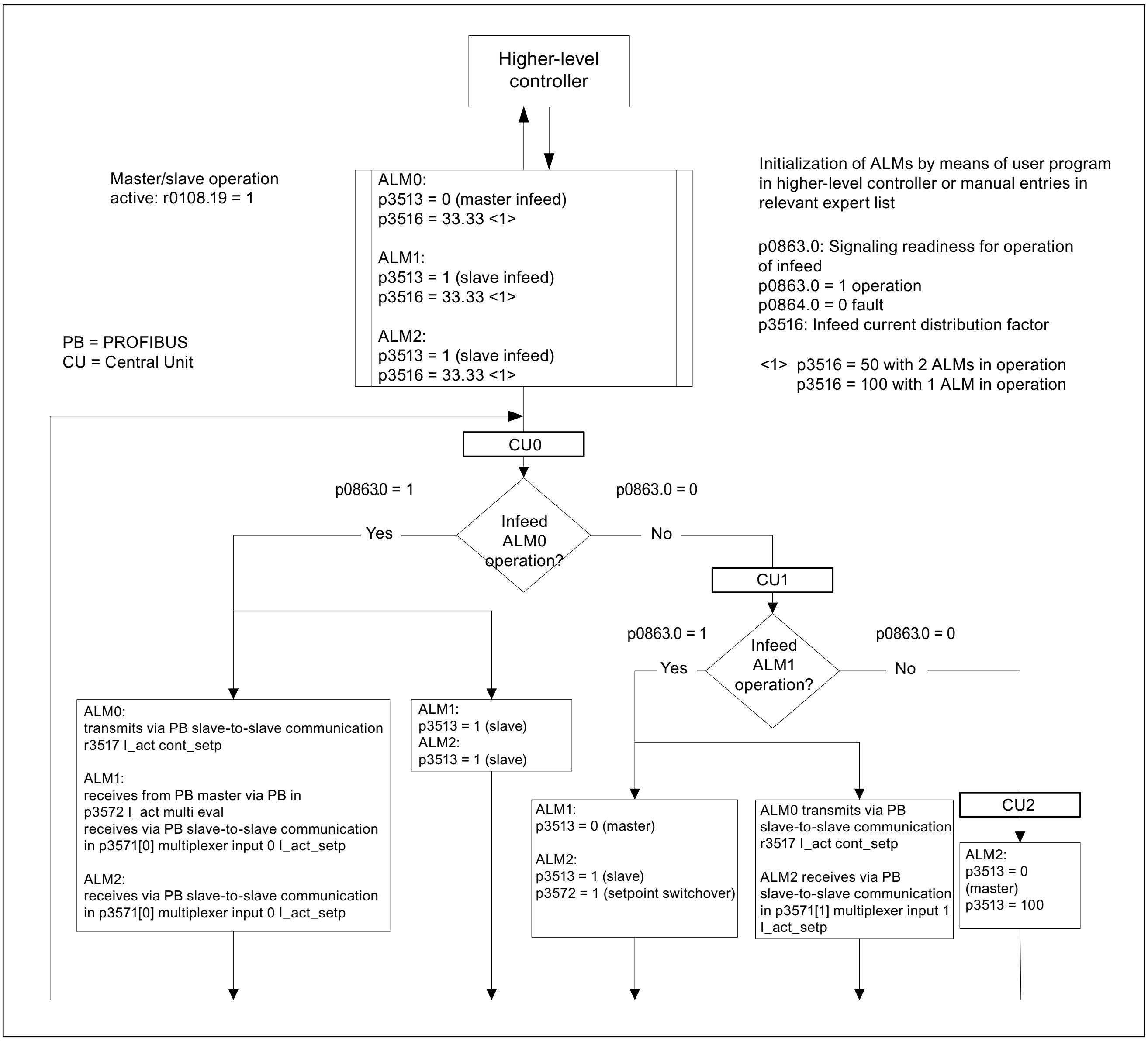

Figure 7-26 Structogram of master/slave operation, 3 identical Active Line Modules (ALMs) of identical output rating, PROFIBUS communication system

Function diagrams

The function of the "Master/slave infeeds" function module is shown in function diagrams 8940 and 8948 (see SINAMICS S120/S150 List Manual).

Explanations for the function diagrams

- **Current setpoint interconnection**
  Parameter p3570 is used to connect the setpoint for the closed-loop current control (active current setpoint from the master). Using parameter p3513, which can be changed in the "ready for operation" state, it is possible to switch between master (V_{dc} control, parameter p3513 = 0) and slave (current control, parameter p3513 = 1) from the higher-level control system.
- **Selection of the current setpoint**
  The current setpoint can be selected by means of a control word (XCS) (p3572) using a multiplexer with 4 inputs (X0 … X3) (p3571.0 … p3571.3). This means that the current setpoint of the new master can be selected when the old master has failed.
- **Selection of the current distribution factor**

  To prevent a reduction in control dynamics of the DC link voltage controller for non-symmetrical loads, this current distribution factor must be updated immediately when an infeed fails or is activated.

  The current distribution factor is calculated from the number of active infeeds and their rated data. The sum of the current distribution factors of all active infeeds must always equal 100 %.

  The current distribution factor can be selected by means of a control word (XCS) (p3577) using a multiplexer with 6 inputs (X0 ... X5) (p3576.0...5).

  Alternatively, a new current distribution factor can be calculated in the higher-level control, sent via cyclic PROFIBUS PZD telegrams and interconnected directly to the connector input "Infeed: additional current distribution factor" (p3579).

  A further alternative is to update the current distribution factor via an acyclic PROFIBUS parameter write order of p3516. This produces deadtimes however.

  For alternatives without multiplexer, this can be used for a different function.
- **V_{dc} control band**
  The V_{dc} limits can be violated in master/slave operation if the DC link load changes abruptly (e.g. load surges or emergency stop). For this reason, the DC link voltage is monitored on the basis of a V_{dc} control band. The V_{dc} control band defines a specific voltage range with hysteresis - set in parameter p3574.0/1 (upper/lower limit V_{dc} voltage band) and p3574.2/3 (hysteresis upper/lower voltage limit). A signal is generated if the DC link voltage leaves this voltage range. By evaluating this signal, the slave is changed over from closed-loop current to closed-loop voltage control. When the DC link voltage returns to within the control band, the slave is switched back to closed-loop current control. The V_{dc} control operates permanently in "standby mode" so that it can be re-activated when necessary.

7.11.5 Commissioning

Line supply and DC link identification routine

Before the option "Master/slave" operation is enabled in STARTER, the line supply and DC link identification runs (see corresponding section in this function manual) must be executed during commissioning for each infeed train.

Please follow the instructions given in the commissioning manual for the commissioning of infeeds.

Once each individual infeed has been identified, the correct inductance for current control and the DC link capacitance for voltage control are set.

If a DC breaker for isolating the infeed from the DC link is installed, DC link identification must be performed again for all active infeeds after one has been disconnected, as it is necessary to acquire the DC link capacitance again. If the DC link capacitance is not adapted in this way, then the change in capacitance will affect the dynamic response of the V_{dc} control.

Note

Aligning the setpoints of the DC link voltage

The setpoints of the DC link voltage V_{dc} from p3510 of the master and the slaves must be set to the same values to
ensure that the V_{dc} tolerance bandwidth monitoring functions correctly.

Activation of the master/slave function

The "Master/slave" function is activated with the checkbox/option "Master/Slave" in the STARTER wizard for the relevant infeed. Parameter r0108.19 can be used to scan for an active function module in the CU or the Active Line Modules (r0108.19 = 1).

All other required parameters are set via the corresponding expert lists for the relevant infeed.

Note

The bus cycle time for Active Line Modules operating in master-slave operation must not exceed 2 ms, If the bus cycle time is higher, then the dynamic response (p3560) must be significantly reduced. This means that load surges can no longer be corrected properly.

Increasing the bus cycle time can cause the DC link voltage to oscillate, an effect which can sometimes be managed by reducing the dynamic response (p3560). The system cannot be guaranteed to function reliably with bus cycle times of > 2 ms.

The Vdc setpoint in p3510 must be set high enough to prevent the standby controller from responding to line overvoltage (the response threshold of 97% can be increased if necessary, but current and voltage harmonics will develop if the setting causes overcontrol).

In any case, the tolerance band must be set wide enough that it will not be violated should the control factor reserve controller still respond because the measures described above have not been implemented.

Master/slave switchover

If a power unit fails during operation, the higher-level controller can switch each infeed train from current control (slave operation) to DC link voltage control (master operation) and vice versa (parameter setting for master: p3513= 0, for slave: p3513 = 1).

Switching in an ALM in operation

In an operational master-slave group, an ALM must first be switched in as a slave.

Shutting down an ALM from an operating group

Shutting down an ALM from the group should be realized in the slave state and with OFF2 (pulse inhibit). If a master fails with a fault (OFF2 response, pulse inhibit), one of the slaves must be immediately switched as master.

Two masters must not be operated simultaneously in the infeed group.

7.11.6 Integration

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8940 Controller control factor reserve/controller DC link voltage
- 8948 Master/slave (r0108.19 = 1)

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p3513 BI: Disable voltage-controlled operation
- p3516 Infeed current distribution factor (parallel connection)
- p3570 CI: Master/slave active current setpoint
- p3571[0...3] CI: Master/slave active current setpoint multiplexer input, multiplexer input value 0 ... 3
- p3572 CI: Master/slave active current setpoint multiplexer selection
- r3573 CO: Master/slave active current setpoint multiplexer output
- p3574[0...3] Master/slave V_{dc} monitoring, Vdc limit values/hysteresis
- r3575.0...2 BO: Master/slave DC link voltage monitoring status

7.12 Connecting the motors in parallel

Description

For easy commissioning of group drives (a number of identical motors operating on one power unit) in control modes servo and vector, the number of parallel-connected motors can be entered in STARTER or in the parameter list (p0306: Number of parallel connected motors).

An equivalent motor is computed internally depending on the number of motors specified. The motor identification run determines the data for an equivalent motor. Motors connected in parallel can also operate on an encoder (on the 1st motor).

Note

For information about parallel connection of Motor Modules, please refer to section "Parallel connection of power units".

Features

- Up to 50 motors connected in parallel can be operated on one converter system.
- It is not permissible to connect synchronous or reluctance motors in parallel.
- The original motor data set (p0300 ff.) is not modified. It is merely the data set transfer to the closed-loop control which is organized according to the number of parallel-connected motors.
- The motor identification routine also works on parallel connections. Supplementary conditions for successful motor identification: The motors are working on the same load and are thus coupled.
- The rotating measurement function also works if the motors can rotate without distance limit. Uneven loading of the motors or a high degree of gear backlash will negatively affect the accuracy of the rotating measurement result.
- The cable lengths for motors connected in parallel must be as symmetrical as possible to afford the most even possible distribution of current among individual motors.

Commissioning via STARTER

Parameter p0306 is assigned in a STARTER commissioning screen. When subsequent parameters are set, p0306 is included in the calculation of the current limit (p0640) and the reference current (p2002).

Parameter p0306 has a value range of 1 to 50 and is MDS-dependent.

To create a parallel connection of motors, the appropriate motor must be selected from the screen list, checkbox "Parallel connection motor" enabled and the number of motors included in the parallel connection entered in the "Number" dropdown box. This display and input function is only available for vector drives. Parallel connections of motors for servo drives can be configured with the expert list (parameter p0306).

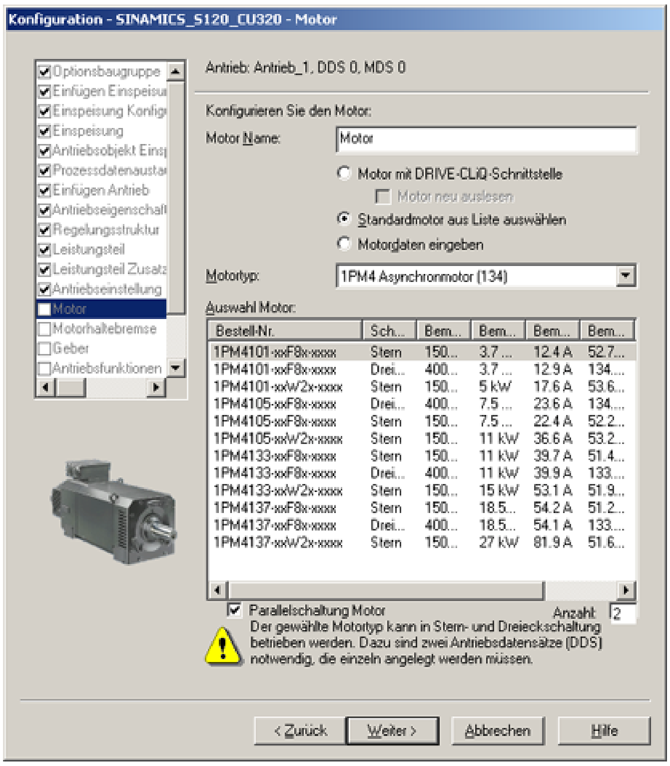

Figure 7-27 Selection of motors for parallel connection

Even SMI motors can be connected in parallel. The first motor is connected to DRIVE-CLiQ via the encoder. The other motors in the connection are of an identical type. Using parameter p0306 and the encoder information obtained via DRIVE-CLiQ, it is possible to determine all the necessary motor data.

Properties of the parallel connection in STARTER

- The rating plate and equivalent circuit diagram parameters are those of the single drive.
- The parallel data set has no code numbers. All motor data are calculated from p0306 and the code numbers of individual motors. The same interlock mechanisms apply as to single drives.
- The "Motor data" screen still displays only the data for the individual motor selected.

Restrictions applicable to parallel connections

The basic governing principle of parallel connections is that the motors involved are mechanically inter-coupled via the load. Where motors need to be decoupled from the connection, the number of motors need to be reduced in p0306 by a DDS/MDS changeover. Since the equivalent circuit diagram changes as a result, it may be necessary to commission these data sets separately (e.g. motor data identification with reduced number of motors). The power unit will otherwise apply false motor data.

An EDS changeover and e.g. 2 SMCs must be used in cases where a motor with encoder needs to be decoupled from connections operating with encoder.

Vector control with encoder for parallel-connected drives functions in the same way as for a single drive if the drives are coupled via the load and the speeds do not differ by more than the working-point-dependent pull-out slip.

Counter-example:
The gear ratios used to couple the motors with the load are large and the backlash and elasticity in the drive train are therefore high. If the load then causes one of the motors to rotate, but the other is still stationary, the drive without an encoder will stall.

If a motor is defective, the individual motor will be shut down on overcurrent by the motor circuit breaker. The power unit will be shut down by the control (if available) or, in the case of a turn-to-turn fault in the motor, the power unit will switch to fault status. The motor must then be decoupled from the parallel grouping. Parameter p0306 is changed by the DDS/MDS changeover.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0300[0...n] Motor type
- p0306[0...n] Number of motors connected in parallel
- p0307[0...n] Rated motor power
- p0640[0...n] Current limit
- p2002 Reference current

7.13 Parallel connection of power units

For the SINAMICS S120 chassis and SINAMICS S120 Cabinet Modules, the modular SINAMICS S120 drive system provides the option of operating both the Line Modules as well as the Motor Modules in parallel.

SINAMICS S120 Motor Modules can only be operated in parallel in the vector mode, but not in the servo mode.

SINAMICS S120 units in the booksize and blocksize formats have not been released for parallel operation.

With the objective of extending the power range, SINAMICS S120 allows the same power units, such as Line Modules and/or Motor Modules, to be connected in parallel (same type, same rated voltage, same type rating and the same firmware version). It is therefore not permissible to mix different types of power unit within the same parallel connection, e.g. a mixture of Basic Line Modules with Smart Line Modules or Basic Line Modules with Active Line Modules.

It can make sense to connect power units (Line Modules and Motor Modules) in parallel for a variety of reasons:

- To boost the converter output if it is not technically or economically feasible to achieve the required output power by any other means.
- To increase availability in cases where it is necessary to maintain emergency operation when a frequency converter develops a fault - and where a reduced power can be tolerated.

Features

The main features of parallel connection are:

- Parallel connection of up to four Motor Modules on one motor
  - Parallel connection of multiple Motor Modules on one motor with separate winding systems (p7003 = 1).

    Note:
    Motors with separate winding systems are recommended.
  - Parallel connection of multiple Motor Modules on one motor with a single winding system (p7003 = 0) is possible.

⚠ CAUTION
Additional information and instructions in the SINAMICS S120 Equipment Manual must be carefully taken into consideration.

- Parallel connection of up to four power units on the infeed side (closed/open loop).
- A Control Unit, which actuates and monitors power units on the line and motor sides connected in parallel, can control an additional drive (see Chapter Additional drive in addition to the parallel connection (Page 408)).

- Redundant operation:
  Two Control Units, which actuate and monitor the line-side and motor-side power units connected in parallel cannot control additional drives.
- Parallel-connected power units must be connected to the same Control Unit.
- A Control Unit CU320-2 can simultaneously actuate a maximum of one parallel connection on the line side and one parallel connection on the motor side.
- Components at the line and motor ends for decoupling the parallel-connected power units and for ensuring symmetrical current distribution are recommended.
- Simple commissioning, because no special parameterization is necessary.
- Individual power units can be parameterized and diagnosed (troubleshooting) with p7000 ff.

The following Modules can be connected in parallel:

- Basic Line Modules, 6-pulse and 12-pulse (each with the relevant line reactors)
- Smart Line Modules, 6-pulse and 12-pulse (each with the relevant line reactors)
- Active Line Modules, 6-pulse and 12-pulse (each with the relevant Active Interface Modules)
- Motor Modules (in vector control mode)

Note

Mixed operation, Line Modules

Exception: Smart Line Modules may be operated together with Basic Line Modules whose last digit of the order number is a "3" (Chassis) or a "2" (Cabinet) with one or several CUs if precisely defined preconditions and the information in the Configuration Manual are maintained. This information can be found in the "SINAMICS - Low Voltage Configuration Manual".

A slight reduction of the rated current must be considered for parallel connection of power units.

The reduction of the rated current (derating) of a power unit for parallel connection is:

- 7.5% for parallel connections of SINAMICS S120 Basic Line Module and SINAMICS S120 Smart Line Module when neither module is equipped with a current compensation control.
- 5.0% for parallel connections of SINAMICS S120 Active Line Module and SINAMICS S120 Motor Module when each module is equipped with a current compensation control.

7.13.1 Applications of parallel connections

Parallel connection of power units

Parallel connections of power units (infeeds can be implemented as either a 6-pulse circuit if the parallel-connected modules are connected to a two-winding transformer, or as a 12-pulse circuit if the parallel-connected modules are connected to a three-winding transformer with secondary windings that supply voltages with a phase shift of 30 °). The following diagram is an overview of the module variants discussed in this section for inclusion in power unit parallel connections.

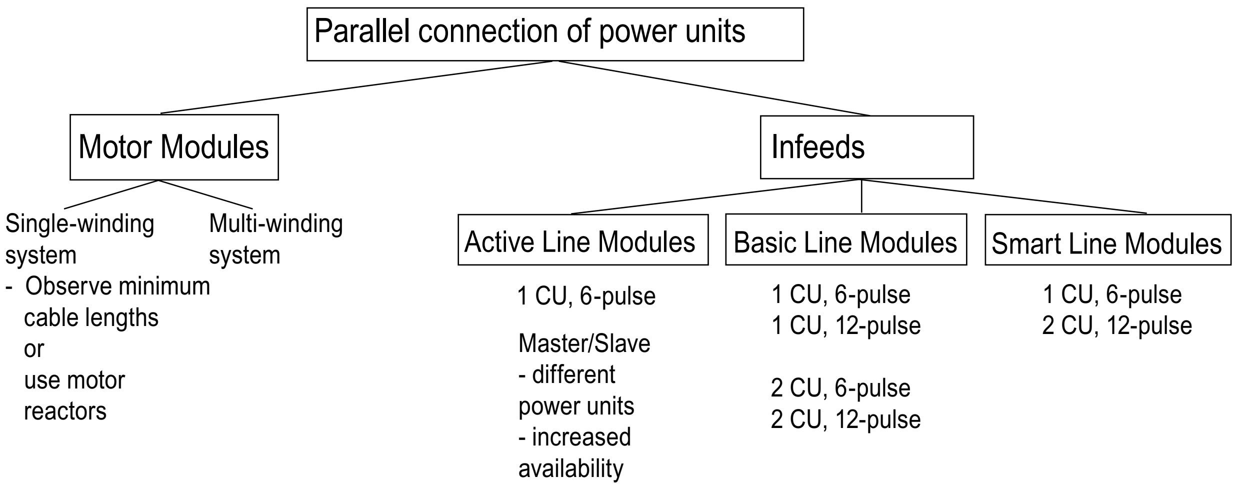

Figure 7-28 Parallel connection of power units - overview

Note

For further information about parallel connection of power units, especially instructions on how to configure them, see "SINAMICS Configuration Manual for G130, G150, S120 Chassis, S120 Cabinet Modules, S150".

Infeed concepts - parallel (one CU) and redundant parallel (two CUs)

Some applications require redundant infeeds for a DC line-up. This requirement can be fulfilled through the implementation of multiple, independent infeeds which are connected in parallel to the DC-line-up. Depending on how the drive is dimensioned, the DC line-up can continue operating at between 50 % to 100 % output when one infeed fails. With the redundant variant of the infeed parallel connection, each infeed is controlled by a separate Control Unit and is thus completely independent. With the non-redundant variant, a single Control Unit generally controls all parallel-connected power units which then, from a practical viewpoint, function like a single, high-output infeed.

The type of circuit required depends on whether the redundancy requirement applies only to the infeed itself or also includes the supply-side transformers or the supply systems (see "SINAMICS Configuration Manual G130, G150, S120 Chassis, S120 Cabinet Modules, S150").

6-pulse infeed
With the 6-pulse infeed circuit variant, the two redundant infeeds of identical type are connected to the supply system via a two-winding transformer. As both infeeds are supplied with exactly the same line voltage, the current distribution is largely symmetrical in normal operation, even with uncontrolled infeeds. The infeeds can thus be dimensioned such that, taking into account a minor current derating factor, each can carry 50 % of the total current. However, if one infeed fails, only half the output remains available. If the full output needs to be available when one infeed fails, then each infeed must be dimensioned to carry the full current.

12-pulse infeed
With the 12-pulse infeed circuit variant, the two redundant infeeds of identical type are also connected to the supply system, but via a three-winding transformer. Depending on the transformer design, the line-side voltages of the two infeeds will include minor tolerances of between about 0.5 % to 1 %. These can cause slightly asymmetrical current distribution in normal operation when uncontrolled infeeds are used and current derating factors must be applied accordingly. If the full output needs to be available when one infeed fails, then each infeed must be dimensioned to carry the full current.

6-pulse, 12-pulse infeed
When separate Control Units are used, pre-charging may not be synchronized accurately enough, i.e. one converter system must be able to pre-charge the total capacitance of the drive line-up. Pre-charging power for the DC link in parallel operation must be dimensioned so that the capacitance of the DC link can be fully charged by a single converter system. Otherwise a separate pre-charging device must be provided.

Basic Line Module (BLM)

Features

- The DC link voltage is greater than the rms value of the line rated voltage by a factor of 1.35.
- They are used in cases where regenerative feedback capability is not required.
- If regenerative operating states occur in the drive line-up, Braking Modules that convert the excess energy to heat in braking resistors must be used.

Basic Line Modules are available for the following voltages and power ratings:

Line voltage / rated power

380 … 480 V 3 AC / 200 ... 710 kW

500 ... 690 V 3 AC / 250 ... 1100 kW

The following rules must be observed when connecting Basic Line Modules in parallel:

- Up to 4 identical Basic Line Modules can be connected in parallel.
- A shared Control Unit must be used to implement the parallel connection.
- Special Line Connection Modules are available for the parallel connection.
- With multiple infeeds, power must be supplied to the systems from a common infeed point (i.e. the modules cannot be operated on different supplies).
- A current reduction (derating) of 7.5 % must be taken into consideration, regardless of the number of modules connected in parallel.

As Basic Line Modules have no current compensation control, the three-winding transformer, power cabling and line reactors must meet the following requirements in order to provide a balanced current:

- Three-winding transformer must be symmetrical, recommended vector groups Dy5d0 or Dy11d0.
- Relative short-circuit voltage of three-winding transformer $u_k \geq 4\%$.
- Difference between relative short-circuit voltages of secondary windings $\Delta u_k \leq 5\%$.
- Difference between no-load voltages of secondary windings $\Delta U \leq 0.5$ %.
- Use of symmetrical power cabling between the transformer and the Basic Line Modules (cables of identical type with the same cross-section and length)
- Use of suitable line reactors for the Basic Line Modules. Line reactors can be omitted if a double-tier transformer is used and only one Basic Line Module is connected to each secondary winding of the transformer.

A double-tier transformer is generally the only means of meeting the requirements of a three-winding transformer for this application. Line reactors must always be installed if other types of three-winding transformer are used. Alternative solutions for obtaining a phase displacement of 30 °, such as two separate transformers with different vector groups, cannot be used due to the inadmissibly high tolerances involved.

6-pulse parallel connection of Basic Line Modules

With the 6-pulse variant of parallel connection, up to four Basic Line Modules on the line side are supplied by a shared two-winding transformer and controlled by a shared Control Unit.

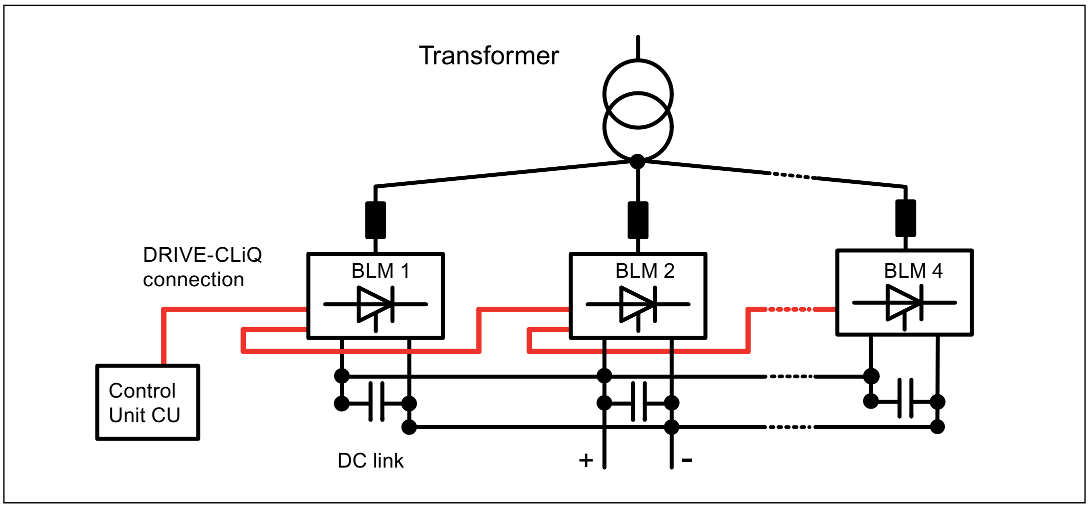

Figure 7-29 Parallel connection BLM 6-pulse single

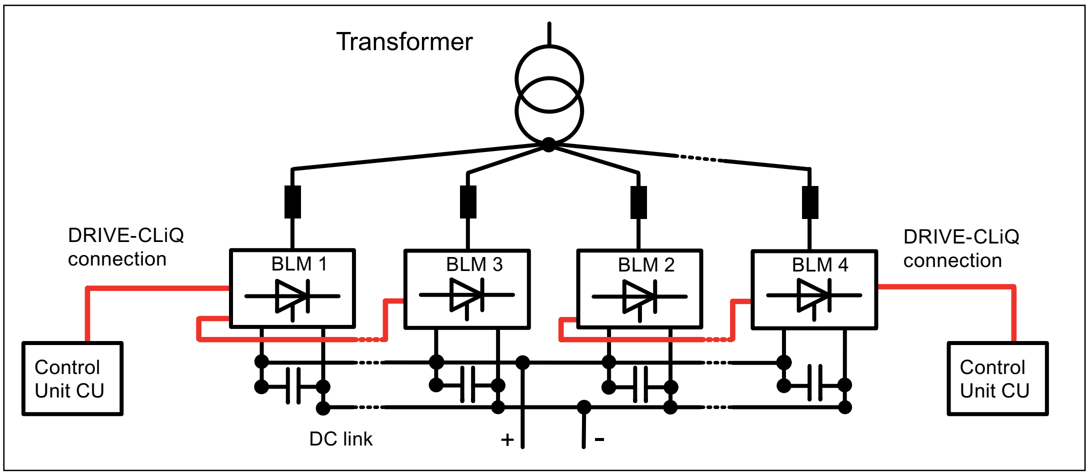

Figure 7-30 Parallel connection BLM 6-pulse redundant

12-pulse parallel connection of Basic Line Modules

With the 12-pulse variant of parallel connection, up to four Basic Line Modules on the line side are supplied by one three-winding transformer. An even number of Basic Line Modules, i.e two or four, must be divided equally between the two secondary windings. The Basic Line Modules of both subsystems are controlled by a common Control Unit - even though the input voltages are 30° out of phase.

There is also the redundant variant with which two BLMs in each case are controlled by one Control Unit.

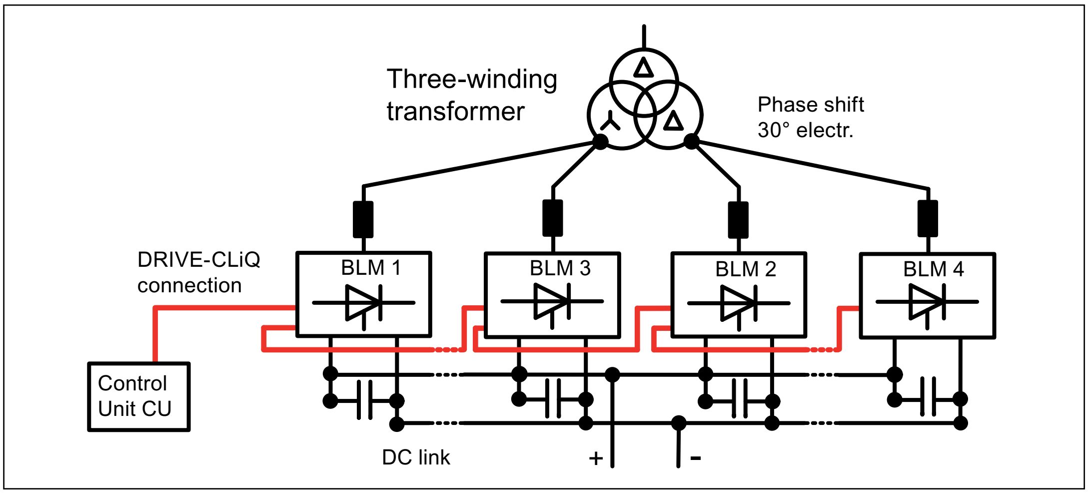

Figure 7-31 Parallel connection BLM 12-pulse single

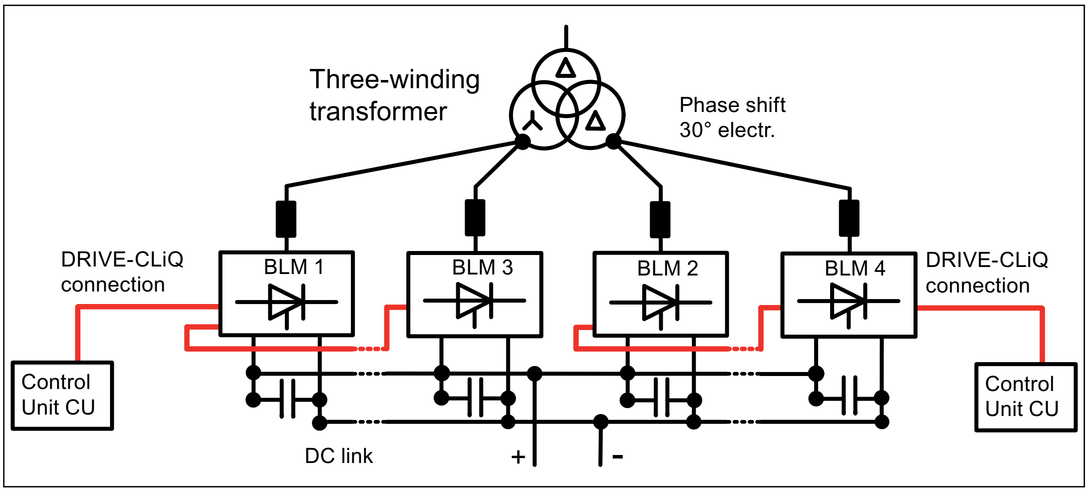

Figure 7-32 Parallel connection BLM 12-pulse redundant

Smart Line Modules (SLM)

Features

Smart Line Modules are infeed/regenerative feedback units. Like the Basic Line Module, they supply energy to the connected Motor Modules, but unlike the Basic Line Module, they are capable of recovering energy to the supply network.
The DC link voltage is greater than the rms value of the line rated voltage by a factor of 1.3.

Smart Line Modules are suitable for connection to grounded (TN, TT) and non-grounded (IT) supply systems. The following voltages and power ratings are available:

Line voltage / rated power

380 … 480 V 3 AC / 250 ... 800 kW

500 ... 690 V 3 AC / 450 ... 1400 kW

The following rules must be observed when connecting Smart Line Modules in parallel:

- Up to 4 identical Smart Line Modules can be connected in parallel.
- A shared Control Unit must be used to implement the parallel connection.
- A 4% reactor is always required upstream of each Smart Line Module for the purpose of current balancing.
- Special Line Connection Modules are available for the parallel connection.
- With multiple infeeds, power must be supplied to the systems from a common infeed point (i.e. the modules cannot be operated on different supplies).
- A derating factor of 7.5 % must be taken into consideration, regardless of the number of modules connected in parallel.

6-pulse parallel connection of Smart Line Modules

With the 6-pulse variant of parallel connection, up to four Smart Line Modules on the line side are supplied by a shared two-winding transformer and synchronously controlled by a shared Control Unit.

As Smart Line Modules have no current compensation control, the current must be balanced by the following measures:

- Use of suitable line reactors for the Smart Line Modules.
- Use of symmetrical power cabling between the transformer and the parallel-connected Smart Line Modules (cables of identical type with the same cross-section and length).
- The current reduction (derating) from the rated value for individual Smart Line Modules in a parallel connection is 7.5 %.

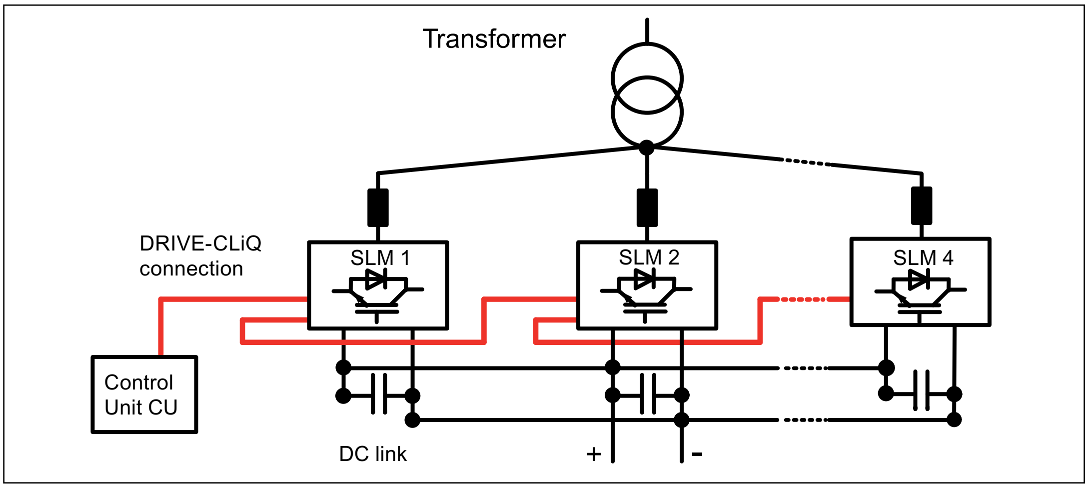

Figure 7-33 Parallel connection SLM 6-pulse single

12-pulse parallel connection of Smart Line Modules

With the 12-pulse variant of parallel connection, up to four Smart Line Modules on the line side are supplied by one three-winding transformer. An even number of Smart Line Modules, i.e two or four, must be divided equally between the two secondary windings. In contrast to Basic Line Modules, the Smart Line Modules of both subsystems have to be controlled by two Control Units due to the 30° phase displacement in the input voltages.

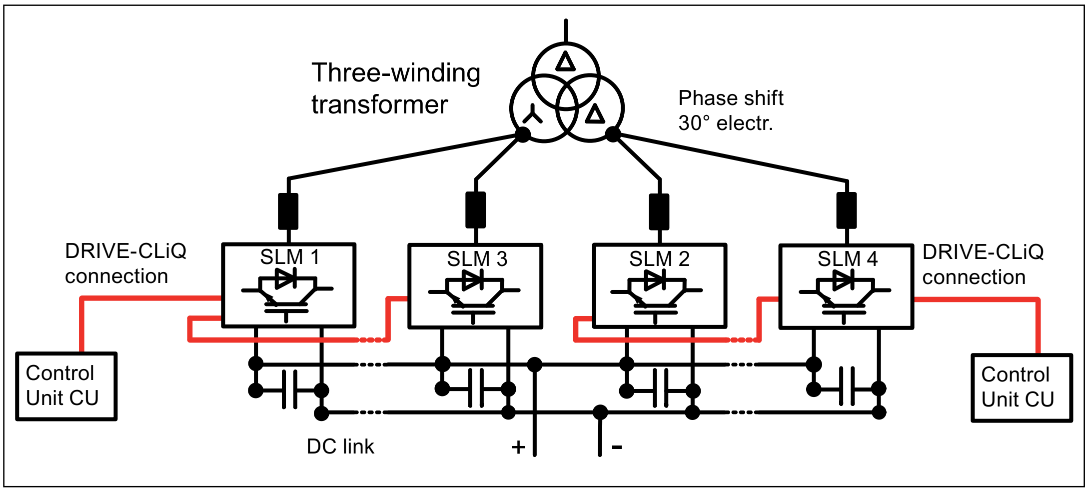

Figure 7-34 Parallel connection SLM 12-pulse redundant

Active Line Modules (ALM)

Features

Active Line Modules can supply the motor with power and recover energy produced in generator mode back to the power network.

The parallel connection of up to four Active Line Modules is supplied by a shared two-winding transformer and controlled synchronously by a shared Control Unit. The modules must not be connected to the supply via a three-winding transformer with phase-displaced secondary voltages.
Active Line Modules produce a stabilized DC voltage that remains constant regardless of fluctuations in the line voltage (the line voltage must range within the permissible tolerances).

The DC link voltage is greater than the rms value of the line rated voltage by a factor of 1.5.

Active Line Modules draw a virtually sinusoidal current from the supply system and cause virtually no line harmonic distortions.

Active Line Modules are available for the following voltages and power ratings:

Line voltage / rated power

380 … 480 V 3 AC / 132 ... 900 kW

500 ... 690 V 3 AC / 560 ... 1400 kW

The following rules must be observed when connecting Active Line Modules in parallel:

- Up to 4 identical Active Line Modules can be connected in parallel.
- Active Line Modules can only be connected and operated in parallel in the vector control mode.
- A shared Control Unit must be used to implement the parallel connection.
- Special Line Connection Modules are available for connecting the modules in parallel.
- With multiple infeeds, power must be supplied to the systems from a common infeed point (i.e. the modules cannot be operated on different supplies).
- A derating factor of 5% must be taken into consideration, regardless of the number of modules connected in parallel.

The following measures help to ensure balanced currents in parallel connections of Active Line Modules:

- Reactors in the Clean Power Filters of the Active Interface Modules.
- Use of symmetrical power cabling between the transformer and the parallel-connected Active Interface Modules / Active Line Modules (cables of identical type with the same cross-section and length).
- The current reduction from the rated value for individual Active Interface Modules / Active Line Modules in a parallel connection is 5 %.

6-pulse parallel connection of Active Line Modules

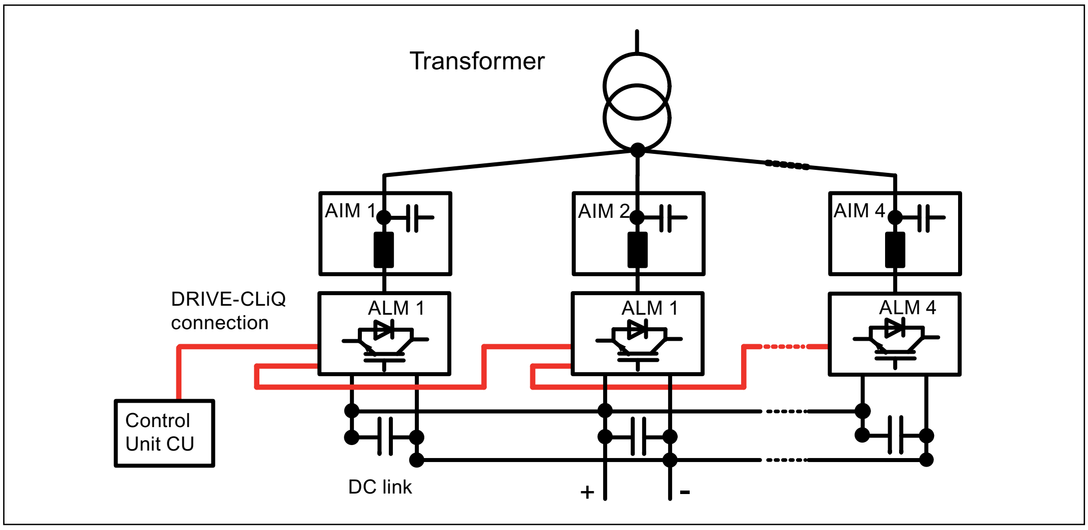

Figure 7-35 Parallel connection ALM 6-pulse single

6-pulse, redundant parallel connection of Active Line Modules with multiple Control Units

For a description of parallel connections of multiple Active Line Modules under the control of separate Control Units, please refer to section " Master/slave function for infeeds".

12-pulse parallel connection of Active Line Modules

The 12-pulse parallel connection can operate in master-slave mode (section "Master/slave function for infeeds").

Modules with different ratings can be included in the connection (as in the case of 6-pulse master-slave operation).

Parallel connection of Motor Modules

Up to four Motor Modules operating in parallel can supply a single motor in vector control mode. The motor can have electrically isolated winding systems or a common winding system. The type of winding system defines

- the decoupling measures to be implemented at the outputs of the parallel-connected Motor Modules
- the modulation systems which may be used to generate pulse patterns.

In conjunction with the type of infeed, the modulation systems define the maximum attainable output voltage or the maximum attainable motor voltage.

Permissible and impermissible winding systems for motors in SINAMICS parallel connections

The following are admissible:

1. Motors with electrically isolated winding systems (multi-winding system) in which the individual systems are not electrically coupled or out of phase with one another.
2. Motors with a common winding system (single winding system) in which all parallel windings in the motor are interconnected in the winding overhang or terminal box in such a way that they have the external appearance of a single winding system.

The following are inadmissible:

1. Motors with electrically isolated winding systems in which the individual systems are out of phase with one another.
2. Motors with separate winding systems on the line side which have a common, internal neutral.

Below are two examples illustrating the possible configuration of parallel connections of motors with a two-winding system or single winding system.

Parallel connection of two Motor Modules on a motor with a two-winding system

Motors with outputs of between about 1 MW and 4 MW for which parallel connections of power units are normally employed are generally designed with multiple parallel windings. If these parallel windings are not interconnected inside the motor, but taken separately to its terminal box(es), then the motor winding systems are separately accessible. In such cases, it is often possible to dimension the parallel connection of S120 Motor Modules in such a way that each motor winding system is effectively supplied by a separate Motor Module in the parallel connection. The diagram below shows this type of arrangement.

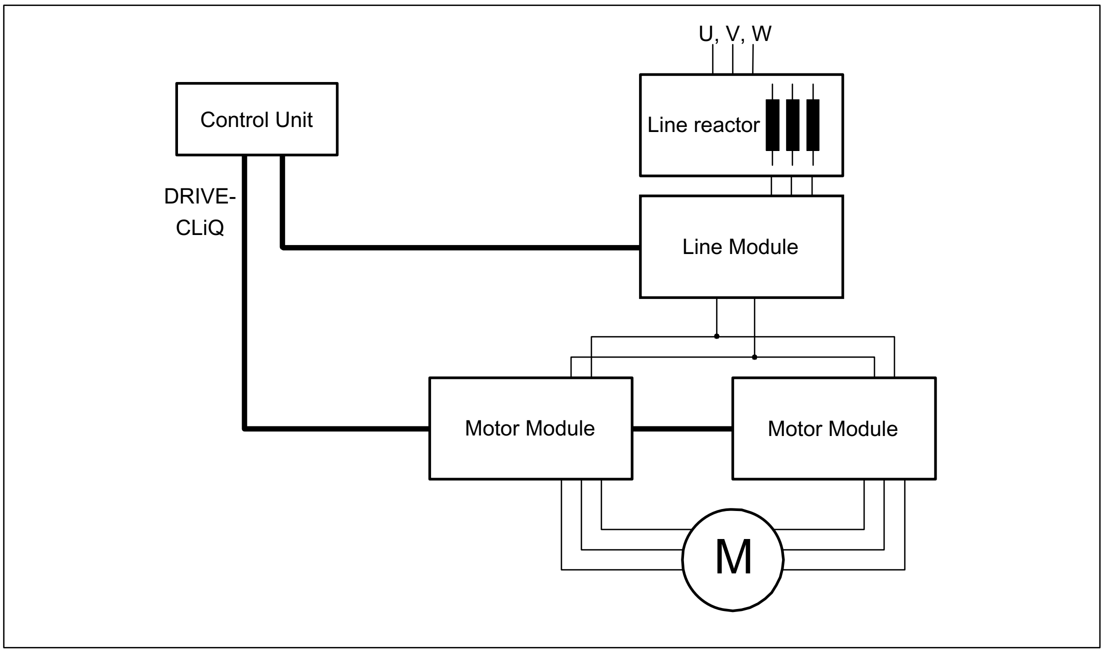

Figure 7-36 Example 1: parallel connection

Owing to the electrical isolation of the winding systems, this arrangement offers the following advantages:

- No decoupling measures need be implemented at the infeed output in order to limit any potential circulating currents between the parallel-connected Motor Modules (no minimum cable lengths and no motor reactors).
- Both types of modulation system, i.e. space vector modulation and pulse-edge modulation can be used, i.e. when the parallel connection is supplied by Basic Line Modules or Smart Line Modules, the maximum obtainable output voltage is almost equal to the three-phase AC line voltage connected to the infeeds (97 %). When the parallel connection is supplied by Active Line Modules, a higher output voltage than the input voltage at the three-phase end can be obtained due to the increased DC link voltage.

The current reduction from the rated value for the individual Motor Modules in a parallel connection is 5 %.

Parallel connection of two Active Line Modules and two Motor Modules on one motor with a single winding system

It is not possible to use motors with separate winding systems for many applications, e.g. it might not be possible to implement the required number of winding systems due to the pole number or because the motor is not supplied by Siemens or because a motor with a common winding system is already available for the application. In such cases, the outputs of the parallel-connected Motor Modules are interconnected via the motor cables in the motor terminal box.

Active Interface Modules isolate switching-frequency harmonics from the supply connection and thus effect basic interference suppression of the supply system. These modules are essential to the operation of Active Line Modules. The VSM10 Voltage Sensing Module also helps Active Line Modules to operate properly when mains power conditions are less than ideal (e.g. severe voltage fluctuations, brief interruptions in the line voltage). VSMs are integrated as standard in the Active Interface Modules for Active Line Modules in chassis format. The following diagram illustrates a parallel connection of Active Line Modules (chassis format) and Motor Modules.

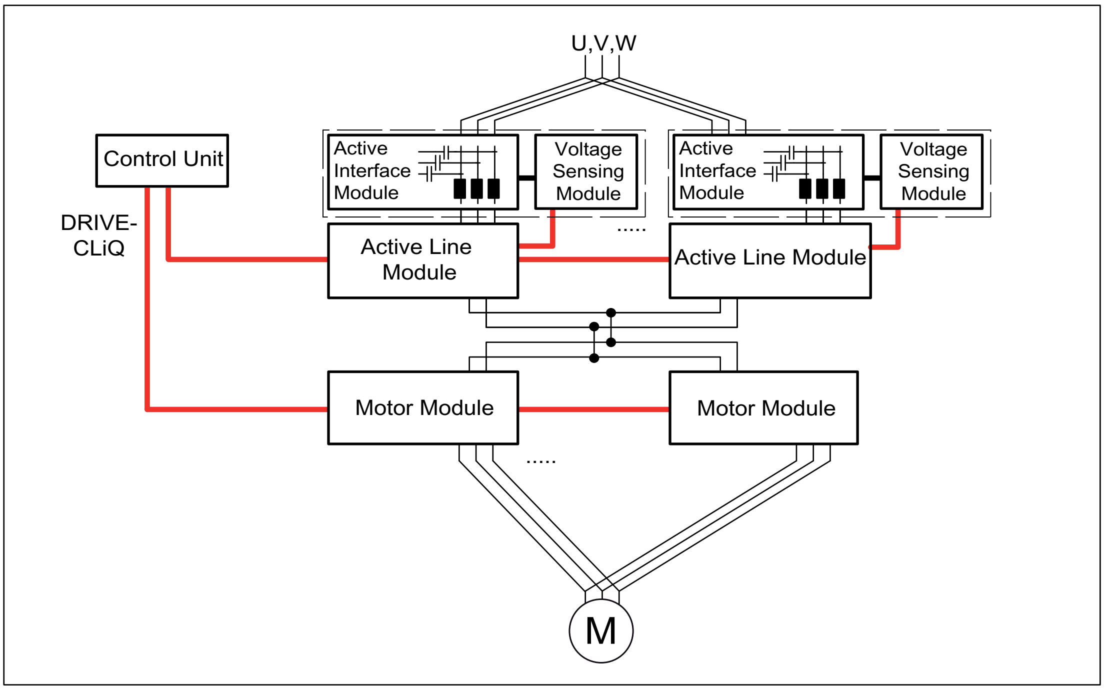

Figure 7-37 Example 2 parallel connection of Active Line Modules (chassis format) and Motor Modules

Owing to the electrical coupling of the winding systems, this arrangement has the following disadvantages:

- Decoupling can be implemented through the use of cables of minimum lengths between the Motor Modules and the motor or alternatively through the installation of motor reactors at the output of each Motor Module. (For details of minimum cable lengths, please refer to section "Parallel connection of Motor Modules for boosting the converter power output" in chapter "Configuring SINAMICS S120 Cabinet Modules" in the "SINAMICS Configuration Manual".
- Space vector modulation is the only permissible modulation system. Since pulse-edge modulation mode is not available, the maximum output voltage is limited to about 92 % of the three-phase input voltage of the infeeds when the parallel connection is supplied by Basic Line Modules or Smart Line Modules. When the parallel connection is supplied by Active Line Modules, a higher output voltage than the input voltage can be obtained due to the increased DC link voltage, even when the unit cannot operate in pulse-edge modulation mode.

The current reduction from the rated value for the individual Motor Modules in a parallel connection is 5 %.

7.13.2 Commissioning

During commissioning, power units connected in parallel are treated like a power unit on the line or motor side.

NOTICE
Parallel connection of Motor Modules in vector control
You have an offline project in vector control with parallel-connected Motor Modules and then transfer it online to the Control Unit. To save the project in the Control Unit, you must perform a POWER ON. When you now switch on, you receive an error message that the online topology is inconsistent. Load the project now to the programming device. This resolves the inconsistency.

For further detailed information about commissioning, supplementary operating conditions and parameterization options, please refer to the following references

- SINAMICS S120 Commissioning Manual
- SINAMICS S120/S150 List Manual starting at parameter r7002ff.

7.13.3 Additional drive in addition to the parallel connection

Frequently, a controlled auxiliary drive is required in addition to the main drives, e.g. as excitation controller for shaft-mounted generators in shipbuilding or as lubricating pump drive, fan drive etc.

For drive units with power units connected in parallel (Line Modules, Motor Modules), an additional drive, a DO (Drive Object) can be supplied as an auxiliary drive. The DO is supplied via a separate Motor Module from the common DC link and actuated from the CU320-2 via a dedicated DRIVE-CLiQ socket.

Conditions for switching in an auxiliary drive

The supplementary conditions for connecting an additional DO to the parallel connections are as follows (also refer to information above):

- Only power units of the same type and the same power rating may be connected together in parallel.
- Up to 4 Line Modules and up to 4 Motor Modules can be connected together in parallel.
- All the Power Modules operate on a common DC link.
- Due to the different cycle times, Line Modules and Motor Modules must be connected to separate DRIVE-CLiQ sockets. Mixed operation at one DRIVE-CLiQ socket results in a malfunction.
- Parameter p9620 (signal source for STO/SBC/SS1) of the DOs of all Motor Modules must be interconnected in the same way.
- The additional DO must be connected to a separate DRIVE-CLiQ socket.
- The maximum power of the auxiliary drive must be selected so that the maximum power of all the Motor Modules incl. the auxiliary drive - does not exceed the total power rating of the parallel Line Modules.
- Existing supplementary conditions and the resulting logic operations and monitoring functions must be adapted to the new requirements.

Creating a project with the appropriate topology

The required topology can be created using either the STARTER or SCOUT tool:

- The project is always created offline.
- The power units connected in parallel are combined by the CU to form a large Line Module or Motor Module.
- The auxiliary drive is assigned a separate DRIVE-CLiQ line.
- The DRIVE-CLiQ connections must be implemented corresponding to the topology that has been created

Example of the required topology

You can see an example created with STARTER below. 3 Basic Line Modules, 2 Motor Modules and an auxiliary drive are configured. The parallel connections can be clearly seen in the topology tree as one infeed and one drive. You can also see the additional auxiliary drive. The DRIVE-CLiQ connections are shown as a thin line. The three parallel Line Modules are connected to one DRIVE-CLiQ line, the two Motor Modules to the next DRIVE-CLiQ line, and the auxiliary drive to a third line.

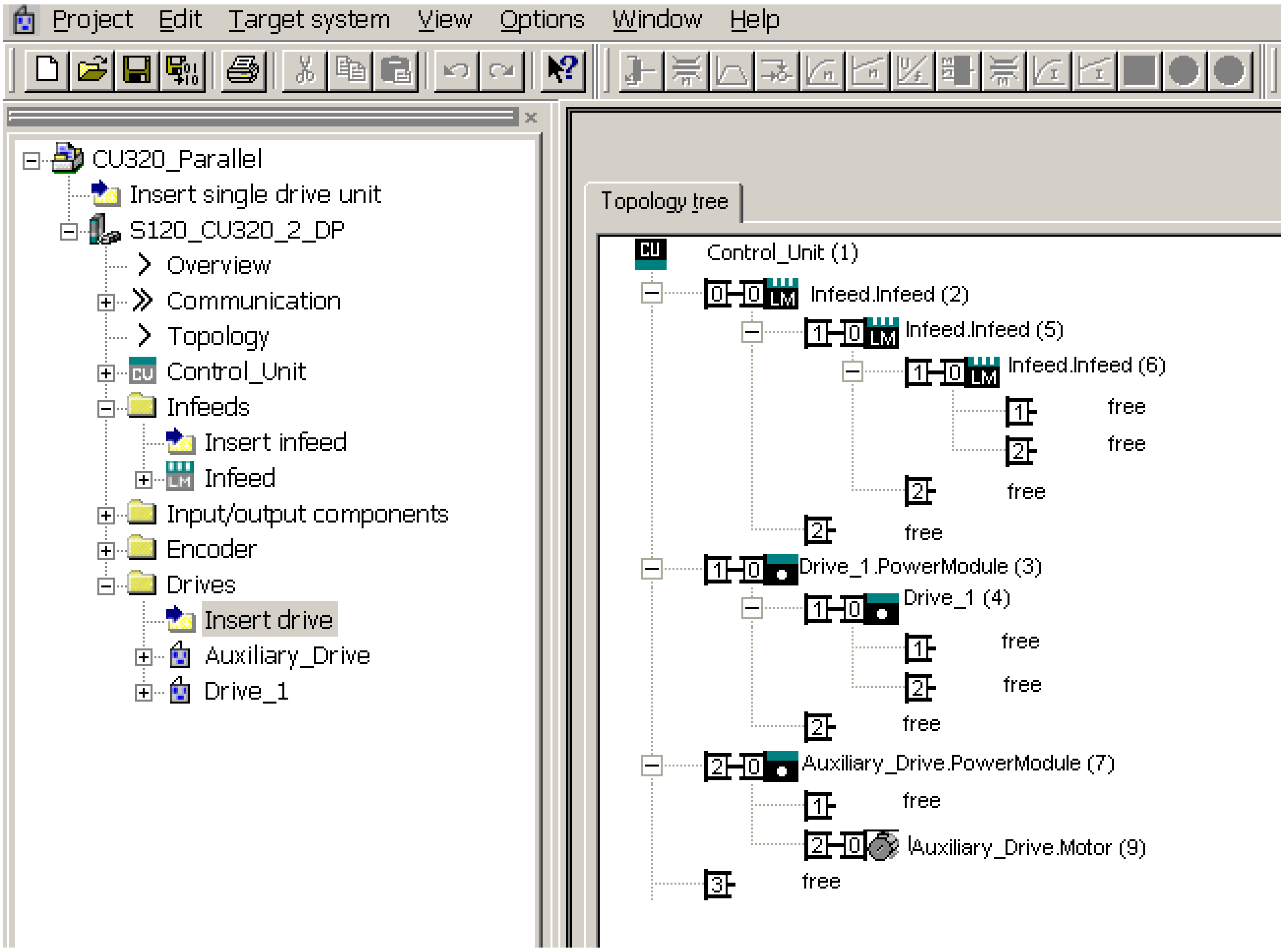

Figure 7-38 Topology with 3 Basic Line Modules, 2 Motor Modules and 1 auxiliary drive with SMI motor

7.13.4 Integration

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0120 Power unit data sets (PDS) number
- p0121 Power unit component number
- p0602 Par_circuit power unit number temperature sensor
- r7000 Par_circuit number of active power units
- p7001[0..n] Par_circuit enable power units
- r7002[0..n] Par_circuit status power units
- p7003 Par_circuit winding system
- p7010 Par_circuit current asymmetry alarm threshold
- p7011 Par_circuit DC link voltage asymmetry alarm threshold
- ...
- p7249 Par_circuit derating factor
- r7250[0...4] Par_circuit power unit rated output
- r7251[0...4] Par_circuit power unit rated current
- r7252[0...4] Par_circuit power unit maximum current
- ..
- r7320[0...n] Par_circuit VSM line filter capacity phase U
- r7321[0...n] Par_circuit VSM line filter capacity phase V
- r7322[0...n] Par_circuit VSM line filter capacity phase W

7.14 Extended stop and retract

Overview

The "extended stop and retract" function module (ESR) allows a workpiece and tool to be separated without causing any damage when a fault situation occurs. The drive axes involved are defined and are retracted and/or stopped in a controlled fashion. For this function, the drives must be operated in the SERVO control mode.

The drive-integrated ESR functions are described in this manual:

1. Extended stopping of the drive
2. Extended retraction of the drive
3. Generator operation with monitoring to buffer the DC link voltage

ESR functions can be initiated from the higher-level control using a trigger signal, or independently in the drives themselves in the event of a fault (the function is integrated in the drive). The ESR functions integrated in the drive act axially.

- Using an axial trigger, ESR functions are directly initiated for an individual axis.
- Using a local trigger on the device itself, the ESR functions are simultaneously initiated for those axes under the drive line that are activated for ESR.

NOTICE
ESR functionality under Safety Integrated Functions
If extended stop and retract are to activated simultaneously with Safety Integrated Functions, the following conditions must also be satisfied. Further information can be found in the SINAMICS S120 Safety Integrated Function Manual.

Example

For a machine tool, several drives are simultaneously operational, e.g. a workpiece drive and various feed drives for a tool. In the case of a fault, it is not permissible that the tool remains inserted in the workpiece. This could make both unusable. The tool and workpiece must be separated from one another in a controlled fashion before the drives are allowed to come to a standstill.

The "extended stop and retract" function module allows drive-integrated retraction using the feed drives and subsequent stopping of the drives. This means, for example when the line supply fails, a drive can be operated in the generator mode. This then supplies energy for the DC link so that the feed drives can retract the tool from the workpiece and then be subsequently stopped.

7.14.1 Preconditions for extended stop and retract

The following is required in order to be able to use these functions:

Hardware:

- CU320-2, order number: 6SL3040-1MA00-0AA1 (DP) or 6SL3040-1MA01-0AA0 (PN)
- The 24 V power supply for the electronics must be secured
- A PG/PC to program the parameters

Software:

- SINAMICS firmware V4.4 or higher

7.14.2 Activating and enabling the ESR function

PG/PC and drive are connected with one another via PROFIBUS or PROFINET.

1. Activate the "Extended stop and retract" function module (ESR) by setting parameter p0108.9 = 1
2. Use parameter p0888 to select the ESR function:
   - p0888 = 0: No function
   - p0888 = 1: Extended stopping (function integrated in the drive)
   - p0888 = 2: Extended retraction (function integrated in the drive)
   - p0888 = 3: Generator operation (Vdc controller)
3. Use p0889 = 1 to enable the ESR response.
4. Transfer the settings into the Control Unit using "RAM to ROM".

The parameterization of p0888 can be changed from a higher-level control depending on the particular situation - as long as the ESR response is not yet enabled.

ESR status

The actual ESR status can be called-up from parameter r0887.0...13.

7.14.3 Valid sources for triggering the ESR functions

Axis-related trigger sources

Conditions for triggering the function:

- ESR function has been configured in the drive with p0888, e.g. stopping or retraction.
- ESR function has been enabled in the drive with p0889 = 1.
- The pulse enable has been set.

A distinction is made between the following initiating fault sources:

1. Internal drive fault
   - Faults with reactions OFF1 or OFF3
   - p0840 (On/OFF1) and p0849 (OFF3) wired to terminal
2. Internal trigger signal
   - The source for the ESR trigger signal is set via BICO using p0890.

Triggering for all drives of a Control Unit

Conditions for triggering the function:

- ESR function has been configured in the drive, e.g. stopping or retraction.
- ESR function has been enabled in the drive.
- The pulse enable has been set.

A distinction is made between the following initiating fault sources:

1. Communication failure:
   - The Control Unit detects the communication failure and triggers autonomous reactions in all the enabled drives.
   - A status checkback signal is no longer possible.
   - The higher-level control removes the "Master control by PLC" signal (F07220).
   - Interruption of data transmission via the field bus (F01910 or F08501)
2. External trigger signal
   - An external trigger signal from the control triggers the ESR function via the telegrams 390, 391 or 392.

7.14.4 Invalid sources

The following DRIVE-CLiQ communication failures do not produce an ESR trigger:

1. Pulse suppression of the Motor Modules is pending
   – The drive performs an OFF2 and coasts to a standstill.
2. Failure of encoder modules as motor measuring system
   – The system is switched over to operation without encoder and a parameterized stop reaction is initiated.
3. Failure of encoder modules as a direct application-specific measuring system
   – The application is deactivated and a parameterized stop reaction initiated.

7.14.5 ESR responses

7.14.5.1 Extended stopping

In the case of a fault, the objective is to stop the drive in a defined fashion. The stopping method is used as long as the drive is still capable of functioning. The function is axially parameterized and operates axially. Axes are not coupled.

Configuring the "extended stop" response

1. The stop response is configured with p0888 = 1.
2. Using p0892, the time is set for which the last setpoint from r1438 is frozen before braking is initiated.
3. The OFF ramp is selected using p0891.

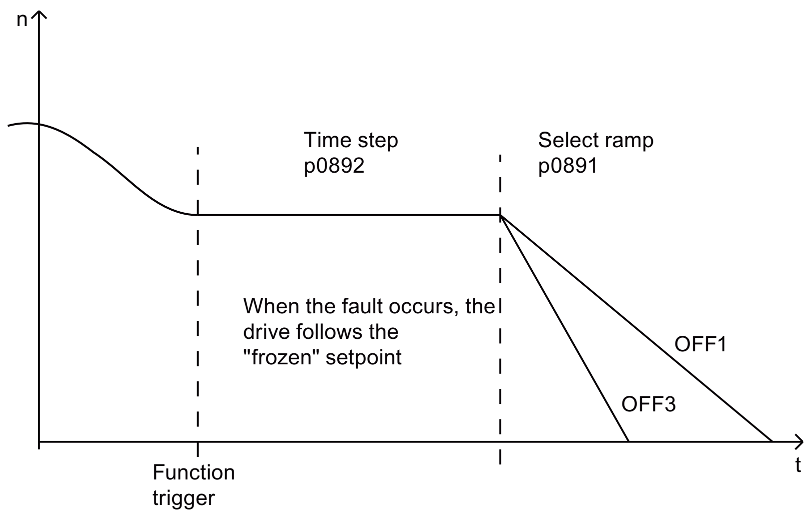

Figure 7-39 OFF ramp with timer

7.14.5.2 Extended retract

In the case of a fault, the objective is to approach a retraction position. The retraction method is used as long as the drive is still capable of functioning. The function is axially parameterized and operates axially. Interpolating coupling of the axes is not realized.

Configuring the "extended retract" response:

1. The retract response is configured with p0888 = 2.
2. The retraction speed is defined using p0893.
3. The time for which the retraction speed should be applied is specified using p0892.
4. The OFF ramp is selected using p0891.

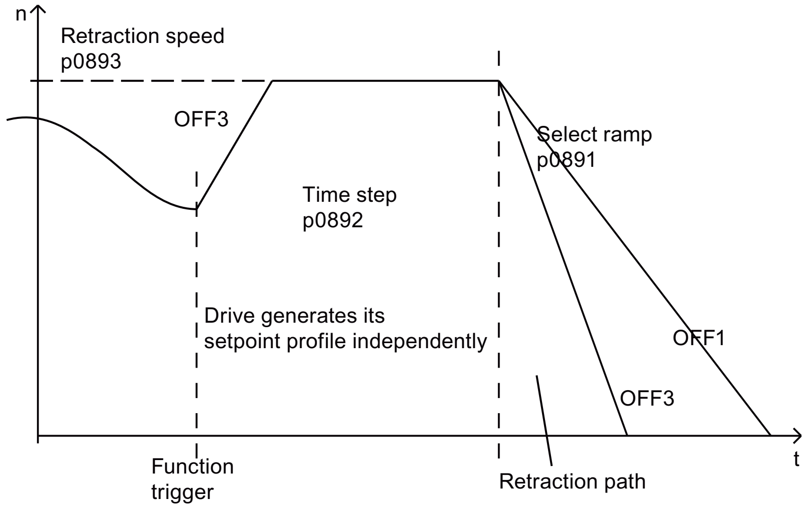

Figure 7-40 OFF ramp with "extended retract"

The retraction speed is not approached suddenly. It is approached via the OFF3 ramp.

Parameter p0893 supplies the ramp-function generator with the setpoint for the ESR retraction speed, which is actuated by an OFF3 ramp in the case of drive-integrated motions. The safety setpoint velocity limiting p1051/p1052 and the normal velocity limits r1084/r1087 are active.

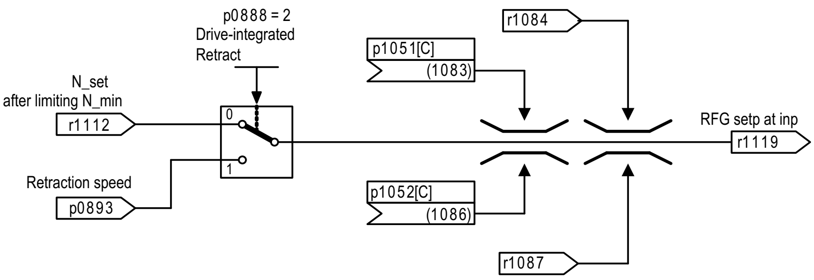

Figure 7-41 Connecting the setpoint channel to the ramp-function generator

7.14.5.3 Regenerative operation

In the case of a fault, the objective is to buffer the DC link until all of the drives connected to the DC link and enabled by ESR have reached their configured final position. To achieve this, a suitable drive in the drive line-up, for example a spindle drive, is braked in generator operation. The DC link voltage is then monitored by the V_{dc_min} controller.

Configuring the "generator operation" response

1. Generator operation of the drive is set using p0888 = 3.
2. The V_{dc} controller must be parameterized.
3. The monitoring of the DC link voltage for generator operation is activated with p1240 = 2.
4. The permissible lower voltage limit V_{dc_min} of the DC link is set using p1248.
5. The infeed detects when the power fails as the DC link voltage drops and this is then signaled as an alarm.

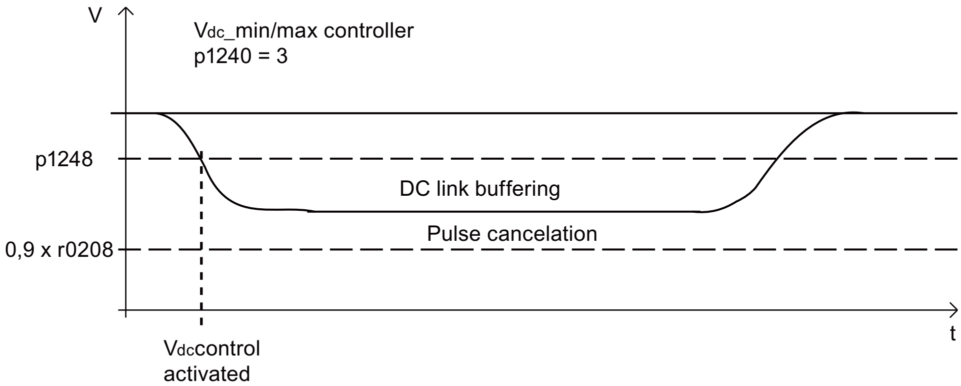

Figure 7-42 DC link voltage setpoint

7.14.6 Restrictions for ESR

ESR and IVPM

Do not use axes of Motor Modules with active IVPM for ESR functions. IVPM voltage monitoring has priority over ESR if an Integrated Voltage Protection Module (IVPM) is installed and has been activated (p1231 = 3).

Operating several axes in the generator mode

Only use one speed-controlled axis to buffer the DC link. If you have parameterized several axes, faults can occur, which undesirably influence one another and therefore the drive line-up as a whole.

Motors that are not suitable for generator operation

Linear motors (1FN) and torque motors (1FW) require an adequately high DC link voltage to brake. They are not suitable to buffer the DC link when operating in the generator mode.

ESR and Safety Integrated

In the event of a communication failure, Safety Integrated only permits a reaction time (p9697/p9897) of max. 800 ms. After expiry of this time limit, pulse suppression of Safety is requested.

7.14.7 PROFIdrive telegram for ESR

A cyclic bit for CU_STW1 is present in PROFIdrive-DO telegrams 390, 391, 392, 393 and 394 to monitor the ESR state.

Table 7- 10 CU_STW1

Signal	Meaning	Interconnection parameters
CU_STW1.2	ESR trigger	p0890.9 = r2090.2

Cyclic bits for STW1 and MELDW are present in the telegrams.

Table 7- 11 STW1

Signal	Meaning	Interconnection parameters
STW1.9	1 = Enable ESR response	p0889 = r2090.9

Table 7- 12 MELDW

Signal	Meaning	Interconnection parameters
MELDW.2	1 = |n_act| < speed threshold value 3 (p2161)	p2082[2] = r2199.0
MELDW.4	1 = Vdc_min controller active (V_{dc}<p1248)	p2082[4] = r0056.15
MELDW.9	1 = ESR response initiated / generator operation active	p2082[9] = r0887.12

7.14.8 Overview of important parameters and function diagrams

Parameters (see SINAMICS S120/S150 List Manual)

- p0108[0...23] drive objects, the function module
- r0108[9] Drive objects function module - extended stop and retract
- r0887 BO: ESR status word
- p0888 ESR configuration
- p0889 BI: Enable ESR response
- p0890 BI: ESR trigger
- p0891 ESR OFF ramp
- p0892 ESR timer
- p0893 ESR velocity / ESR speed
- p1051 [0...n] CI: Speed limit in RFG, positive direction of rotation
- p1052 [0...n] CI: Velocity limit RFG, negative direction
- p1084 CO: Speed limit positive effective
- p1087 CO: Speed limit negative effective
- p1240[0...n] Vdc controller or Vdc monitoring configuration
- p1248[0...n] DC link voltage threshold, lower
- p1438 CO: Speed controller, speed setpoint

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2443 Signal targets for STW1 in interface mode SIMODRIVE 611 universal (p2038 = 1)
- 2456 Signal sources for MELDW
- 2495 Signal targets for CU_STW1
- 3082 Setpoint channel - Extended Stop and Retract (ESR, r0108.9 = 1)

7.15 Moment of inertia estimator

For operation without encoder, it is important to know the moment of inertia: On the one hand, you have to know how fast the frequency can be adjusted in controlled mode (at speeds lower than p1755) without causing the motor to stall. On the other, in closed-loop operation (speeds above p1755) there is speed/torque precontrol that "hides" the low control dynamics in the speed setpoint performance for operation without encoder. To work ideally, this precontrol must also exactly know the moment of inertia. If an incorrect moment of inertia is parameterized, the error is interpreted as a pseudo load torque in the precontrol, with the result that the speed controller compensates during acceleration; this causes undershoot or overshoot at the end of the acceleration process because this pseudo load torque must be reduced in the I component. This transient response is audible because the speed controller dynamics are low in encoderless operation.

The moment of inertia estimator can also be activated in operation with encoder; however, speed/torque precontrol must then be activated (p1402.4 = 1). Otherwise, the moment of inertia is not included in the motor control and an online estimation does not make any sense.

Prerequisites and mode of operation

If an unknown load is present during speed change, it is not possible to determine the moment of inertia. Though the total torque of the motor is known, you do not know which share is used for acceleration and which for the load. For this reason, the prerequisite for the moment of inertia estimator is that the acceleration or braking procedures (through the speed setpoint) take place without load (processing). For individual phases in which processing is required during the speed setpoint adjustment (e.g. for thread cutting), the estimator can be frozen using a BICO switch (source of p1502 = 1) to prevent a wrong estimate falsifying a correct moment of inertia determined previously.

Generally, however, phases are required in which the speed is adjusted without load. The moment of inertia is then determined from the motor torque and the speed change, smoothed as appropriate and adapted online. For initial adaptation, the system waits for a certain measuring time (100 ms) so that the mechanical transient does not falsify determination of the overall moment of inertia. Determination is carried out only in the closed-loop range for encoderless operation because the actual speed value is known here only. The estimator operates over the entire speed range during operation with encoder; in all other cases, however, only during a sufficient speed adjustment in the control performance (|r1518[1]| > 0.05*|p1538 – p1539|) and if freezing of the estimator is not requested via p1502. The start value of the estimator is the parameterized moment of inertia (p0341 * p0341 + p1498). This must be set to the greatest occurring moment of inertia so that the motor does not stall the first time it is accelerated in the open-loop controlled range. As long as the pulses are not deleted, the current estimated value of the moment of inertia is always used in the motor model. This value can be monitored in r1493. The estimated moment of inertia is reset to the parameterized value with each pulse inhibit. The speed controller is not adapted to the estimated moment of inertia.

Parameterization and activation

To activate the moment of inertia estimator, set

- p0108[Drive number - 1].10 = 1
- p1400.Bit18 = 1

A data set changeover can be used to activate or deactivate the moment of inertia estimator. For operation with encoder, p1402.4 = 1 must also be set. If the function for adapting the moment of inertia via BICO (p1497 connected) is activated, the moment of inertia estimator is not active. If there are changes in the speed setpoint while under load, you should always set the source of p1502 = 1 to freeze the currently estimated value for the moment of inertia during this period. Otherwise the prerequisite for the moment of inertia estimator is that changes to the speed setpoint are made while not under load. The estimated moment of inertia can be monitored in p1493.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0108[0...23] drive objects, the function module
- p0341[0...n] Motor moment of inertia
- p1400[0...n] Speed control configuration
- p1402[0...n] Closed-loop current control and motor model configuration
- r1493 CO: Moment of inertia, total
- p1497[0...n] CI: Moment of inertia scaling
- p1498[0...n] Load moment of inertia
- p1502[0...n] BI: Freezing the moment of inertia estimator
- r1518[0...1] CO: Accelerating torque
- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit
- p1755[0...n] Motor model changeover speed encoderless operation

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 thermal power unit monitor is responsible for identifying 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

  Is used to monitor the temperature r0037.0 of the heatsink on the power semiconductors (IGBT).

- Chip temperature - A05001 - F30025

  Significant temperature differences can occur between the IGBT barrier junction and the heat sink. The calculated depletion layer temperature is displayed in r0037[13...18]; the monitoring ensures that the specified maximum depletion layer temperature is not exceeded.

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 temperature difference between two sensors must not exceed more than 15 Kelvin (K); a temperature difference of 5 K is set for the temperature monitoring of the heat sink and the air intake. This means that 15 K or 5 K below the shutdown threshold an alarm is issued regarding the pending overtemperature. Using p0294, it is only possible to change the alarm threshold so that an alarm is received earlier. This means that an intervention can then be made in the drive process (e.g. reduce the load, reduce the ambient temperature).

Overload responses

The power unit responds with alarm A07805. The Control Unit initiates the parameterized responses via p0290 at the same time that the alarm is issued. 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 the 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 significantly reduces the converter output current which, in turn, reduces the 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 with alarm A05000 (power unit: Overtemperature inverter heat sink), A05001 (power unit: Overtemperature chip) or A07850 (drive: Power unit overload I2t). The time until shutdown, however, is not defined and depends on the degree of overload.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8014 Thermal monitoring, power unit

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r0036 CO: Power unit overload I2t
- r0037 CO: Power unit temperatures
- p0290 Power unit overload response
- p0294 Power unit alarm for I2t overload

8.3 Block protection

Description

The "Motor blocked" fault is only output if the speed of the drive is below the adjustable 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 F07900 are generated.

The enable for blocked motor monitoring can be deactivated using p2144.

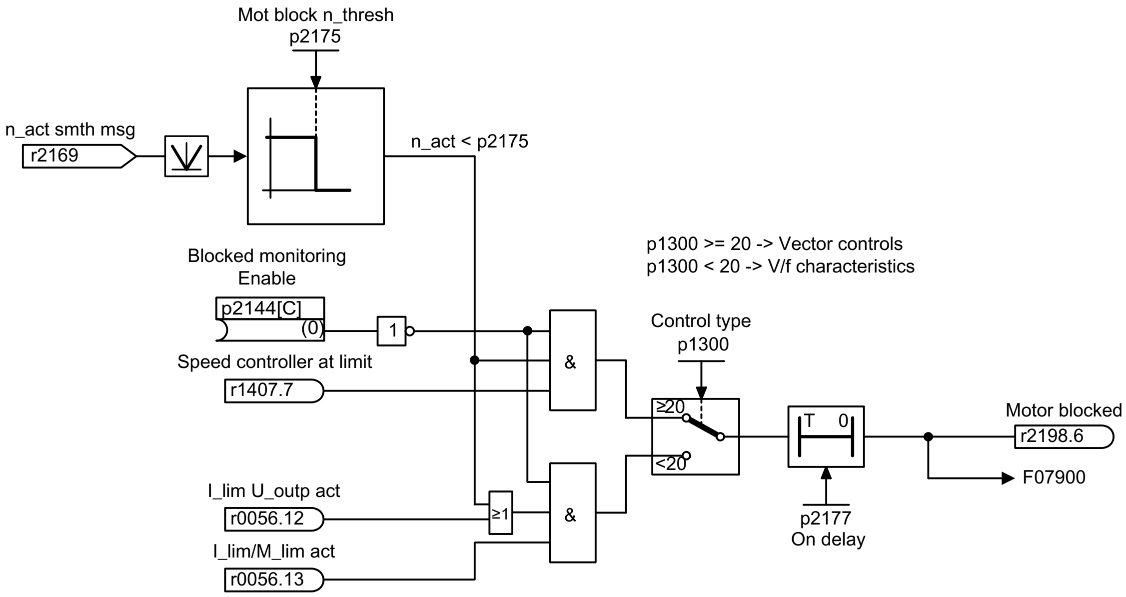

Figure 8-1 Block protection

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8012 Signals and monitoring functions - Torque messages, motor blocked/stalled

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p2144 BI: Blocked motor monitoring enable (negated)
- 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 the error threshold value set in p1745 is exceeded when in the low speed range (less than p1755 * (100% - p1756)), r1408.12 (motor stalled) is set.

If one of the two signals is set, then after the delay time in p2178, fault F7902 (motor stalled) is output.

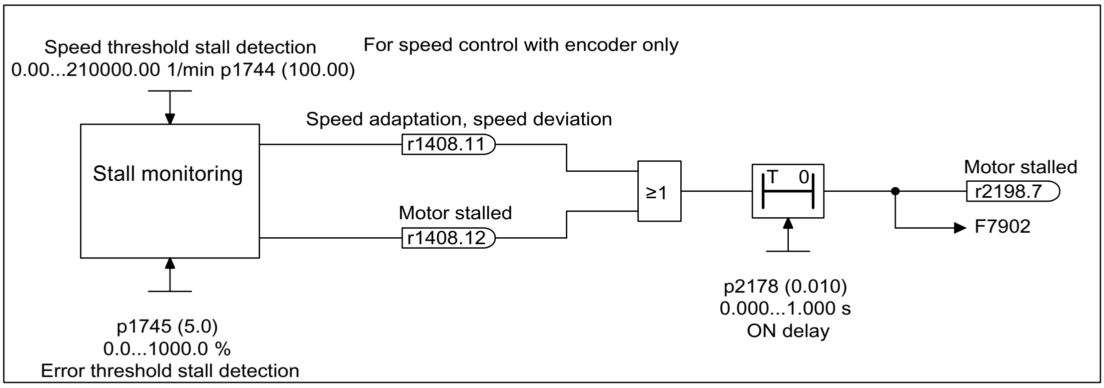

Figure 8-2 Stall protection

Function diagrams (see SINAMICS S120/S150 List Manual)

- 6730 Current control
- 8012 Torque messages, motor blocked/stalled

Overview of important parameters (see SINAMICS S120/S150 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 monitoring

8.5.1 Description

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 (p0600 = 0 or 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.

8.5.2 Temperature connection at the customer terminal block TM31

Temperature measurement via KTY

The device is connected to terminals X522:7 (Temp+) and X522:8 (Temp-) on the customer terminal block (TM31) in the forward direction of the diode. The measured temperature is limited to between –140 °C and +188,6 °C and is made available for further evaluation.

- Activate motor temperature measurement via the external sensor: p0600 = 10
  If the customer terminal block TM31 (option G60) is present and on completion of commissioning, the source for the external sensor is set to the customer terminal block (p0603 = {TM31} r4105).
- Set the KTY temperature sensor type: p4100 = 2

Temperature measurement via PTC

The device is connected to terminal X522:7/8 on the customer terminal block (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.

- Activate motor temperature measurement via the external sensor: p0600 = 10
  If the customer terminal block TM31 (option G60) is present and on completion of commissioning, the source for the external sensor is set to the customer terminal block (p0603 = {TM31} r4105).
- Set the PTC temperature sensor type: p4100 = 1

8.5.3 Temperature connection to a Sensor Module

Temperature measurement via KTY

The device is connected to the appropriate terminals Temp- and Temp+ on the Sensor Module in the forward direction of the diode (see corresponding section in chapter "Electrical installation").

- Activate motor temperature measurement via encoder 1: p0600 = 1.
- Set the KTY temperature sensor type: p0601 = 2

Temperature measurement via PTC

The device is connected to the appropriate terminals Temp- and Temp+ on the Sensor Module (see corresponding section in chapter "Electrical installation"). The threshold for switching to an alarm or fault is 1650 Ω.

- Activate motor temperature measurement via encoder 1: p0600 = 1.
- Set the PTC temperature sensor type: p0601 = 1

8.5.4 Temperature connection directly on the Control Interface Module

Temperature measurement via KTY

The device is connected to terminals X41:3 (Temp-) and X41:4 (Temp+) on the Control Interface Module in the forward direction of the diode.

- Activate motor temperature measurement via Motor Module: p0600 = 11.
- Set the KTY temperature sensor type: p0601 = 2

Temperature measurement via PTC

The device is connected to terminals X41:3 (Temp-) and X41:4 (Temp+) on the Control Interface Module. The threshold for switching to an alarm or fault is 1650 Ω.

- Activate motor temperature measurement via Motor Module: p0600 = 11.
- Set the PTC temperature sensor type: p0601 = 1

Temperature measurement via PT100

The device is connected to terminals X41:3 (Temp-) and X41:4 (Temp+) on the Control Interface Module. p0624 can be used to set the temperature offset for the PT100 measured value.

- Activate motor temperature measurement via Motor Module: p0600 = 11.
- Set the PT100 temperature sensor type: p0601 = 5

8.5.5 Temperature sensor evaluation

Temperature measurement via KTY or PT100

- When the alarm threshold is reached (set via p0604; delivery state after commissioning 120 °C), alarm A07910 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, delivery state after commissioning 155 °C), fault F07011 is triggered in conjunction with the setting in p0610.

Temperature measurement via PTC

- Alarm A07910 is triggered once the PTC responds.
- Fault F07011 is triggered once the waiting time defined in p0606 has elapsed.

Sensor monitoring for wire breakage/short-circuit

If the temperature of the motor temperature monitor is outside the range -140 °C to +250 °C, the sensor cable is broken or has short-circuited. Alarm A07015 ("Drive: Motor temperature sensor alarm") is triggered. Fault F07016 (“Drive: Motor 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.

Thermal 3 mass model (for induction machines)

For induction machines, the motor temperature is calculated using the thermal 3 mass model. This makes a thermal motor protection possible even for operation without temperature encoder or with temperature sensor deactivated (p0600 = 0).

For operation with a KTY encoder, the calculated temperature value of the 3 mass model permanently tracks the measured temperature value. When the temperature encoder is deactivated (p0600 = 0), the current temperature is used.

Thermal I2t motor model (for permanently excited synchronous machines)

By using the thermal I2t motor model, heating of the motor windings through dynamic motor loads is also determined in addition to the data recorded via temperature sensor.

If the thermal I2t motor model is activated via p0612.0 = 1, it calculates the motor load (r0034) from the following values:

- Absolute current actual value (r0068[0])
- Motor stall current (p0318),
- I2t motor model thermal time constant (p0611)
- measured motor temperature (r0035) or motor ambient temperature (p0625) for operation without temperature sensor

If the fault threshold is exceeded (set via p0605; delivery state after commissioning 155 °C), alarm A0712 "I2t motor model overtemperature" is triggered.

When the I2t motor model fault threshold is reached (p0615), fault F07011 is triggered in conjunction with the setting in p0610.

8.5.6 Function diagrams

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8017 Thermal I2t motor model
- 9576 Temperature evaluation KTY/PTC
- 9577 Sensor monitoring KTY/PTC

8.5.7 Parameter

Table 8- 2 Overview of important parameters (see SINAMICS S120/S150 List Manual)

Temperature sensor evaluation

- r0035 CO: Motor temperature
- p0600 Motor temperature sensor for monitoring
- p0601 Motor temperature sensor type
- p0603 Motor temperature signal source
- p0604 Motor overtemperature fault threshold
- p0605 Motor overtemperature alarm threshold
- p0606 Motor overtemperature timer
- p0607 Temperature sensor fault timer
- p0610 Motor overtemperature response
- p0624 Motor temperature offset PT100
- p4100 TM31 temperature evaluation sensor type
- r4105 CO: TM31 temperature evaluation actual value

Thermal I2t motor model (for permanently excited synchronous machines)

- r0034 CO: Motor load
- r0068[0] CO: Absolute actual current, unsmoothed
- p0318 Motor stall current
- p0605 Motor overtemperature alarm threshold
- p0610 Motor overtemperature response
- p0611 I2t motor model thermal time constant
- p0612 Thermal motor model configuration
- p0615 I2t motor model fault threshold
- p0625 Motor ambient temperature

Safety Integrated basic functions 9

9.1 Latest information

Important note for maintaining the operational safety of your system:

⚠ WARNING
Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operating company. The supplier is also obliged to comply with special product monitoring measures. For this reason, we publish a special newsletter containing information on product developments and features that are (or could be) relevant when operating safety-related systems. You should subscribe to the corresponding newsletter in order to obtain the latest information and to allow you to modify your equipment accordingly.

Go into the Internet under:

http://automation.siemens.com

To subscribe to the newsletter, please proceed as follows:

1. Select the desired language for the webpage.
2. Click on the menu item "Support".
3. Click on the menu item "Newsletter".

Note

You have to register and log in if you want to subscribe to any newsletters. You will be led automatically through the registration process.

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4. Click on "Login" and log in with your access data. If you do not yet have a login and password, select "Yes, I would like to register now".

   You can subscribe to the individual newsletters in the following window.
5. Select the document type you wish to be informed about under "Select document type for topic and product newsletters".
6. Under the "Product Support" heading on this page, you can see which newsletter is currently available.

7. Open the subject area "Safety Engineering - Safety Integrated".

   You will now be shown which newsletter is available for this particular subject area or topic. You can subscribe to the appropriate newsletter by clicking on the box. If you require more detailed information on the newsletters then please click on these. A small supplementary window is opened from where you can take the appropriate information.
8. At the very least, register for the newsletters for the following product areas:
   - Safety Integrated for SIMOTION
   - Drives

9.2 General information

Note

This manual describes the Safety Integrated Basic Functions.

The Safety Integrated Extended Functions are described in the following documentation:

References: /FHS/ SINAMICS S120 Function Manual Safety Integrated.

9.2.1 Explanations, standards, and terminology

Safety Integrated

The "Safety Integrated" functions enable the implementation of highly effective application-oriented functions for man and machine protection. 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 directives, however, they are not binding.

Below is a list of standards and guidelines for safety technology.

- EC Machinery Directive 2006/42/EC

  This guideline defines basic protection measures for safety technology.
- EN 292-1

  Basic terminology and general design principles.
- EN 954-1/ ISO 13849-1

  Safety-related parts of control systems
- EN 1050

  Risk assessment
- EN 60204-1:2006

  Safety of machinery - Electrical equipment of machines - Part 1: Electrical equipment of machinery - General requirements
- 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.
- IEC 61800-5-2

  Adjustable-speed electrical power drive systems
  Part 5-2: Safety requirements - Functional

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/ ISO 13849-1.
- Safety integrity level 2 (SIL 2) to IEC 61508.

In addition, the SINAMICS S120 safety functions are normally certified by independent institutions. A list of currently certified components is available on request from your local Siemens office.

Note

When operated in dry areas, SINAMICS equipment with three-phase motors conforms to Low-Voltage Directive 2006/95/EC.

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 (r0110) also increases the safety monitoring clock cycle.

Data cross-check

A cyclic cross-check of the safety-related data in the two monitoring channels is carried out.

If any data are inconsistent, a stop response is triggered with any Safety function.

Overview of parameters (see SINAMICS S120/S150 List Manual)

- r9780 SI Monitoring clock cycle (Control Unit)
- r9880 SI Monitoring clock cycle (Motor Module)

9.2.2 Supported functions

The functions listed here are in conformance with the IEC 61508, SIL2 standard, in the operating mode with a high demand, Category 3 and Performance Level d (PL d) acc. to ISO 13849-1 (2006) as well as IEC 61800-5-2.

The following Safety Integrated functions (SI functions) are available:

- **Safety Integrated Basic Functions**

  These functions are part of the standard scope of the drive and can be used without any additional license:

  – Safe Torque Off (STO)

    STO is a safety function that prevents the drive from restarting unexpectedly, in accordance with EN 60204-1:2006 Section 5.4.

  – 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 60204-1:2006 can be implemented.

  – Safe Brake Control (SBC)

    The SBC function permits the safe control of a holding brake.

    SBC is supported only by Power/Motor Modules in chassis format with order number xxx3 or higher. Blocksize Power Modules also require a Safe Brake Relay for this function.

- **Safety Integrated Extended Functions (including the Basic Functions)**

  An additional license that will be charged for is required to use Safety Integrated Extended Functions. The Safety Integrated Extended Functions

  – Safe Torque Off (STO)

  – Safe Stop 1 (SS1, time and acceleration controlled)

  – Safe Brake Control (SBC)

  – Safe Stop 2 (SS2)

  – Safe Operating Stop (SOS)

  – Safely Limited Speed (SLS)

  – Safe Speed Monitor (SSM)

  – Safe Acceleration Monitor (SAM)

  – Safe Brake Ramp (SBR)

  – Safe Direction (SDI)

  – Safety Info Channel (SIC)

  You can find a description in the following reference:

  Reference: /FHS/ SINAMICS S120 Safety Integrated Function Manual.

9.2.3 Controlling the Safety Integrated functions

The following options for controlling Safety Integrated functions are available:

Table 9- 1 Controlling the Safety Integrated functions

	Terminals (on the Control Unit and Motor/Power Module)	PROFIsafe based on PROFIBUS or PROFINET	TM545F
Basic Functions	Yes	Yes	No
Extended Functions	No	Yes	Yes

For Extended Functions, control is also possible via the Terminal Module TM54F. In this case, control via terminals **and** TM54F or terminals **and** PROFIsafe can be simultaneously selected.

NOTICE

Safety Integrated functions with SIMOTION

PROFISafe via PROFINET is not permitted with SIMOTION.

NOTICE

PROFIsafe or TM54F

Using a Control Unit, control is possible either via PROFIsafe or TM54F. Mixed operation is not permissible.

Note

When controlling Safety Integrated functions via a TM54F, you may only assign each drive to precisely one drive group of the TM54F.

9.2.4 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, checksum calculations (Cyclic Redundancy Check, CRC) are performed on the Safety parameter data and checked. The display parameters are not contained in the CRC.
- Data storage: The parameters are stored on the non-volatile memory 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.

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 reference 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)

During each ramp-up procedure, the actual checksum is calculated via the Safety parameters and then compared with the reference checksum.

If the actual and reference checksums are different, fault F01650/F30650 or F01680/F30680 is output and an acceptance test requested.

Safety Integrated versions

The Safety firmware 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)

Password

The Safety password protects the Safety parameters against unintentional or unauthorized access.

In the 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.

- When Safety Integrated is commissioned for the first time, the following applies:
  - Safety passwords = 0
  - Default setting for p9761 = 0

  In other words:
  The Safety password does not need to be set during first 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 memory 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.

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.

Or contact your regional Siemens office and ask for the password to be deleted (complete drive project must be made available).

Overview of important parameters for "Password" (see SINAMICS S120/S150 List Manual)

- p9761 SI password input
- p9762 SI password new
- p9763 SI password acknowledgement

9.2.5 Forced dormant error detection

Forced dormant error detection or test of the switch-off signal paths for Safety Integrated Basic Functions

The forced dormant error detection function at the switch-off signal paths is used to detect software/hardware faults at both monitoring channels in time and is automated by means of activation/deactivation of the "Safe Torque Off" function.

To fulfill the requirements of ISO 13849-1 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. This functionality must be implemented by means of forced dormant error detection function, triggered either in manual mode or by the automated 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, an alarm is only output to inform the user that a forced dormant error detection run is due and to 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).

Examples of when to carry out forced dormant error detection:

- When the drives are at a standstill after the system has been switched on (POWER ON).
- When the protective door is opened.
- At defined intervals (e.g. every 8 hours).
- In automatic mode (time and event dependent)

9.3 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.
>
> It may be necessary to carry out a partial or complete acceptance test or a simplified functional test (see the "Acceptance test" chapter) after making certain changes or replacements.
>
> 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 has to be incorporated in the protective door interlocking logic.

> ⚠ 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 firmware update via p7826 = 1 (upgrade and downgrade) must not be deactivated under any circumstances when using Safety Integrated.

> ⚠ 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.

9.4 Safe Torque Off (STO)

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 energy feed to the motor.

When the function is selected, the drive unit is in a "safe status". The switching on inhibited function prevents the drive unit from being restarted.

The two-channel pulse suppression function 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, i.e. it is available for each drive and must be individually commissioned.
- The function must be enabled using parameters.
- When the "Safe Torque Off" function is selected, the following applies:
  - The motor cannot be started accidentally.
  - The pulse suppression safely disconnects the torque-generating energy feed to the motor.
  - The power unit and motor are not electrically isolated.
- Extended acknowledgment:

  If STO is selected/deselected (and p9307.0/p9507.0 = 1 are set), safety messages (in addition to fault messages) are also canceled automatically.
- A debounce function can be applied to the terminals of the Control Unit and the Motor Module/Power Module to prevent incorrect trips due to signal disturbances. The filter times are set using parameters p9651 and p9851.

⚠ WARNING
Appropriate measures must be taken to ensure that the motor does not undesirably move once the energy feed has been disconnected, e.g. against coasting down or for a hanging/suspended axis, the "Safe Brake Control" (SBC) function should be enabled, also refer to Chapter "Safe Brake Control".

⚠ CAUTION
If two power transistors simultaneously fail in the power unit (one in the upper and one in the lower bridge), then this can cause brief 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" function

The "Safe Torque Off" function is enabled via the following parameters:

- STO via terminals:
  p9601.0 = 1, p9801.0 = 1
- STO via PROFIsafe:
  - p9601.0 = 0, p9801.0 = 0
  - p9601.2 = 0, p9801.2 = 0
  - p9601.3 = 1, p9801.3 = 1
- STO via PROFIsafe and terminals:
  - p9601.0 = 1, p9801.0 = 1
  - p9601.2 = 0, p9801.2 = 0
  - p9601.3 = 1, p9801.3 = 1

Selecting/deselecting "Safe Torque Off"

The following is executed when "Safe Torque Off" is selected:

- Each monitoring channel triggers safe pulse suppression via its switch-off signal path.
- A motor holding brake is closed (if connected and configured).

Deselecting "Safe Torque Off" represents an internal safety acknowledgement. The following is executed:

- Each monitoring channel cancels safe pulse suppression via its switch-off signal path.
- The Safety requirement "Close motor holding brake" is canceled.
- Any pending STOP F or STOP A commands are canceled (see r9772 / r9872).
- The cause of the fault must be removed.
- The messages in the fault memory must be additionally reset using the general acknowledgement mechanism.

Note

If "Safe Torque Off" is selected and deselected through one channel within the time in p9650/p9850, the pulses are suppressed without a message being output.

However, if you want a message to be displayed, then you must reconfigure N01620/N30620 as an alarm or fault using p2118 and p2119.

Restart after the "Safe Torque Off" function has been selected

1. Deselect the function.
2. Issue drive enable signals.
3. Cancel the "switching on inhibited" and switch the drive back on.
   - 1/0 edge at input signal "ON/OFF1" (cancel "switching on inhibited")
   - 0/1 edge at input signal "ON/OFF1" (switch on drive)

Status for "Safe Torque Off"

The status of the "Safe Torque Off" (STO) function is displayed using the parameters r9772, r9872, r9773 and r9774.

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 for the "Safe Torque Off" function

For the response times when the function is selected/deselected via input terminals, see the table in "Response times".

Internal armature short-circuit with the "Safe Torque Off" function

The function "internal armature short-circuit" can be configured together with the "STO" function. However, only one of the two functions can be selected, as an OFF2 is also always triggered when STO is selected. This OFF2 disables the function "Internal armature short-circuit".

The "STO" safety function has the higher priority when simultaneously selected. If the "STO" function is initiated, then an activated "internal armature short-circuit" is disabled.

Overview of important parameters (see the SINAMICS S120/S150 List Manual)

- p9601 SI enable, functions integrated in the drive (Control Unit)
- 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 (group STO)
- p0799 CU inputs/outputs sampling time
- r9780 SI Monitoring clock cycle (Control Unit)
- p9801 SI enable, functions integrated in the drive (Motor Module)
- r9880 SI Monitoring clock cycle (Motor Module)

9.5 Safe Stop 1 (SS1, time controlled)

General description

The "Safe Stop 1" (SS1) function allows the drive to be stopped in accordance with EN 60204-1, Stop Category 1. The drive decelerates with the OFF3 ramp (p1135) once "Safe Stop 1" is selected and switches to "Safe Torque Off" once the delay time set in p9652/p9852 has elapsed.

CAUTION
If the "Safe Stop 1" function (time-controlled) function has been selected by parameterizing a delay in p9652/p9852, STO can no longer be selected directly via terminals.

Functional features of Safe Stop 1

SS1 is enabled when p9652 and p9852 (delay time) are not equal to "0".

- The precondition is that the Basic Functions or STO are enabled via terminals and/or PROFIsafe.
  - p9601.0/p9801.0 = 1 (enable via terminals)
  - p9601.3/p9801.3 = 1 (enable via PROFIsafe)
- Setting parameter p9652/p9852 has the following effect:

Setting	Effect	Control mode for Basic Functions
p9652/p9852 = 0	STO enabled	Via terminals
	STO enabled and SS1 not enabled (cannot therefore be selected)	Via PROFIsafe
p9652/p9852 > 0	SS1 enabled	Via PROFIsafe or terminals

- 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 selected, the delay timer runs down - even if the function is deselected during this time. In this case, after the delay time has expired, the STO/SBC function is selected and then again deselected immediately.

  Note

  So that the drive is able to travel down the OFF3 ramp completely and any motor holding brake present can be applied, the delay time should be set as follows:

  - Motor holding brake parameterized: Delay time ≥ p1135 + p1228 + p1217
  - Motor holding brake not parameterized: Delay time ≥ p1135 + p1228

- The selection is realized through two channels - however braking along the OFF3 ramp, only through one channel.
- A debounce function can be applied to the terminals of the Control Unit and the Motor Module in order to prevent incorrect trips due to signal disturbances. The filter times are set using parameters p9651 and p9851.

Prerequisite

STO via terminals (p9601.0 = p9801.0 =1) or Basic Functions via PROFIsafe (p9601.2 = p9801.2 = 0 and p9601.3 = p9801.3 = 1) must be configured.

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 data cross-check (p9650/p9850 and p9658/p9858). Otherwise the drive will coast down after p9650 + p9658 have elapsed.

Status for Safe Stop 1

The status of the "Safe Stop 1" (SS1) function is displayed using the parameters r9772, r9872, r9773 and r9774.

Alternatively, the status of the functions can be displayed using the configurable messages N01621 and N30621 (configured using p2118 and p2119).

Overview of important parameters (see the SINAMICS S120/S150 List Manual)

- p1135[0...n] OFF3 ramp-down time
- p9652 SI Safe Stop 1 delay time (Control Unit)
- r9772 CO/BO: SI Status (Control Unit)
- r9773 CO/BO: SI Status (Control Unit + Motor Module)
- r9774 CO/BO: SI Status (group STO)
- r9872 CO/BO: SI Status (Motor Module)
- p9852 SI Safe Stop 1 delay time (Motor Module)

9.6 Safe Brake Control (SBC)

Description

The "Safe Brake Control" function (SBC) is used to control holding brakes that function according to the closed-circuit 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 involves a safe, two-channel method.

Note

- Chassis components support this function from an order number with the ending ...xxx3. A Safe Brake Adapter is needed in addition for this design.
- To ensure that this function can be used for Blocksize Power Modules, 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 mechanical defects. The system does not detect whether a brake is e.g. worn or has a mechanical defect, whether it opens or closes. A cable break or a short-circuit in the brake winding is only detected when the state changes, i.e. when the brake either opens or closes.

Functional features of "Safe Brake Control"

- When "Safe Torque Off" (STO) is selected or when safety monitoring functions respond, SBC is executed with safe pulse suppression.
- 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 using parameters.
- When the state changes, electrical faults, such as e.g. a short-circuit in the brake winding or wire breakage can be detected.

Enabling the "Safe Brake Control" 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 cannot be used until at least one safety monitoring function has been enabled (i.e. p9601 = p9801 ≠ 0).

Two-channel brake control

Note

Connecting the brake

The brake cannot be directly applied at the Motor Module of chassis format. The connection terminals are only designed for 24 V DC with 150 mA; the Safe Brake Adapter is required for larger currents and voltages.

The brake is essentially controlled from the Control Unit. Two signal paths are available for applying the brake.

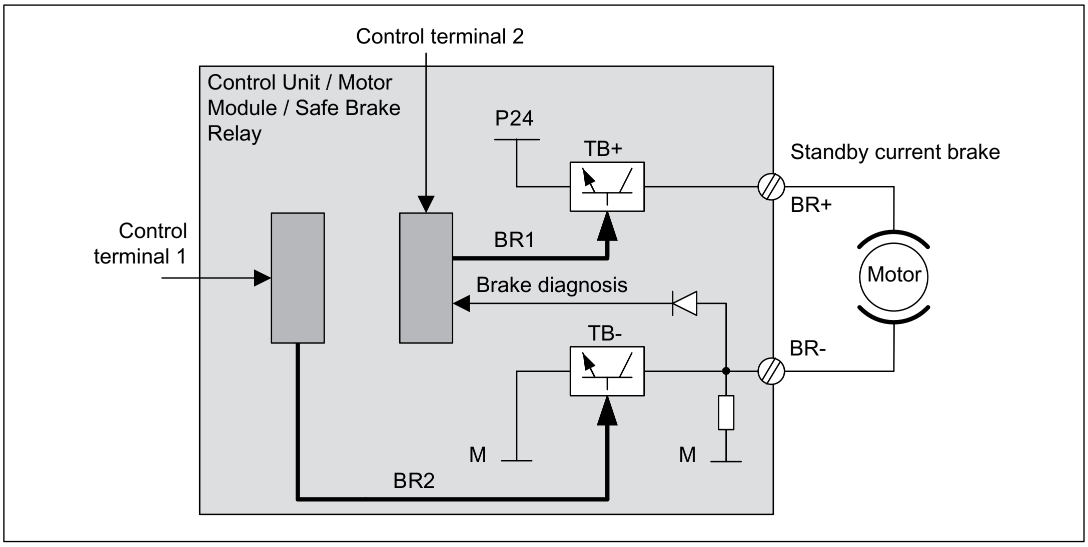


Figure 9-1 Two-channel brake control, blocksize (example)

For the "Safe Brake Control" function, the Motor/Power Module assumes a monitoring function to ensure that when the Control Unit fails or malfunctions the brake current is interrupted therefore closing the brake.

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.

Safe Brake Control for Motor Modules of chassis format

To be able to set higher power in the brakes of devices of this format, an additional Safe Brake Adapter (SBA) module is needed. You can find more information on the connection and wiring of the Safe Brake Adapter in the Equipment Manual.

Using parameters p9621/p9821, you can define via which digital input the Safe Brake Adapter's feedback signal (brake released or applied) is channeled to the Control Unit.

Further functionality and the activation of the brake, i.e. reaching the safe status, are in this case the same as the above described procedure for booksize devices.

Response time with the "Safe Brake Control" function

For the response times when the function is selected/deselected via input terminals, see the table in "Response times".

NOTICE
When the brake is controlled via a relay with "Safe Brake Control":
If "Safe Brake Control" is used, it is not permissible to control the brake via a relay. It may result in faults being triggered in the brake control.

Overview of important parameters (see the SINAMICS S120/S150 List Manual)

- p0799 CU inputs/outputs sampling time
- p9602 SI enable safe brake control (Control Unit)
- p9621 BI: SI Signal source for SBA (Control Unit)
- p9622[0...1] SI SBA relay wait times (Control Unit)
- r9780 SI Monitoring clock cycle (Control Unit)
- p9802 SI enable safe brake control (Motor Module)
- p9821 BI: SI Signal source for SBA (Motor Module)
- p9822[0...1] SI SBA relay wait times (Motor Module)
- r9880 SI Monitoring clock cycle (Motor Module)

9.7 Response times

The Basic Functions are executed in the monitoring clock cycle (p9780). PROFIsafe telegrams are evaluated in the PROFIsafe scan cycle, which corresponds to twice the monitoring clock cycle (PROFIsafe scan cycle = 2 × r9780).

Controlling Basic Functions via terminals on the Control Unit and Motor Module

The following table lists the response times from the control via terminals until the response actually occurs.

Table 9- 2 Response times for control via terminals on the Control Unit and the Motor Module.

Function	Typical	Worst case
STO	2 x r9780 + t_E	4 x r9780 + t_E
SBC	4 x r9780 + t_E	8 x r9780 + t_E
SS1 (time controlled) Selection up until braking is initiated	2 x r9780 + t_E + 2 ms	4 x r9780 + t_E + 2 ms

The following applies for t_E (debounce time of the used digital input F-DI):

p9651 = 0	t_E = p0799 (default = 4 ms)
p9651 ≠ 0	t_E = p9651 + 1 ms

⚠ CAUTION

Response time of Power Module PM340 for STO, controlled via terminals:

5 x r9780 + p0799

Controlling Basic Functions via Profisafe

The following table lists the response times from receiving the PROFIsafe telegram at the Control Unit up to initiating the particular response.

Table 9- 3 Response times when controlling via PROFIsafe

Function	Typical	Worst case
STO	5 x r9780	5 x r9780
SBC	6 x r9780	10 x r9780
SS1 (time controlled) Selection up until STO is initiated	5 x r9780 + p9652	5 x r9780 + p9652
SS1 (time controlled) Selection up until SBC is initiated	6 x r9780 + p9652	10 x r9780 + p9652
SS1 (time controlled) Selection up until braking is initiated	2 x r9780 + 2 ms	4 x r9780 + 2 ms

9.8 Control signals via terminals on the Control Unit and Motor/Power Module

Features

- Only for the STO, SS1 (time-controlled) and SBC functions
- Dual-channel structure via two digital inputs (Control Unit/power unit)
- A debounce function can be applied to the terminals of the Control Unit and the Motor Module to prevent incorrect trips due to signal disturbances or test signals. The filter times are set using parameters p9651 and p9851.
- Different terminal blocks depending on the format
- Automatic ANDing of up to 8 digital inputs (p9620[0...7]) on the Control Unit for chassis format power units connected in parallel

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- 4 Inputs for safety functions

Module	1. Switch-off signal path (p9620[0])	2. Switch-off signal path (EP terminals)
Control Unit CU320-2	X122.1....6 / X132.1…6 DI 0...7/16/17/20/21	
Single Motor Module Booksize/Booksize Compact	(see CU320-2)	X21.3 and X21.4 (on the Motor Module)
Single Motor Module/ Power Module Chassis	(see CU320-2)	X41.1 and X41.2
Double Motor Module Booksize/Booksize Compact	(see CU320-2)	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/CUA32	(see CU320-2)	X210.3 and X210.4 (on the CUA31/CUA32)
Control Unit CU310-2	X120.3/6/9 X121.1...4	X120.4 and X120.5
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, Control Unit**

   The desired input terminal is selected via BICO interconnection (BI: p9620[0]).

2. **Switch-off signal path Motor Module/Power Module**

   The input terminal is the "EP" terminal ("Enable Pulses")

   The EP terminal is periodically interrogated with a sampling time, which is rounded off to an integer multiple of the current controller cycle; however, it is a minimum of 1 ms. (example: t_i = 400 µs, t_{EP} => 3 x t_i = 1.2 ms)

Both terminals must be operated simultaneously within the discrepancy time p9650/p9850, otherwise a fault will be issued.

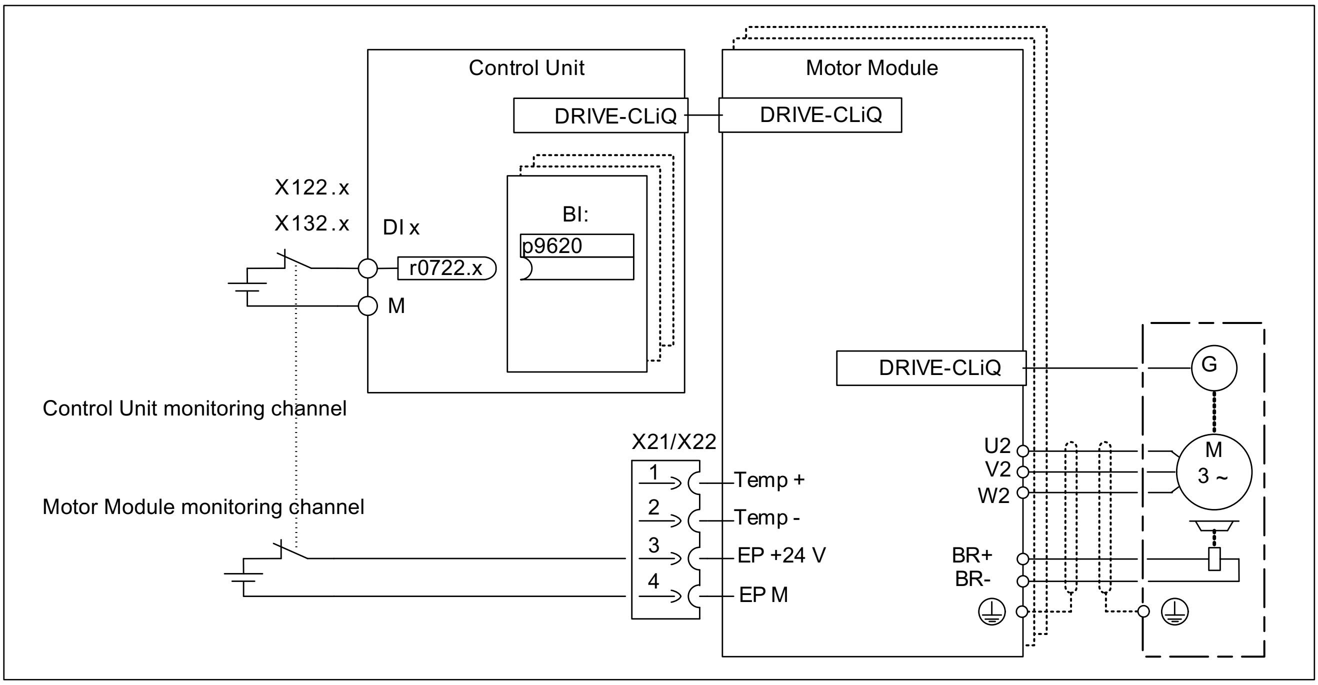


Figure 9-2 Example: Terminals for "Safe Torque Off": example for Motor Modules Booksize and CU320-2

Grouping drives

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

   By connecting the binector input to the joint input terminal on the drives in one group.

2. Switch-off signal path (Motor Module/Power Module with CUA3x)

   By appropriately wiring the terminals for the individual Motor Modules/Power Modules with CUA31/CUA32 assigned to the group.

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.

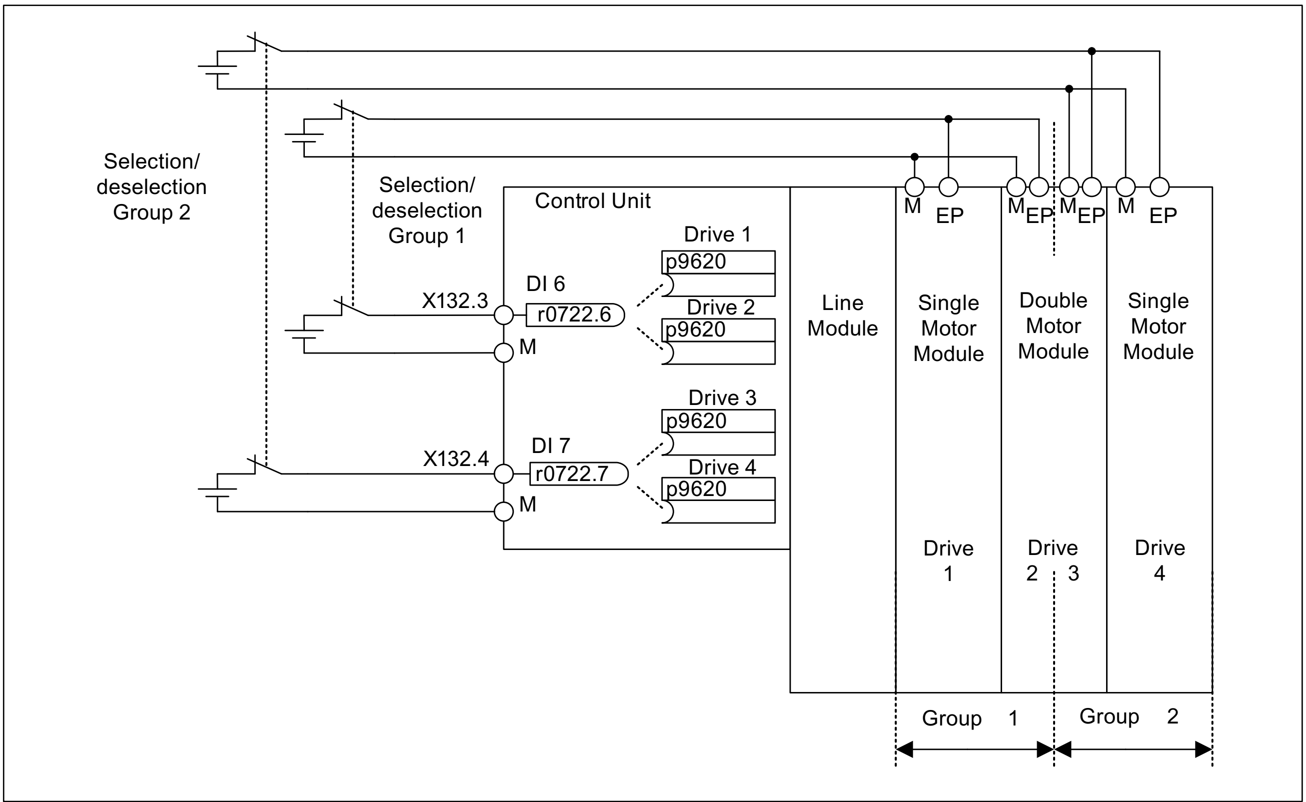


Figure 9-3 Example: Grouping terminals with Motor Modules Booksize and CU320-2

Information on the parallel connection of chassis type Motor Modules

When chassis type Motor Modules 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.

9.8.1 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 SGE changeover tolerance time (Control Unit)
- p9850 SI SGE changeover tolerance time (Motor Module)

Note

To avoid incorrect triggering of fault messages, on these inputs the tolerance time must always be set to be smaller than the shortest time between two switching events (ON/OFF, OFF/ON).

If the "Safe Torque Off" function is not selected/deselected within the tolerance time, this is detected by the cross-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.

9.8.2 Bit pattern test

Bit pattern test of fail-safe outputs

The inverter normally responds immediately to signal changes in its fail-safe inputs. This is not desired in the following case: Several control modules test their fail-safe outputs using bit pattern tests (on/off tests) to identify faults due to either short or cross circuiting. When you interconnect a fail-safe input of the inverter with a fail-safe output of a control module, the inverter responds to these test signals.

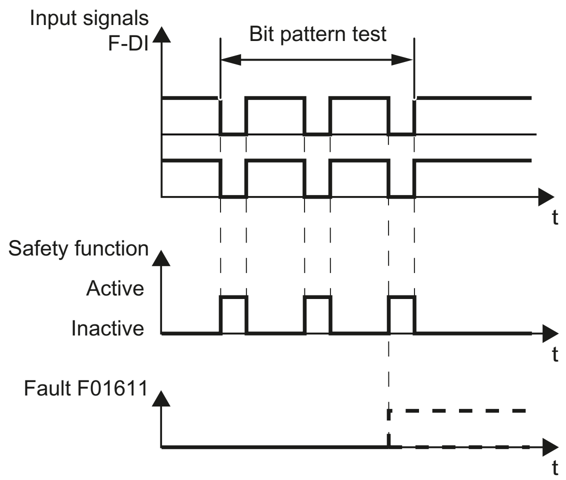


Figure 9-4 Inverter response to a bit pattern test

Note

If the test pulses lead to unintended triggering of the Safety Integrated functions, a filtering (p9651/p9851 SI STO/SBC/SS1 debounce time) of the terminal inputs must be parameterized.

Overview of important parameters (see the SINAMICS S120/S150 List Manual)

- p9651 SI STO/SBC/SS1 debounce time (Control Unit)
- p9851 SI STO/SBC/SS1 debounce time (Control Unit)

9.9 Commissioning the "STO", "SBC" and "SS1" functions

9.9.1 General information about commissioning safety functions

Commissioning notes

NOTICE
For safety-relevant reasons, using the STARTER commissioning tool (or SCOUT) you can only set the safety-relevant parameters of the Control Unit offline. In order to set the safety-relevant parameters of the Motor Module, establish an online connection to SINAMICS S120 and copy the parameters using the "Copy parameter" button on the start screen of the safety configuration into the Motor Module.

Note

- The "STO", "SBC" and "SS1" functions are drive specific. This means that the functions must be commissioned individually for each drive.
- 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 initiates stop response 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 suppression 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 firmware 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, an acceptance test must be carried out (see chapter "Acceptance test and acceptance protocol"). This is indicated by fault F01650 (fault value: 2004).

NOTICE
Once a project has been downloaded, it must be stored on the non-volatile memory card (copy from RAM to ROM).

Replacing Motor Modules with a more recent firmware version

1. After a Motor Module fails, a more recent firmware version can be installed on the new Motor Module.
2. If the old and new devices have different firmware versions, it may be necessary to adjust the reference checksums (p9899) (see the following table). This is indicated by fault F30650 (fault value: 1000).

Table 9- 5 Adapting the reference checksum (p9899)

no.	Parameter	Description/comments
1	p0010 = 95	Safety Integrated: set commissioning mode.
2	p9761 = "Value"	Enter the Safety password.
3	p9899 = "r9898"	Adapt the reference checksum on the Motor Module
4	p0010 ≠ 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.

9.9.2 Procedure for commissioning "STO", "SBC" and "SS1"

To commission the "STO", "SBC" and "SS1" functions via terminals, carry out the following steps:

Table 9- 6 Commissioning the "STO", "SBC" and "SS1" functions

<table>
<tr><th>No.</th><th>Parameter</th><th>Description/comments</th></tr>
<tr><td>1</td><td>p0010 = 95</td><td>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 test certificate, see step 15.
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 stop responses 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 means, the "STO" function cannot be selected/deselected while safety commissioning mode is active because this would constantly force safe pulse suppression.</td></tr>
<tr><td>2</td><td>p9761 = "Value"</td><td>Enter 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 first commissioning.</td></tr>
<tr><td>3</td><td>
p9601.0
p9801.0</td><td>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 data cross-check and must, therefore, be identical.</td></tr>
</table>

No.	Parameter	Description/comments
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 data cross-check 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).
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 data cross-check 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.

No.	Parameter	Description/comments
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 are not subject to a data cross-check during this tolerance time. • Both parameters are included in the data cross-check and must, therefore, be identical. A difference of one safety monitoring clock cycle is tolerated for the values.
8	 p9658 = "Value" p9858 = "Value"	**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 stop response 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 stop response". • 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 data cross-check and must, therefore, be identical. A difference of one safety monitoring clock cycle is tolerated for the values.
9	p9659 = "Value"	**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.
10	 p9799 = "r9798" p9899 = "r9898"	**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.

No.	Parameter	Description/comments
11	 p9762 = "Value" p9763 = "Value"	**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.
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 reset must be carried out with POWER ON.
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.

9.9.3 Safety faults

The fault messages for Safety Integrated Basic Functions are stored in the standard message buffer and can be read from there. In contrast, the fault messages for Safety Integrated Extended Functions are stored in a separate Safety message buffer (see chapter "Message buffer").

When faults associated with Safety Integrated Basic Functions occur, the following stop responses can be initiated:

Table 9- 7 Stop responses to Safety Integrated Basic Functions

<table>
<tr><th>Stop response</th><th>Triggered ...</th><th>Action</th><th>Effect</th></tr>
<tr><td>STOP A cannot be acknowledged</td><td>For all non-acknowledgeable Safety faults with pulse suppression.</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></tr>
<tr><td>STOP A</td><td>For all acknowledgeable Safety faults
As a follow-up reaction of STOP F.</td></tr>
<tr><td></td><td colspan="3">STOP A corresponds 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. holding or operating brake.
When STOP A is present, "Safe Torque Off" (STO) is active.</td></tr>
<tr><td>STOP F</td><td>If an error occurs in the data cross-check.</td><td>Transition to STOP A.</td><td>Follow-up response STOP A with adjustable delay (factory setting without delay) if one of the Safety functions is selected</td></tr>
<tr><td></td><td colspan="3">STOP F is permanently assigned to the data cross-check (DCC). 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 active.</td></tr>
</table>

⚠ 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 (not a safety brake!) with sufficient holding force.

Acknowledging the Safety faults

There are several options for acknowledging Safety faults (for more details see S120 Commissioning Manual):

1. Faults associated with Safety Integrated Basic Functions must be acknowledged as follows:
   - Remove the cause of the fault.
   - Deselect "Safe Torque Off" (STO).
   - Acknowledge the fault.

     If the Safety commissioning mode is exited when the Safety functions are switched off (p0010 = value not equal to 95 when p9601 = p9801 = 0), then all the Safety faults can be acknowledged.

     Once Safety commissioning mode has been selected again (p0010 = 95), all the faults that were previously present reappear.
2. The higher-level controller sets the signal "Internal Event ACK" via the PROFIsafe telegram (STW bit 7). A falling edge in this signal resets the status "Internal Event" and so acknowledges the fault.

NOTICE
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 functions are described in the following document:

Reference: SINAMICS S120/S150 List Manual

9.10 Acceptance test and certificate

Note

After commissioning the Safety Integrated functions, you can use STARTER to create an acceptance report template containing the parameters to be documented (see STARTER → Drive unit → Documentation).

The acceptance test requirements (configuration check) for electrical drive safety functions emanate from DIN EN 61800-5-2, Chapter 7.1 Point f). The acceptance test "configuration check" is named in this standard.

- Description of the application including a picture
- Description of the safety relevant components (including software versions) which are used in the application
- List of the PDS(SR) [Power Drive System(Safety Related)] safety functions used
- Results of all tests of these safety functions, using the specified testing procedure
- List of all safety relevant parameters and their values in the PDS(SR)
- Checksum, test date and confirmation by testing personnel

The acceptance test for systems with Safety Integrated functions (SI functions) is focused on validating the functionality of Safety Integrated monitoring and stop functions implemented in the drive system. The test objective is to verify proper implementation of the defined safety functions and of test mechanisms (forced dormant error detection measures) and to examine the response of specific monitoring functions to the explicit input of values outside tolerance limits. The test must cover all drive-specific Safety Integrated motion monitoring functions and global Safety Integrated functionality of Terminal Module TM54F (if used).

⚠ WARNING

A new acceptance test must be carried out if any changes were made to SI function parameters and must be logged in the acceptance report.

Note

The acceptance test is designed to ensure that the safety functions are correctly parameterized. The measured values (e.g. distance, time) and the system behavior identified (e.g. initiation of a specific stop) can be used for checking the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot be used, for example, to derive maximum values for over-travel.

9.10.1 Acceptance test structure

Authorized person, acceptance report

The test of each SI function must be carried out by an authorized person and logged in the acceptance report. The report must be signed by the person who carried out the acceptance test. The acceptance report must be kept in the logbook of the relevant machine. Access rights to SI parameters must be protected by a password. Only the procedure must be documented in the acceptance report – the password itself must not appear there. 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 acceptance test.

Note

- Observe the information in the chapter "Procedures for initial commissioning".
- The acceptance report presented below is both an example and recommendation.
- An acceptance report template in electronic format is available at your local Siemens sales office.

Necessity of an acceptance test

A complete acceptance test (as described in this chapter) is required after initial commissioning of Safety Integrated functionality on a machine. Safety-related function expansions, transfer of the commissioning settings to other series machines, hardware changes, software upgrades or similar, permit the acceptance test to be performed with a reduced scope if necessary. A summary of conditions which determine the necessary test scope or proposals in this context is provided below.

In order to define a partial acceptance test, it is necessary in the first instance to specify the acceptance test objects, and in the second instance to define logical groups which represent the elements of the acceptance test. The acceptance test must be carried out separately for each individual drive (as far as the machine allows).

Prerequisites for the acceptance test

- The machine is properly wired.
- All safety equipment such as protective door monitoring devices, light barriers or emergency limit switches are connected and ready for operation.
- Commissioning of the open-loop and closed-loop control should be completed, as e.g. the over-travel distance may otherwise change as a result of a changed dynamic response of the drive control. These include, for example:
  - Configuration of the setpoint channel
  - Position control in the higher-level controller
  - Drive control

9.10.1.1 Content of the complete acceptance test

A) Documentation

Documentation of the machine and of safety functions

1. Machine description (with overview)
2. Specification of the controller (if this exists)
3. Configuration diagram
4. Function table:
   - Active monitoring functions depending on the operating mode and the protective door,
   - Other sensors with protective functions,
   - The table is part or is the result of the configuring work.
5. SI functions for each drive
6. Information about safety equipment

B) Functional testing of safety functions

Detailed function test and evaluation of SI functions used. For some functions this contains trace recordings of individual parameters. The procedure is described in detail in section Acceptance tests.

When testing the functions STO, SS1 and SBC, you do not have to make any trace recording.

C) Functional testing of the forced dormant error detection

Testing the forced dormant error detection of the safety functions on each drive (for each control type).

- Testing the forced dormant error detection of the safety function on the drive
  - If you are using Basic Functions, you need to activate and then deactivate STO once again.
  - If you are using Extended Functions, you need to carry out a test stop.

D) Conclusion of the report

Report of the commissioning status tested and countersignatures

1. Inspection of SI parameters
2. Logging of checksums (for each drive)
3. Issuing of the Safety password and documenting this process (do not specify the Safety password in the report!)
4. RAM to ROM backup, upload of project data to STARTER, and backup of the project
5. Countersignature

9.10.1.2 Content of the partial acceptance test

A) Documentation

Documentation of the machine and of safety functions

1. Extending/changing the hardware data
2. Extending/changing the software data (specify version)
3. Extending/changing the configuration diagram
4. Extending/changing the function table:
   – Active monitoring functions depending on the operating mode and the protective door
   – Other sensors with protective functions
   – The table is part or is the result of the configuring work
5. Extending/changing the SI functions per drive
6. Extending/changing the specifications of the safety equipment

B) Functional testing of safety functions

Detailed function test and evaluation of SI functions used. For some functions this contains trace recordings of individual parameters. The procedure is described in detail in section Acceptance tests.

The function test can be left out if no parameters of the individual safety functions have been changed. In the case that only parameters of individual functions have been changed, only these functions need to be tested anew.

When testing the functions STO, SS1 and SBC, you do not have to make any trace recording.

C) Functional testing of the forced dormant error detection

Testing the forced dormant error detection of the safety functions on each drive (for each control type).

- Testing the forced dormant error detection of the safety function on the drive
  – If you are using Basic Functions, you need to activate and then deactivate STO once again.
  – If you are using Extended Functions, you need to carry out a test stop.

D) Functional testing of actual value acquisition

1. General testing of actual value acquisition
   – After exchanging the component, initial activation and brief operation in both directions.

⚠ WARNING
During this process, all personnel must keep out of the danger area.

2. Test of failsafe actual value acquisition
   – Only necessary if Extended Functions are used
   – If the motion monitoring functions are activated (e.g. SLS or SSM with hysteresis), briefly operate the drive in both directions.

E) Conclusion of the report

Report of the commissioning status tested and countersignatures

1. Extension of checksums (for each drive)
2. Countersignature

9.10.1.3 Test scope for specific measures

Scope of partial acceptance tests for specific measures

The measures and points specified in the table refer to the information given in section Content of the partial acceptance test (Page 468).

Table 9- 8 Scope of partial acceptance tests for specific measures

Measure	A) Documentation	B) Functional testing of safety functions	C) Functional testing of forced dormant error detection	D) Functional testing of actual value acquisition	E) Conclusion of the report
Replacement of the encoder system	Yes, Points 1 and 2	No	No	Yes	Yes
Replacement of an SMC/SME	Yes, Points 1 and 2	No	No	Yes	Yes
Replacement of a motor with DRIVE-CLiQ	Yes, Points 1 and 2	No	No	Yes	Yes
Replacement of the Control Unit/ power unit hardware	Yes, Points 1 and 2	No	Yes, only Point 1	Yes, only Point 1	Yes
Replacement of the Power Module or Safe Brake Relay	Yes, Points 1 and 2	Yes, Points 1 or 2 and 3	Yes, only Point 1	Yes, only Point 1	Yes
Replacing the TM54F	Yes, Points 1 and 2	Yes, but only testing of the selection of the safety functions	Yes	Yes, only Point 1	Yes
Firmware – upgrade (CU/power unit/ Sensor Modules)	Yes, only Point 2	Yes, if new safety functions are to be used	Yes	Yes, only Point 1	Yes
Change to a single parameter of a safety function (e.g. SLS limit)	Yes, Points 4 and 5.	Yes, test the appropriate function	No	Yes	Yes
Transfer of project data to other machines (series commissioning)	Yes	Yes, but only testing of the selection of the safety functions	Yes	Yes	Yes

9.10.2 Safety logbook

Description

The "Safety Logbook" function is used to detect changes to safety parameters that affect the associated CRC sums. CRCs are only generated when p9601/p9801 (SI enable, functions integrated in the drive CU/Motor Module) is > 0.

Data changes are detected when the CRCs of the SI parameters change. Each SI parameter change that is to become active requires the reference CRC to be changed so that the drive can be operated without SI fault messages. In addition to functional safety changes, safety changes as a result of hardware being replaced can be detected when the CRC has changed.

The following changes are recorded by the safety logbook:

- Functional changes are recorded in the checksum r9781[0]:
  - Functional cyclic redundancy checks of the basic safety functions integrated in the drive (p9799, SI setpoint checksum SI parameters CU), for each axis.
  - Enable drive-integrated functions (p9601)

9.10.3 Documentation

Table 9- 9 Machine description and overview diagram

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Electrical axes	
Other axes	
Spindles	
Overview diagram of machine	

Table 9- 10 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 =
Safety Integrated checksums			
Basic Functions	**Drive number**	**SI reference checksum SI parameters (Control Unit)**	**SI reference checksum SI parameters (Motor Module)**
		p9799 =	p9899 =

Table 9- 11 SI functions for each drive

Drive number	SI function

Table 9- 12 Description of safety equipment

Examples: Wiring of STO terminals (protective door, Emergency Off), grouping of STO terminals, holding brake for vertical axis, etc.

9.10.4 Acceptance tests

9.10.4.1 General information about acceptance tests

Note

As far as possible, the acceptance tests are to be carried out at the maximum possible machine speed and acceleration rates to determine the maximum braking distances and braking times that can be expected.

Note

Non-critical alarms

When evaluating the alarm buffer you can tolerate the following alarms:

- A01697 SI Motion: Motion monitoring test required
- A01796 SI Motion CU: Waiting for communication

These alarms occur after every system startup and can be evaluated as non-critical. You do not need to include these alarms in the acceptance report.

9.10.4.2 Acceptance test for Safe Torque Off (STO)

Table 9- 13 "Safe Torque Off" acceptance test

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via terminals and/or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• STO function enabled (on-board terminals / PROFIsafe p9601.0 = 1 and/or p9601.3 = 1)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7]); see note "non-critical alarms" in section Acceptance tests".	
	• r9772.17 = r9872.17 = 0 (STO deselection via terminals - DI CU / EP terminal Motor Module); only relevant for STO via terminal	
	• r9772.20 = r9872.20 = 0 (STO deselection via PROFIsafe); only relevant for STO via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – Control Unit)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – Motor Module)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
2.	Run the drive	
	• Ensure that the correct drive is running	
	Select STO when you issue the traversing command and 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[0..7], r2122[0..7])	
	• r9772.17 = r9872.17 = 1 (STO selection via terminal - DI CU / EP terminal Motor Module); only relevant for STO via terminal	
	• r9772.20 = r9872.20 = 1 (STO selection via PROFIsafe); only relevant for STO via PROFIsafe	
	• r9772.0 = r9772.1 = 1 (STO selected and active – Control Unit)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – Motor Module)	
	• r9773.0 = r9773.1 = 1 (STO selected and active – drive)	
	• r9774.0 = r9774.1 = 1 (STO selected and active - group); only relevant for grouping	

No.	Description	Status
3.	Deselect STO and check the following:	
	• No Safety faults and alarms (r0945[0..7], r2122[0..7])	
	• r9772.17 = r9872.17 = 0 (STO deselection via terminals - DI CU / EP terminal Motor Module); only relevant for STO via terminal	
	• r9772.20 = r9872.20 = 0 (STO deselection via PROFIsafe); only relevant for STO via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – Control Unit)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – Motor Module)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
	• r0046.0 = 1 (drive in "switch-on inhibited" state)	
4.	Acknowledge "switch-on inhibit" and run the drive. Ensure that the correct drive is running.	
	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 • Correct wiring of the switch-off signal path (only via terminal) • Correct assignment of the terminals for STO on the Control Unit • Correct STO grouping (if available) • Correct parameterization of the STO function	

9.10.4.3 Acceptance test for Safe Stop 1, time controlled (SS1)

Table 9- 14 "Safe Stop 1" function

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via terminals and/or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• STO function enabled (on-board terminals / PROFIsafe p9601.0 = 1 and/or p9601.3 = 1)	
	• Enable SS1 function (p9652 > 0, p9852 > 0)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7]); see note "non-critical alarms" in section Acceptance tests".	
	• r9772.22 = r9872.22 = 0 (SS1 deselection via terminals – DI CU / EP terminal Motor Module); only relevant for SS1 via terminal	
	• r9772.23 = r9872.23 = 0 (SS1 deselection via PROFIsafe); only relevant for SS1 via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO inactive – CU)	
	• r9772.5 = r9772.6 = 0 (SS1 deselected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO inactive – MM)	
	• r9872.5 = r9872.6 = 0 (SS1 deselected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO inactive – drive)	
	• r9773.5 = r9773.6 = 0 (SS1 deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO inactive - group); only relevant for grouping	
	• r9774.5 = r9774.6 = 0 (SS1 deselected and inactive - group); only relevant for grouping	
2.	Run the drive	
	Check whether the correct drive is operational	
	Select SS1 when you issue the traversing command and check the following:	
	• The drive is braked along the OFF3 ramp (p1135)	
	Before the SS1 delay time (p9652, p9852) expires, the following applies:	
	• r9772.22 = r9872.22 = 1 (SS1 selection via terminals – DI CU / EP terminal Motor Module); only relevant for SS1 via terminal	
	• r9772.23 = r9872.23 = 1 (SS1 selection via PROFIsafe); only relevant for SS1 via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO active - CU)	
	• r9772.5 = r9772.6 = 1 (SS1 selected and active – CU)	
	• r9872.0 = r9872.1 = 0 (STO inactive - MM)	
	• r9872.5 = r9872.6 = 1 (SS1 selected and active – MM)	

No.	Description	Status
	• r9773.0 = r9773.1 = 0 (STO inactive)	
	• r9773.5 = r9773.6 = 1 (SS1 selected and active – drive)	
	• r9774.0 = r9774.1 = 0 (STO inactive - group); only relevant for grouping	
	• r9774.5 = r9774.6 = 1 (SS1 selected and active - group); only relevant for grouping	
	STO is initiated after the SS1 delay time expires (p9652, p9852).	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.0 = r9772.1 = 1 (STO active - CU)	
	• r9772.5 = r9772.6 = 1 (SS1 selected and active – CU)	
	• r9872.0 = r9872.1 = 1 (STO selected and active – MM)	
	• r9872.5 = r9872.6 = 1 (SS1 selected and active – MM)	
	• r9773.0 = r9773.1 = 1 (STO selected and active)	
	• r9773.5 = r9773.6 = 1 (SS1 selected and active – drive)	
	• r9774.0 = r9774.1 = 1 (STO selected and active - group); only relevant for grouping	
	• r9774.5 = r9774.6 = 1 (SS1 selected and active - group); only relevant for grouping	
3.	Canceling SS1	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.22 = r9872.22 = 0 (SS1 deselection via terminals – DI CU / EP terminal Motor Module); only relevant for SS1 via terminal	
	• r9772.23 = r9872.23 = 0 (SS1 deselection via PROFIsafe); only relevant for SS1 via PROFIsafe	
	• r9772.0 = r9772.1 = 0 (STO inactive – CU)	
	• r9772.5 = r9772.6 = 0 (SS1 deselected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO inactive - MM)	
	• r9872.5 = r9872.6 = 0 (SS1 deselected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO inactive – drive)	
	• r9773.5 = r9773.6 = 0 (SS1 deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO inactive - group); only relevant for grouping	
	• r9774.5 = r9774.6 = 0 (SS1 deselected and inactive - group); only relevant for grouping	
	• r0046.0 = 1 (drive in "switch-on inhibited" state)	
4.	Acknowledge "switch-on inhibit" and run the drive. Ensure that the correct drive is running.	
	The following is tested: • Correct parameterization of the SS1 function	

9.10.4.4 Acceptance test for "Safe Brake Control" (SBC)

Table 9- 15 "Safe Brake Control" function

No.	Description	Status
Note: The acceptance test must be individually conducted for each configured control. The control can be realized via terminals and/or via PROFIsafe.		
1.	Initial state	
	• Drive in "Ready" state (p0010 = 0)	
	• STO function enabled (on-board terminals / PROFIsafe p9601.0 = 1 and/or p9601.3 = 1)	
	• Enable SBC function (p9602 = 1, p9802 = 1)	
	• Brake as in sequence control or brake always released (p1215 = 1 or p1215 = 2)	
	• No Safety faults and alarms (r0945, r2122); see note "Non-critical alarms" in section "Acceptance tests".	
	• r9772.4 = r9872.4 = 0 (SBC not requested)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
2.	Run drive (if applied, brake is released)	
	• Check whether the correct drive is operational	
	Select STO/SS1 when you issue the traversing command and check the following:	
	• The brake is applied (for SS1 the drive is previously decelerated along the OFF3 ramp)	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.4 = r9872.4 = 1 (SBC requested)	
	• 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)	
	• r9774.0 = r9774.1 = 1 (STO selected and active - group); only relevant for grouping	
3.	Deselect STO and check the following:	
	• No Safety faults and alarms (r0945[0...7], r2122[0...7])	
	• r9772.4 = r9872.4 = 0 (deselect SBC)	
	• r9772.0 = r9772.1 = 0 (STO deselected and inactive – CU)	
	• r9872.0 = r9872.1 = 0 (STO deselected and inactive – MM)	
	• r9773.0 = r9773.1 = 0 (STO deselected and inactive – drive)	
	• r9774.0 = r9774.1 = 0 (STO deselected and inactive - group); only relevant for grouping	
	• r0046.0 = 1 (drive in "switch-on inhibited" state)	

<table>
<tr><th>No.</th><th>Description</th><th>Status</th></tr>
<tr><td rowspan="2">4.</td><td colspan="2">Acknowledge "switch-on inhibit" and run the drive. Check whether the correct drive is operational.</td></tr>
<tr><td>The following is tested:
• The brake is connected properly
• The hardware is functioning properly
• The SBC is parameterized correctly
• Forced dormant error detection of the brake control</td><td></td></tr>
</table>

9.10.5 Completion of certificate

SI parameters

	Specified values checked?	
	Yes	No
Control Unit		
Motor Module		

Checksums

Basic functions			
Drive name	Drive number	SI reference checksum SI parameters (Control Unit)	SI reference checksum SI parameters (Motor Module)
		p9799 =	p9899 =
		p9799 =	p9899 =
		p9799 =	p9899 =
		p9799 =	p9899 =
		p9799 =	p9899 =
		p9799 =	p9899 =

Drive name	Drive number	SI reference checksum SI parameters (Control Unit)	SI reference checksum SI parameters (Motor Module)
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =
		p9399[0] = p9399[1] =	p9729[0] = p9729[1] = p9729[2] =

Safety logbook

	Functional[1)]
Checksum for functional tracking of changes	r9781[0] =
Checksum for hardware dependent tracking of changes	r9781[1] =
Time stamp for functional tracking of changes	r9782[0] =
Time stamp for hardware dependent tracking of changes	r9782[1] =

1) These parameters can be found in the expert list of the Control Unit.

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

9.11 Overview of parameters and function diagrams

Function diagrams (see SINAMICS S120/S150 List Manual)

- 2800 Parameter manager
- 2802 Monitoring and faults/alarms
- 2804 Status words
- 2810 Safe Torque Off (STO)
- 2814 Safe brake control (SBC)

Overview of parameters (see SINAMICS S120/S150 List Manual)

Table 9- 16 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	
p9610	p9810	SI PROFIsafe address (Control Unit)	
p9620	-	SI signal source for Safe Torque Off	
p9650	p9850	SI SGE changeover, tolerance time (Motor Module)	
p9651	p9851	SI STO/SBC/SS1 debounce time (Control Unit)	
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)

Communication 10

10.1 Communication according to PROFIdrive

10.1.1 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

PROFINET for drive technology is standardized and described in the following document:

- PROFIBUS Profile PROFIdrive – Profile Drive Technology, Version V4.1, May 2006,

PROFIBUS User Organization e. V.

Haid-und-Neu-Straße 7, D-76131 Karlsruhe, http://www.profibus.com

Order no. 3.172, spec. Chapter 6

- IEC 61800-7

Controller, Supervisor, and Drive Unit

- Properties of the Controller, Supervisor, and Drive Unit

Table 10- 1 Properties of the Controller, Supervisor, and Drive Unit

Properties	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).

Table 10- 2 Properties of IF1 and IF2

	IF1	IF2
PROFIdrive	Yes	No
Standard telegrams	Yes	No
Clock cycle synchronization	Yes	Yes
DO types	All	All
Can be used for	PROFINET IO, PROFIBUS	PROFINET IO, PROFIBUS, CANopen
Cyclic operation possible	Yes	Yes
PROFIsafe possible	Yes	Yes

Note

For additional information on the IF1 and IF2 interfaces, see section "Parallel operation of communication interfaces" 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. PROFIdrive features a total of 6 application classes, 4 of which 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 include simple frequency converters for controlling pumps and fans.

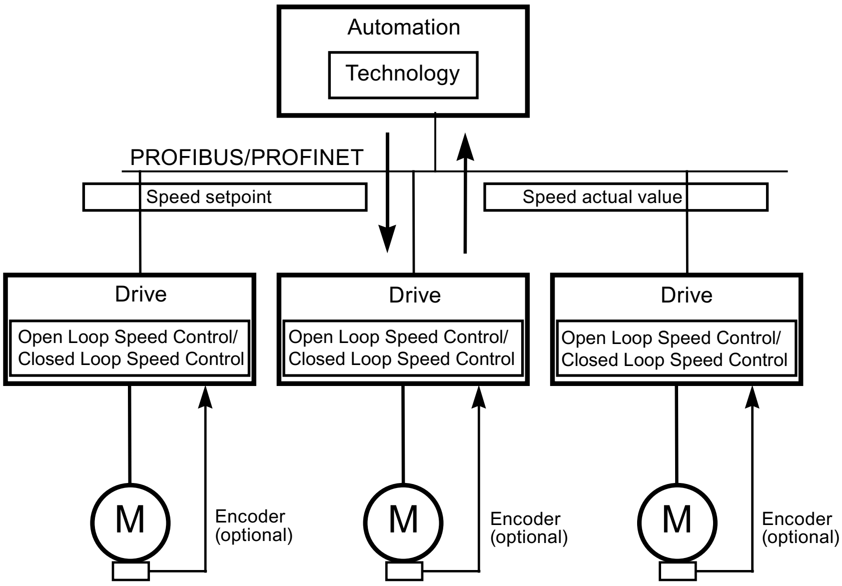


Figure 10-1 Application class 1

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 setpoint cascades, winding drives, and speed synchronization applications for continuous processes with a continuous web.

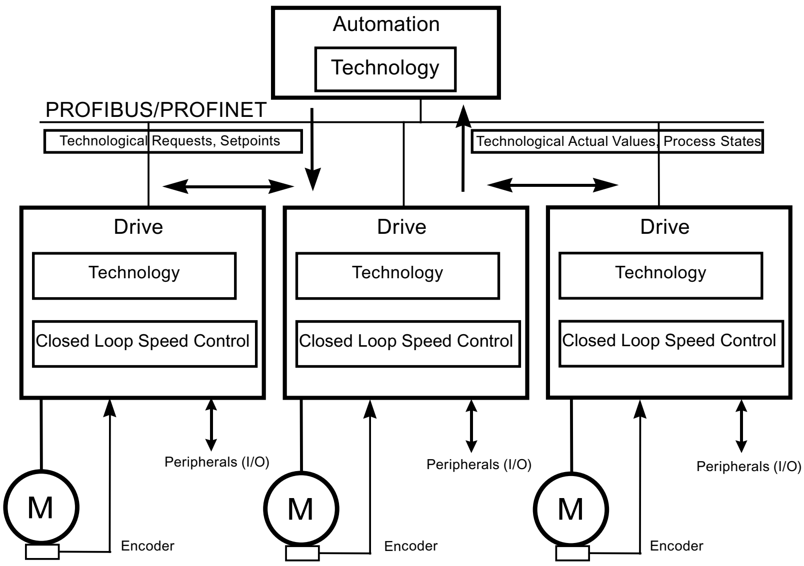


Figure 10-2 Application class 2

Application class 3 (positioning drive)

In addition to the drive control, the drive also includes a positioning control, which means that it operates as a self-contained single-axis positioning drive while the higher-level technological processes are performed 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.

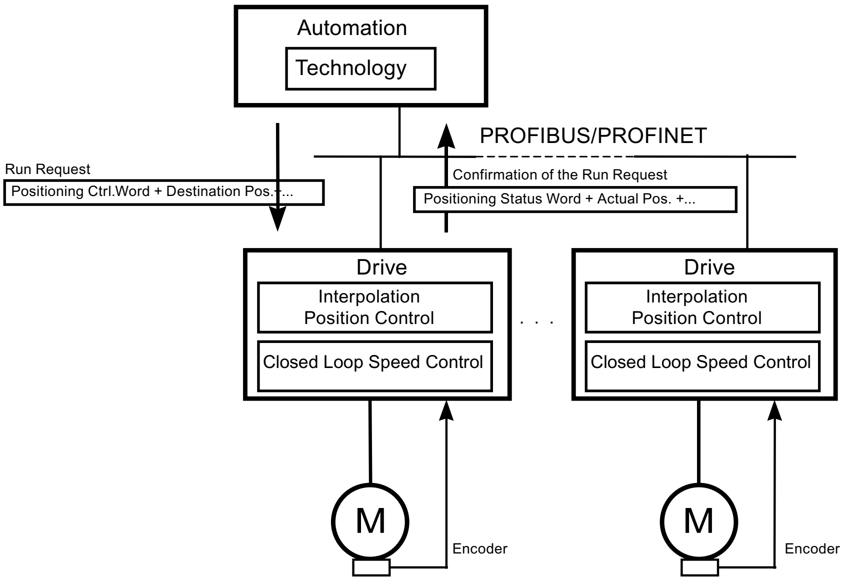


Figure 10-3 Application class 3

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.

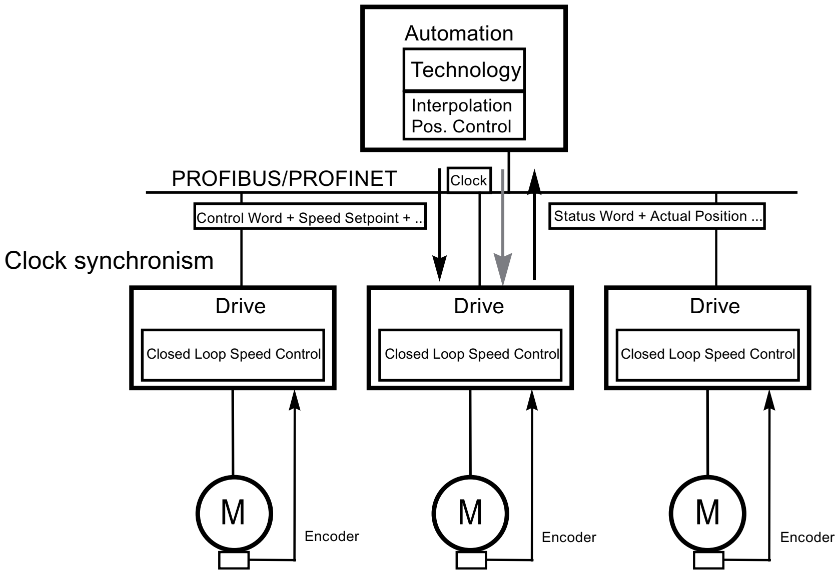


Figure 10-4 Application class 4

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- 3 Selection of telegrams as a function of the application class

Telegram (p0922 = x)	Description	Class 1	Class 2	Class 3	Class 4
1	Speed setpoint, 16 bit	x	x		
2	Speed setpoint, 32 bit	x	x		
3	Speed setpoint, 32 bit with 1 position encoder		x		x
4	Speed setpoint, 32 bit with 2 position encoders				x
5	Speed setpoint, 32 bit with 1 position encoder and DSC				x
6	Speed setpoint, 32 bit with 2 position encoders and DSC				x
7	Positioning, telegram 7 (basic positioner)			x	
9	Positioning, telegram 9 (basic positioner with direct input)			x	
20	Speed setpoint, 16 bit VIK-NAMUR	x	x		
81	Encoder telegram, 1 encoder channel				x
82	Extended encoder telegram, 1 encoder channel + speed actual value 16 bits				x
83	Extended encoder telegram, 1 encoder channel + speed actual value 32 bits				x
102	Speed setpoint, 32 bit with 1 position encoder and torque reduction				x
103	Speed setpoint, 32 bit with 2 position encoders and torque reduction				x
105	Speed setpoint, 32 bit with 1 position encoder, torque reduction and DSC				x
106	Speed setpoint, 32 bit with 2 position encoders, torque reduction and DSC				x
110	Basic positioner with MDI, override and XIST_A			x	
111	Basic positioner in MDI mode			x	
116	Speed setpoint, 32 bit with 2 position encoders, torque reduction and DSC, plus load, torque, power and current actual values				x
118	Speed setpoint, 32 bit with 2 external position encoders, torque reduction and DSC, as well as actual load, torque, power, and current values				x
125	DSC with torque reduction, 1 position encoder (encoder 1)				x
126	DSC with torque precontrol, 2 position encoders (encoder 1 and encoder 2)				x
136	136 DSC with torque precontrol, 2 position encoders (encoder 1 and encoder 2), 4 trace signals				x
139	Closed-loop speed / position control with DSC and torque pre-control, 1 position encoder, clamping status, supplementary actual values				x
220	Speed setpoint, 32 bit for metal industry	x			

Telegram (p0922 = x)	Description	Class 1	Class 2	Class 3	Class 4
352	Speed setpoint, 16 bit, PCS7	x	x		
370	Infeed	x	x	x	x
371	Infeed, metal industry	x			
390	Control Unit with digital inputs/outputs	x	x	x	x
391	Control Unit with digital inputs/outputs and 2 measuring probes	x	x	x	x
392	Control Unit with digital inputs/outputs and 6 measuring probes	x	x	x	x
393	Control Unit with digital inputs/outputs, analog input and 8 measuring probes	x	x	x	x
394	Control Unit with digital inputs/outputs	x	x	x	x
700	Safety Info Channel	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

When a telegram is selected via p0922, the drive unit (Control Unit) process data that is transferred is determined.

From the perspective of the drive unit, the received process data represents 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 setpoint, 16 bit
   – 2 Speed setpoint, 32 bit
   – 3 Speed setpoint, 32 bit with 1 position encoder
   – 4 Speed setpoint, 32 bit with 2 position encoders
   – 5 Speed setpoint, 32 bit with 1 position encoder and DSC
   – 6 Speed setpoint, 32 bit with 2 position encoders and DSC
   – 7 Positioning, telegram 7 (basic positioner)
   – 9 Positioning, telegram 9 (basic positioner with direct input)
   – 20 Speed setpoint, 16 bit VIK-NAMUR
   – 81 Encoder telegram, 1 encoder channel
   – 82 Extended encoder telegram, 1 encoder channel + speed actual value 16 bit
   – 83 Extended encoder telegram, 1 encoder channel + speed actual value 32 bit

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 setpoint, 32 bit with 1 position encoder and torque reduction
   – 103 Speed setpoint, 32 bit with 2 position encoders and torque reduction
   – 105 Speed setpoint, 32 bit with 1 position encoder, torque reduction and DSC
   – 106 Speed setpoint, 32 bit with 2 position encoders, torque reduction and DSC
   – 110 Positioning, telegram 10 (basic positioner with MDI, override and Xist_A)
   – 111 Positioning, telegram 11 (basic positioner in MDI mode)
   – 116 Speed setpoint, 32 bit with 2 position encoders, torque reduction and DSC, plus load, torque, power and current actual values
   – 118 Speed setpoint, 32 bit with 2 external position encoders, torque reduction and DSC, as well as actual load, torque, power, and current values
   – 125 DSC with torque precontrol, 1 position encoder (encoder 1)
   – 126 DSC with torque precontrol, 2 position encoders (encoder 1 and encoder 2)
   – 136 DSC with torque precontrol, 2 position encoders (encoder 1 and encoder 2), 4 trace signals
   – 139 closed-loop speed / position control with DSC and torque pre-control, 1 position encoder, clamping status, supplementary actual values
   – 220 Speed setpoint, 32 bit for metal industry

   Note

   Telegram 220 is tailored for I IS MT applications. Compatibility of the telegram is therefore only guaranteed within I IS MT applications. For other users, incompatibilites can occur when using this telegram.

   – 352 Speed setpoint, 16 bit, PCS7 (SINAMICS G only)
   – 370 Infeed
   – 371 Infeed, metal industry
   – 390 Control Unit with digital inputs/outputs
   – 391 Control Unit with digital inputs/outputs and 2 measuring probes
   – 392 Control Unit with digital inputs/outputs and 6 measuring probes
   – 393 Control Unit with digital inputs/outputs, analog input and 8 measuring probes
   – 394 Control Unit with digital inputs/outputs
   – 700 Safety Info Channel

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	TM120	ENCODER
Receive process data							
DWORD connector output	r2060[0 ... 18]	r2060[0 ... 30]	-	-	-	-	r2060[0 ... 2]
WORD connector output	r2050[0 ... 19]	r2050[0 ... 31]	r2050[0 ... 4]	r2050[0 ... 4]	r2050[0 ... 4]	r2050[0 ... 4]	r2050[0 ... 3]
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], p2084[0...15] / r2089[0 ... 4]						
Send process data							
DWORD connector input	p2061[0 ... 26]	p2061[0 ... 30]	-	-	-	-	p2061[0 ... 10]
WORD connector input	p2051[0 ... 27]	p2051[0 ... 31]	p2051[0 ... 14]	p2051[0 ... 7]	p2051[0 ... 4]	p2051[0 ... 4]	p2051[0 ... 11]
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.
- Exceptions here are telegrams 20, 111, 220, and 352. Here, selected PZDs can be interconnected as required in the transmit/receive telegram.
- When you change p0922 ≠ 999 to p0922 = 999, the previous telegram interconnection is retained and can be changed.
- 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 way to create 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 Master. This enables cyclic communication of a PROFIdrive master.
  - with unchanged configuration to drive units that have a different number of drive objects.
  - with deactivated DOs without having to change the project.
- 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 apply as reference variables (telegram contents = 4000 hex or 4000 0000 hex for double words if the input variable has the value p200x).

Structure of the telegrams

You can find the structure of the telegrams in the SINAMICS S120 List Manual in the following function diagrams:

- 2420: Overview of standard telegrams and process data
- 2422: Overview of manufacturer-specific telegrams and process data, part 1/3
- 2423: Overview of manufacturer-specific telegrams and process data, part 2/3
- 2424: Overview of manufacturer-specific telegrams and process data, part 3/3

Depending on the drive object, only certain telegrams can be used:

Drive object	Telegrams (p0922)
A_INF	370, 371, 999
B_INF	370, 371, 999
S_INF	370, 371, 999
SERVO	1, 2, 3, 4, 5, 6, 102, 103, 105, 106, 116, 118, 125, 126, 136, 139, 220, 999
SERVO (EPOS)	7, 9, 110, 111, 999
SERVO (cl. loop pos ctrl)	139, 999
VECTOR	1, 2, 20, 220, 352, 999
VECTOR (EPOS)	7, 9, 110, 111, 999
ENCODER	81, 82, 83, 999
TM15DI_DO	No predefined telegram.
TM31	No predefined telegram.
TM41	3, 999
TM120	No predefined telegram.
TB30	No predefined telegram.
CU_S	390, 391, 392, 393, 394, 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 28, receive 20
• VECTOR	32
• ENCODER	Send 12, receive 4
• TM15DI_DO	5
• TM31	5
• TM120	5
• TM41	Send 28, receive 20
• TM120	5
• TB30	5
• CU	Send 21, 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 telegrams 102, 103, 105, 106, 116, 118, 125, 126, 136 and 139 are set, the Interface Mode is permanently specified (p2038 = 1) and cannot be changed.
When positioning telegrams 7, 9, 110, and 111 are set, Interface Mode is set by default (p2038 = 0) and cannot be changed.
When standard telegram 20 is set, Interface Mode is set by default (p2038 = 2) and cannot be changed.
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 S120/S150 List Manual)

- 2410 PROFIBUS address, diagnostic
- 2498 E_DIGITAL interconnection

10.1.3.2 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 are 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- 4 Overview of control words and setpoints, profile specific, see function diagram [2439]

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)
NSET_A	Speed setpoint A (16-bit)	5	I16	p1155 p1070(ext. setpoint.)
NSET_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 (16 bit)	22	U16	(bit serial)
A_DIGITAL _1	Digital outputs (16 bit)		U16	(bit serial)
XERR	Position deviation	25	I32	p1190
KPC	Position controller gain factor	26	I32	p1191
SATZANW	Block selection	32	U16	(bit serial)
MDI_TARPOS	MDI target position	34	I32	p2642
MDI_VELOCITY	MDI velocity	35	I32	p2643
MDI_ACC	MDI acceleration	36	I16	p2644
MDI_DEC	MDI delay	37	I16	p2645
MDI_MOD	MDI mode specification	38	U16	(bit serial)
STW2_ENC	Control word 2 encoder	80	U16	
1) Data type according to PROFIdrive profile V4: I16 = Integer16, I32 = Integer32, U16 = Unsigned16, U32 = Unsigned32 2) Bit-serial interconnection: refer to the following pages				

Table 10- 5 Overview of control words and setpoints, manufacturer specific, see function diagram [2440]

Abbreviation	Name	Signal number	Data type 1)	Interconnection parameters
MOMRED	Torque reduction	101	I16	p1542
M_VST	Torque precontrol value	112	U16	p1513
DSC_STW	Control word for DSC splines	114	U16	p1194
T_SYMM	Symmetrization constant	115	U16	p1195
MT_STW	Measuring probe control word	130	U16	p0682
POS_STW	Position control word	203	U16	(bit serial)
OVERRIDE	Override in positioning mode	205	I16	p2646
POS_STW1	Position control word 1	220	U16	(bit serial)
POS_STW2	Position control word 2	222	U16	(bit serial)
MDI_MODE	MDI mode	229	U16	p2654
M_LIM	Torque limit	310	U16	p1503, p1552, p1554
M_ADD	Supplementary torque	311	U16	p1495
E_STW1	Control word 1, for Active Infeed (Active Line Module, Smart Line Module)	320	U16	(bit serial)2)
STW1_BM	Control word 1, variant for metal industry (BM)	322	U16	(bit serial)2)
STW2_BM	Control word 2, variant for metal industry (BM)	324	U16	(bit serial)2)
E_STW1_BM	Control word 1, for Infeed, metal industry (Active Line Module, Basic Line Module, Smart Line Module)	326	U16	(bit serial)2)
CU_STW1	Control word 1 for Control Unit	500	U16	(bit serial)
1) Data type according to PROFIdrive profile V4: I16 = Integer16, I32 = Integer32, U16 = Unsigned16, U32 = Unsigned32 2) Bit-serial interconnection: refer to the following pages				

STW1 (control word 1)

See function diagram [2442]

Table 10- 6 Description of STW1 (control word 1)

Bit	Meaning	Remarks		BICO
0	ON/OFF1	0/1	ON Pulse enable possible	BI: p0840
		0	OFF1 Braking with the ramp-function generator, then pulse suppression and switching on inhibited.	
1	OFF2	1	No OFF2 Enable possible	BI: p0844
		0	Immediate pulse suppression and switching on inhibited	
	Note: Control signal OFF2 is generated by ANDing BI: p0844 and BI: p0845.			
2	OFF3	1	No OFF3 Enable possible	BI: p0848
		0	Quick stop (OFF3) Braking with OFF3 ramp p1135, then pulse suppression and switching on inhibited.	
	Note: Control signal OFF3 is generated by ANDing BI: p0848 and BI: p0849.			
3	Enable operation	1	Enable operation Pulse enable possible	BI: p0852, p1224.1 (with extended brake control only)
		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	Start ramp-function generator	1	Start ramp-function generator	BI: p1141
		0	Freeze ramp-function generator	
	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	-	-	-

Bit	Meaning	Remarks		BICO
10	Master control by PLC	1	Master control by PLC This signal must be set so that the process data transferred via PROFIdrive are accepted and become effective.	BI: p0854
		0	PLC has no master control Process data transferred via PROFIdrive are rejected - i.e. 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	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, setpoint, lower	1	Motorized potentiometer, setpoint, lower	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, r0108.4 = 1

See function diagram [2475]

Table 10- 7 Description of STW1 (control word 1), positioning mode

Bit	Meaning	Remarks		Parameter
0	ON/OFF1	0/1	ON Pulse enable possible	BI: p0840
		0	OFF1 Braking with the ramp-function generator, then pulse suppression and switching on inhibited.	
1	OFF2	1	No OFF2 Enable possible	BI: p0844
		0	OFF2 Immediate pulse suppression and switching on inhibited	
	Note: Control signal OFF2 is generated by ANDing BI: p0844 and BI: p0845.			
2	OFF3	1	No OFF3 Enable possible	BI: p0848
		0	Quick stop (OFF3) Braking with OFF3 ramp p1135, then pulse suppression and switching on inhibited.	

Bit	Meaning	Remarks		Parameter
	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: p2641
		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 control by PLC	1	Master control by PLC This signal must be set so that the process data transferred via PROFIdrive are accepted and become effective.	BI: p0854
		0	No control by PLC Process data transferred via PROFIdrive are rejected - i.e. 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 referencing	
12	Reserved	-	-	-
13	External block change	0/1	External set change is initiated	BI: p2633
		0	No effect	
14	Reserved	-	-	-
15	Reserved	-	-	-

STW2 (control word 2)

See function diagram [2444]

Table 10- 8 Description of STW2 (control word 2)

Bit	Meaning	Remarks		Parameter
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 stop (not with telegrams 9, 110)	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 changeover	0/1	Motor changeover complete	BI: p0828[0]
		0	No effect	
12	Master sign-of-life bit 0	-	User data integrity (4-bit counter)	CI: p2045
13	Master sign-of-life bit 1	-		
14	Master sign-of-life bit 2	-		
15	Master sign-of-life bit 3	-		

STW1_BM (control word 1, metal industry)

See function diagram [2425].

Table 10- 9 Description of STW1_BM (control word 1, metal industry)

Bit	Meaning	Remarks		Parameter
0	ON/OFF1	0/1	ON Pulse enable possible	BI: p0840
		0	OFF1 Braking with the ramp-function generator, then pulse suppression and switching on inhibited	
1	OFF2	1	No OFF2 Enable possible	BI: p0844
		0	Immediate pulse suppression and switching on inhibited	
	Note: Control signal OFF2 is generated by ANDing BI: p0844 and BI: p0845.			
2	OFF3	1	No OFF3 Enable possible	BI: p0848
		0	Quick stop (OFF3) Braking with OFF3 ramp p1135, then pulse suppression and switching on inhibited.	
	Note: Control signal OFF3 is generated by ANDing BI: p0848 and BI: p0849.			
3	Enable operation	1	Enable operation Pulse enable possible	BI: p2816.0
		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	Restart ramp-function generator	1	Restart ramp-function generator	BI: p1141
		0	Freeze ramp-function generator	
	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	-	-	-

Bit	Meaning	Remarks		Parameter
10	Master control by PLC	1	Master control by PLC This signal must be set so that the process data transferred via PROFIdrive are accepted and become effective.	BI: p0854
		0	PLC has no master control Process data transferred via PROFIdrive are rejected - i.e. assumed to be zero.	
	Note: This bit should not be set "1" until PROFIdrive has returned an appropriate status via ZSW1_BM.9 = "1".			
11 ... 15	Reserved	-	-	-

STW2_BM (control word 2, metal industry)

See function diagram [2426].

Table 10- 10 Description of STW2_BM (control word 2, metal industry)

Bit	Meaning	Remarks		Parameter
0	Drive data set selection CDS bit 0	-	-	p0810
1	Drive data set selection CDS bit 1	-	-	p0811
2	Motor data set selection DDS bit 0	-	-	p0820
3	Motor data set selection DDS bit 1	-	-	p0821
4	Motor data set selection DDS bit 2	-	-	p0822
5	Bypass ramp-function generator	1	Function module "Extended setpoint generator" must be selected	p1122
6	Reserved	-	-	-
7	Enable load compensation	1	Set speed controller I component	p1477
8	Enable droop	1	Set scaling for droop feedback (not applicable to servo)	p1492
9	Enable speed controller (incl. brake)	1	Enable the speed controller and the brake. Controller enable via r2093.9. Parameter p0856 remains freely interconnectable for "extended brake control".	p0856, p2093.9
10	Reserved	-	-	-
11	Speed/torque-controlled operation	1	Slave drive torque control Set the signal source for switchover between speed and torque control	p1501
12	Reserved	-	-	-
13	Reserved	-	-	-
14	Reserved	-	-	-
15	Controller sign of life toggle bit	1	Toggle bit communication active	r2081.15
		0	Toggle bit communication not active	

STW2_ENC

See function diagram [2433].

Table 10- 11 Description STW2_ENC (control word 2 encoder)

Bit	Meaning	Remarks		Parameter
0...7	Reserved	–	–	–
7	Acknowledge fault	0/1	Acknowledge fault	BI: p2103
	Note: Faults are acknowledged at a 0/1 edge via BI: p2103 or BI: p2104 or BI: p2105.			
8, 9	Reserved	–	–	–
10	Master control by PLC	1	Master control by PLC This signal must be set so that the process data transferred via PROFIdrive are accepted and become effective.	BI: p0854
		0	No master control by PLC Process data transferred via PROFIdrive is rejected - i.e. assumed to be zero.	
	Note: This bit should not be set to "1" until PROFIdrive has returned an appropriate status via E_ZSW1.9 = "1".			
11	Reserved	–	–	–
12	Controller sign-of-life bit 0	–		
13	Controller sign-of-life bit 1	–		
14	Controller sign-of-life bit 2	–		
15	Controller sign-of-life bit 3	–		

NSET_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.

  NSET_A = 4000 hex or 16384 dec ≙ speed in p2000

NSET_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.

  NSET_B = 4000 0000 hex or 1 073 741 824 dec ≙ speed in p2000

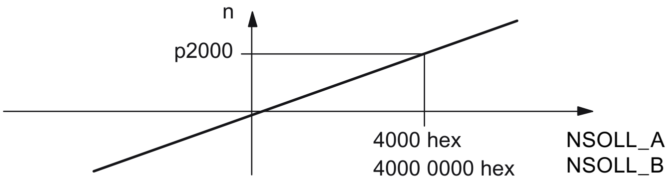


Figure 10-5 Normalization of speed

Note

Operation of motors in the field-weakening range

If the motors are to be operated in the field-weakening range > 2:1, the value of parameter p2000 must be set ≤ 1/2 x maximum speed of the drive object.

Gn_STW (encoder n control word)

This process data belongs to the encoder interface.

A_DIGITAL
MT_STW
CU_STW1

These process data are part of the central process data.

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.

Value range: 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.

DSC_STW

Control word for DSC splines

Table 10- 12 Description DSC_STW

Bit	Meaning	Remarks		Parameter
0	DSC with spline on	1	DSC with spline on	CI: p1194
		0	DSC with spline off	
1...3	Reserved	–	–	–
4	Speed pre-control for DSC with spline on	1	Speed pre-control for DSC with spline on	CI: p1194
		0	Speed pre-control for DSC with spline off	
5	Torque pre-control for DSC with spline on	1	Torque pre-control for DSC with spline on	CI: p1194
		0	Torque pre-control for DSC with spline off	
6...15	Reserved	-		-

T_SYMM

DSC symmetrizing time constant

Sets the signal source for the symmetrizing time constant T_SYMM for DSC with spline.

- T_SYMM = 0:

  Symmetrization is deactivated
- T_SYMM > 0:

  The position setpoint is always made symmetrical.

The symmetrizing time constant T_SYMM has the unit 10 µs in the Unsigned16 format.

MOMRED (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 MOMRED control word, the signal flow is automatically interconnected up to the point where the torque limit is scaled.

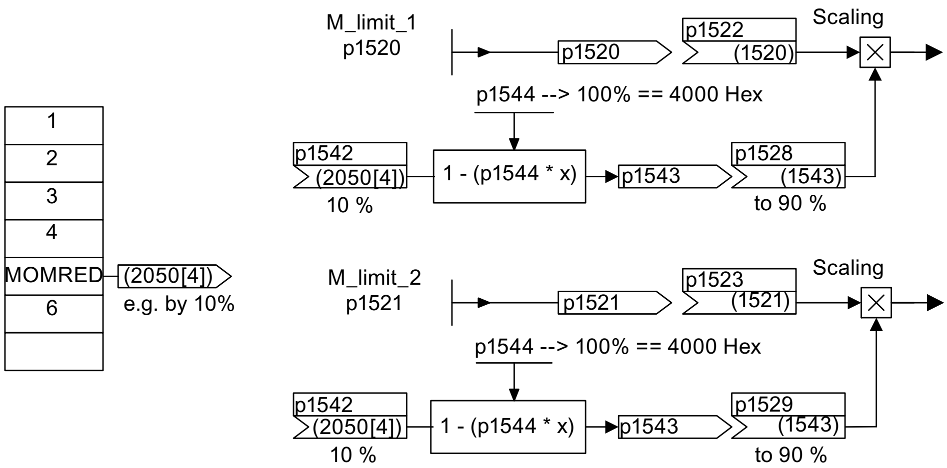


Figure 10-6 MOMRED setpoint

MOMRED 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.

SATZANW (positioning mode, r0108.4 =1)

See function diagram [2476]

Table 10- 13 Description of SATZANW (positioning mode, p0108.4 =1)

Bit	Meaning	Remarks		Parameter
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	Deactivate MDI	
Note: See also: SINAMICS S120 Function Manual, section "Basic positioner"				

POS_STW (positioning mode, r0108.4 = 1)

See function diagram [2462].

Table 10- 14 Description of POS_STW (positioning mode, r0108.4 = 1)

Bit	Meaning	Remarks		Parameter
0	Tracking mode	1	Activate tracking mode	BI: 2655
		0	Tracking mode deactivated	
1	Set reference point	1	Set reference point	BI: 2596
		0	Do not set reference point	
2	Reference cam	1	Reference cam active	BI: 2612
		0	Reference cam not active	
3...4	Reserved	-	-	-
5	Incremental jog	1	Incremental jog active	BI: 2591
		0	Jog velocity active	
6...15	Reserved	-	-	-
Note: See also: SINAMICS S120 Function Manual, section "Basic positioner"				

POS_STW1 (control word 1, positioning mode, r0108.4 = 1)

See function diagram [2463].

Table 10- 15 Description of POS_STW1 (control word 1)

Bit	Meaning	Remarks		Parameter
0	EPOS traversing block selection bit 0	Traversing block selection		BI: p2625
1	EPOS traversing block selection bit 1			BI: p2626
2	EPOS traversing block selection bit 2			BI: p2627
3	EPOS traversing block selection bit 3			BI: p2628
4	EPOS traversing block selection bit 4			BI: p2629
5	EPOS traversing block selection bit 5			BI: p2630
6...7	Reserved	-	-	-
8	EPOS direct setpoint input/MDI positioning type Set the signal source for the positioning type in mode "Direct setpoint input/MDI".	1 0	Absolute positioning is selected. Relative positioning is selected.	BI: p2648
9	EPOS direct setpoint input/MDI, positive direction selection	 0/0 1/0 0/1 1/1	During "set-up": If both directions (p2651, p2652) are selected or deselected, the axis remains stationary. During "positioning": BI: p2651 / BI: p2652 Position absolutely via shortest route. Position absolutely in the positive direction. Position absolutely in the negative direction. Position absolutely via shortest route.	BI: p2651
10	EPOS direct setpoint input/MDI, negative direction selection			BI: p2652
11	Reserved	-	-	-
12	EPOS direct setpoint input/MDI, acceptance method selection Set the signal source for the method of accepting values in mode "Direct setpoint input/MDI".	1 0	Continuous acceptance of values Please see the description in the List Manual. Values are only accepted when BI: p2650 = 0/1 signal (rising edge).	BI: p2649
13	Reserved	-	-	-
14	EPOS direct setpoint input/MDI, setup selection Set the signal source for set-up in mode "Direct setpoint input/MDI".	1 0	Set-up selected. Positioning selected.	BI: p2653
15	EPOS direct setpoint input/MDI selection Set the signal source for the selection of mode "Direct setpoint input/MDI".	-	-	BI: p2647

POS_STW2 (control word 2, positioning mode, r0108.4 = 1)

See function diagram [2464]

Table 10- 16 Description of POS_STW2 (control word 2, positioning mode, r0108.4 = 1)

Bit	Meaning	Remarks		Parameter
0	Tracking mode	1	Activate tracking mode	BI: p2655
		0	Tracking mode deactivated	
1	Set reference point	1	Set reference point	BI: p2596
		0	Do not set reference point	
2	Reference cam	1	Reference cam active	BI: p2612
		0	Reference cam not active	
3	Reserved	-	-	-
4	Reserved	-	-	-
5	Incremental jog	1	Incremental jog active	BI: p2591
		0	Jog velocity active	
6	Reserved	-	-	-
7	Reserved	-	-	-
8	Reference type selection	1	Flying referencing	BI: p2597
		0	Reference point approach	
9	Reference point approach start direction	1	Start in negative direction	BI: p2604
		0	Start in positive direction	
10	LR measuring probe evaluation, selection Set the signal source for selection of the measuring probe.	1	Measuring probe 2 is activated when BI: p2509 = 0/1 edge activated.	BI: p2510
		0	Measuring probe 1 is activated when BI: p2509 = 0/1 edge activated.	
11	LR measuring probe evaluation edge Set the signal source for edge evaluation of the measuring probe.	1	Falling edge of measuring probe (p2510) is activated when BI: p2509 = 0/1 edge activated.	BI: p2511
		0	Rising edge of measuring probe (p2510) is activated when BI: p2509 = 0/1 edge activated.	
12	Reserved	-	-	-
13	Reserved	-	-	-
14	EPOS software limit switch activation Set the signal source for activation of "Software limit switches".	1	Axis is referenced (r2684.11 = 1) and BI: p2582 = 1 signal.	BI: p2582
		0	Software limit switches inoperative: - Modulo offset active (BI: p2577 = 1 signal). - Reference point approach is executed.	
15	EPOS STOP cam activation Set the signal source for activation of "STOP cams".	1	BI: p2568 = 1 signal --> Evaluation of the STOP cam minus (BI: p2569) and STOP cam plus (BI: p2570) is active.	BI: p2568
		0	Evaluation of STOP cams is not active	
Note: See also: SINAMICS S120 Function Manual, section "Basic positioner"				

OVERRIDE (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%.

MDI_TARPOS (MDI position)

This process data defines the position for MDI sets.

Normalization: 1 corresponds to 1 LU

MDI_VELOCITY (MDI velocity)

This process data defines the velocity for MDI sets.

Normalization: 1 corresponds to 1000 LU/min

MDI_ACC (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.

MDI_DEC (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 to 0.1 ... 100% internally.

MDI_MOD

For a detailed table see function diagram [2480].

Table 10- 17 Signal targets for MDI_MOD (positioning mode, r0108.4 = 1)

Bit	Meaning				Interconnection parameter
0	0 = Relative positioning is selected 1 = Absolute positioning is selected				p2648 = r2094.0
1 2	0 = Absolute positioning through the shortest distance 1 = Absolute positioning in the positive direction 2 = Absolute positioning in the negative direction 3 = Absolute positioning through the shortest distance				p2651 = r2094.1 p2652 = r2094.2
3...15	Reserved	-	-	-	-

MDI_MODE

This process data defines the mode for MDI sets.

Precondition: p2654 > 0
MDI_MODE = xx0x hex → Absolute
MDI_MODE = xx1x hex → Relative
MDI_MODE = xx2x hex → Abs_pos (only for modulo correction)
MDI_MODE = xx3x hex → Abs_neg (only for modulo correction)

E_STW1 (control word for infeeds)

See function diagram [2447].

Table 10- 18 Description of E_STW1 (control word for infeeds)

Bit	Meaning	Remarks		Parameter
0	ON/OFF1	0/1	ON Pulse enable possible	BI: p0840
		0	OFF1 Reduce DC link voltage via ramp (p3566), followed by pulse inhibit/line contactor open	
1	OFF2	1	No OFF2 Enable possible	BI: p0844
		0	OFF2 Immediate pulse suppression and switching on inhibited	
	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 fault	0/1	Acknowledge fault	BI: p2103
	Note: Faults are acknowledged at a 0/1 edge via BI: p2103 or BI: p2104 or BI: p2105.			
8...9	Reserved	-	-	-

Bit	Meaning	Remarks		Parameter
10	Master control by PLC	1	Master control by PLC This signal must be set so that the process data transferred via PROFIdrive are accepted and become effective.	BI: p0854
		0	No master control by PLC Process data transferred via PROFIdrive are rejected - i.e. assumed to be zero.	
	Note: This bit should not be set to "1" until PROFIdrive has returned an appropriate status via E_ZSW1.9 = "1".			
11...15	Reserved	-	-	-

E_STW1_BM (control word for infeeds, metal industry)

See function diagram [2427].

Table 10- 19 Description of E_STW1_BM (control word for infeeds, metal industry)

Bit	Meaning	Remarks		Parameter
0	ON/OFF1	0/1	ON Pulse enable possible	BI: p0840
		0	OFF1 Reduce DC link voltage via ramp (p3566), followed by pulse inhibit/line contactor open	
1	OFF2	1	No OFF2 Enable possible	BI: p0844
		0	OFF2 Immediate pulse suppression and switching on inhibited	
	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...6	Reserved	-	-	-
7	Acknowledge fault	0/1	Acknowledge fault	BI: p2103
	Note: Faults are acknowledged at a 0/1 edge via BI: p2103 or BI: p2104 or BI: p2105.			
8...9	Reserved	-	-	-
10	Master control by PLC	1	Master control by PLC This signal must be set so that the process data transferred via PROFIdrive are accepted and become effective.	BI: p0854
		0	No master control by PLC Process data transferred via PROFIdrive are rejected - i.e. assumed to be zero.	
	Note: This bit should not be set "1" until PROFIdrive has returned an appropriate status via E_ZSW_BM.9 = "1".			
11...14	Reserved	-	-	-
15	Controller sign of life toggle bit	1	Toggle bit communication active	r2081.15
		0	Toggle bit communication not active	

M_ADD

Supplementary torque with telegram 220 (metal industry).

M_LIM

Torque limit with telegram 220 (metal industry).

Not available in V/f control mode.

M_VST

The summed precontrol value is transferred via this setpoint:

- Dynamic M setpoint + (quasi) steady-state M setpoint

10.1.3.3 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 are 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- 20 Overview of status words and actual values, profile specific, see function diagram [2449]

Abbreviation	Name	Signal number	Data type 1)	Interconnection parameter
ZSW1	Status word 1	2	U16	r2089[0]
ZSW2	Status word 2	4	U16	r2089[1]
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_ZSW	Encoder 1 status word	10	U16	r0481[0]
G1_XIST1	Encoder 1 actual position value 1	11	U32	r0482[0]
G1_XIST2	Encoder 1 actual position value 2	12	U32	r0483[0]
G2_ZSW	Encoder 2 status word	14	U16	r0481[1]
G2_XIST1	Encoder 2 actual position value 1	15	U32	r0482[1]
G2_XIST2	Encoder 2 actual position value 2	16	U32	r0483[1]
G3_ZSW	Encoder 3 status word	18	U16	r0481[2]
G3_XIST1	Encoder 3 actual position value 1	19	U32	r0482[2]
G3_XIST2	Encoder 3 actual position value 2	20	U32	r0483[2]
E_DIGITAL	Digital input (16Bit)	21	U16	r2089[2]
E_DIGITAL _1	Digital input (16Bit)	22	U16	
XIST_A	Actual position value A	28	I32	r2521[0]
AKTSATZ	EPOS selected block	33	U16	r2670
IAIST_GLATT	Output current smoothed	51	I16	r0068[1]
ITIST_GLATT	Active current smoothed	52	I16	r0078[1]
MIST_GLATT	Torque actual value, smoothed	53	I16	r0080[1]
PIST_GLATT	Actual active power, smoothed	54	I16	r0082[1]
NIST_A_GLATT	Actual speed A (16 bit), smoothed	57	I16	r0063[1]
MELD_ NAMUR	NAMUR message bit bar	58	U16	r3113
IAIST	Output current actual value	59	I16	r0068[0]
MIST	Actual torque value	60	I16	r0080[0]
ZSW2_ENC	Status word 2 encoder	81	U16	–
S_ZSW1B	Safety status word 1B for PROFIdrive with PROFIsafe	92	U16	r2139

1) Data type according to 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

Table 10- 21 Overview of status words and actual values, manufacturer specific, see function diagram [2450]

Abbreviation	Name	Signal number	Data type 1)	Interconnection parameter
MELDW	Message word	102	U16	r2089[2]
MSOLL_GLATT	Torque setpoint, smoothed	120	I16	r0079[1]
AIST_GLATT	Torque utilization smoothed	121	I16	r0081
MT_ZSW	Probe status word	131	U16	r0688
MT1_ZS_F	Probe 1 time stamp, falling edge	132	U16	r0687[0]
MT1_ZS_S	Probe 1 time stamp, rising edge	133	U16	r0686[0]
MT2_ZS_F	Probe 2 time stamp, falling edge	134	U16	r0687[1]
MT2_ZS_S	Probe 2 time stamp, rising edge	135	U16	r0686[1]
MT3_ZS_F	Probe 3 time stamp, falling edge	136	U16	r0687[2]
MT3_ZS_S	Probe 3 time stamp, rising edge	137	U16	r0686[2]
MT4_ZS_F	Probe 4 time stamp, falling edge	138	U16	r0687[3]
MT4_ZS_S	Probe 4 time stamp, rising edge	139	U16	r0686[3]
MT5_ZS_F	Probe 5 time stamp, falling edge	140	U16	r0687[4]
MT5_ZS_S	Probe 5 time stamp, rising edge	141	U16	r0686[4]
MT6_ZS_F	Probe 6 time stamp, falling edge	142	U16	r0687[5]
MT6_ZS_S	Probe 6 time stamp, rising edge	143	U16	r0686[5]
MT7_ZS_F	Probe 7 time stamp, falling edge	144	U16	r0687[6]
MT7_ZS_S	Probe 7 time stamp, rising edge	145	U16	r0686[6]
MT8_ZS_F	Probe 8 time stamp, falling edge	146	U16	r0687[7]
MT8_ZS_S	Probe 8 time stamp, rising edge	147	U16	r0686[7]
POS_ZSW	Positioning status word	204	U16	r2683
POS_ZSW1	Position status word 1	221	U16	r2089[3]
POS_ZSW2	Position status word 2	223	U16	r2089[4]
FAULT_CODE	Fault code	301	U16	r2131
WARN_CODE	Alarm code	303	U16	r2132
E_ZSW1	Status word 1, for Active Infeed (Active Line Module, Smart Line Module)	321	U16	r2089[1]
ZSW1_BM	Status word 1, variant for metal industry (BM)	323	U16	r2089[0]
ZSW2_BM	Status word 2, variant for metal industry (BM)	325	U16	r2089[1]
E_ZSW1_BM	Status word 1 for infeed, variant for metal industry (Basic Line Module, Smart Line Module, Active Line Module)	327	U16	r2080
SP_ZSW	Clamping system, status word	400	U16	–
SP_XIST_A	Clamping system, position actual value analog	401	U16	–
SP_XIST_D	Clamping system, position actual value digital	402	U16	–
SP_KONFIG	Clamping system, actual configuration	403	U16	–
CU_ZSW1	Status word 1 for Control Unit	501	U16	r2089[1]
S_V_LIMIT_B	SLS speed limit	61001	U32	-

1) Data type according to 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

ZSW1 (status word 1)

See function diagram [2452]

Table 10- 22 Description of ZSW1 (status word 1)

Bit	Meaning	Remarks		Parameter
0	Ready for switching on	1	Ready for switching on Power supply on, electronics initialized, line contactor released if necessary, pulses inhibited.	BO: r0899.0
		0	Not ready for switching on	
1	Ready for operation	1	Ready for operation Voltage at Line Module (i.e. line contactor closed (if used)), field being built up.	BO: r0899.1
		0	Not ready for operation Reason: No ON command present	
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 "switching on inhibited" once the fault has been acknowledged and the cause has been remedied. The active faults are stored in the fault buffer.	BO: r2139.3
		0	No fault active No active fault in the fault buffer.	
4	Coasting down active (OFF2)	1	No OFF2 active	BO: r0899.4
		0	Coasting down active (OFF2) An OFF2 command is active.	
5	Quick stop active (OFF3)	1	No OFF3 active	BO: r0899.5
		0	Quick stop active (OFF3) An OFF3 command is active.	
6	Switching on inhibited	1	Switching on inhibited A restart is only possible by means of OFF1 and then ON.	BO: r0899.6
		0	No "switching on inhibited" Switching on is possible.	
7	Alarm active	1	Alarm active The drive is operational again. No acknowledgement necessary. The active alarms are stored in the alarm buffer.	BO: r2139.7
		0	No alarm active No active alarm in the alarm buffer.	

Bit	Meaning	Remarks		Parameter
8	Speed setpoint-actual value deviation within the tolerance bandwidth	1	Setpoint/actual value monitoring within tolerance band Actual value within a tolerance band; dynamic overshoot or undershoot for t < t_{max} permissible, e.g. n = n_{set}± f = f_{set}±, etc., t_{max} can be parameterized	BO: r2197.7
		0	Setpoint/actual value monitoring not within tolerance band	
9	Control request to PLC	1	Control requested 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
		0	I, M or P limit reached or exceeded	
12	Holding brake open	1	Holding brake opened	BO: r0899.12
		0	Holding brake closed	
13	No motor overtemperature alarm	1	Motor overtemperature alarm not active	BO: r2135.14
		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 active	BO: r2135.15
		0	Alarm, converter thermal overload The overtemperature alarm for the converter is active.	

ZSW1 (status word 1, positioning mode, r0108.4 = 1)

See function diagram [2479]

*Valid for p0922 = 111 (telegram 111).

For p0922 = 110 (telegram 110): Bits 14 and 15 reserved.

Table 10- 23 Description of ZSW1 (status word 1, positioning mode)

Bit	Meaning	Remarks		Parameter
0	Ready for switching on	1	Ready for switching on Power supply on, electronics initialized, line contactor released if necessary, pulses inhibited.	BO: r0899.0
		0	Not ready for switching on	
1	Ready for operation	1	Ready for operation Voltage at Line Module (i.e. line contactor closed (if used)), field being built up.	BO: r0899.1
		0	Not ready for operation Reason: No ON command present	
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 "switching on inhibited" once the fault has been acknowledged and the cause has been remedied. The active faults are stored in the fault buffer.	BO: r2139.3
		0	No fault active No active fault in the fault buffer.	
4	Coasting down active (OFF2)	1	No OFF2 active	BO: r0899.4
		0	Coasting down active (OFF2) An OFF2 command is active.	
5	Quick stop active (OFF3)	1	No OFF3 active	BO: r0899.5
		0	Quick stop active (OFF3) An OFF3 command is active.	
6	Switching on inhibited	1	Switching on inhibited A restart is only possible by means of OFF1 and then ON.	BO: r0899.6
		0	No "switching on inhibited" Switching on is possible.	
7	Alarm active	1	Alarm active The drive is operational again. No acknowledgement necessary. The active alarms are stored in the alarm buffer.	BO: r2139.7
		0	No alarm active No active alarm in the alarm buffer.	

Bit	Meaning	Remarks		Parameter
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 request to PLC	1	Control requested 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*	Axis accelerating (telegram 111)	1	Axis is accelerating.	BO: r2684.4
		0	Axis is not accelerating.	
15*	Axis decelerating (telegram 111)	1	Axis is decelerating.	BO: r2684.5
		0	Axis is not decelerating.	

ZSW2 (status word 2)

See function diagram [2454]

Table 10- 24 Description of ZSW2 (status word 2)

Bit	Meaning	Remarks		Parameter
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
4	DDS eff., bit 4	–		BO: r0051.4
5	Alarm class bit 0	–	Bits 5-6: Alarm stage of SINAMICS drives, transferred as attribute in alarm message value = 0: Alarm (previous alarm stage) value = 1: Alarm class A value = 2: Alarm class B value = 3: Alarm class C	BO: r2139.11
6	Alarm class bit 1	–		BO: r2139.12
7	Parking axis	1	Axis parking active	BO: r0896.0
		0	Axis parking not active	
8	Travel to fixed stop	1	Travel to fixed stop	BO: r1406.8
		0	No travel to fixed stop	
9	Reserved	–	–	–
10	Pulses enabled	1	Pulses enabled	BO:r0899.11
		0	Pulses not enabled	
11	Data set changeover	1	Data record changeover active	BO: r0835.0
		0	Data set changeover active	
12	Slave sign-of-life bit 0	–	User data integrity (4-bit counter)	Implicitly interconnected
13	Slave sign-of-life bit 1	–	–	–
14	Slave sign-of-life bit 2	–	–	–
15	Slave sign-of-life bit 3	–	–	–

ZSW1_BM (status word 1, metal industry)

See function diagram [2428].

Table 10- 25 Description of ZSW1_BM (status word 1, metal industry)

Bit	Meaning	Remarks		Parameter
0	Ready for switching on	1	Ready for switching on Power supply on, electronics initialized, line contactor released if necessary, pulses inhibited.	BO: r0899.0
		0	Not ready for switching on	
1	Ready for operation	1	Ready for operation Voltage at Line Module (i.e. line contactor closed (if used)), field being built up.	BO: r0899.1
		0	Not ready for operation Reason: No ON command present	
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 "switching on inhibited" once the fault has been acknowledged and the cause has been remedied. The active faults are stored in the fault buffer.	BO: r2139.3
		0	No fault active No active fault in the fault buffer.	
4	Coasting down active (OFF2)	1	No OFF2 active	BO: r0899.4
		0	Coasting active (OFF2) An OFF2 command is active.	
5	Quick stop active (OFF3)	1	No OFF3 active	BO: r0899.5
		0	Quick stop active (OFF3) An OFF3 command is active.	
6	Switching on inhibited	1	Switching on inhibited A restart is only possible by means of OFF1 and then ON.	BO: r0899.6
		0	No "switching on inhibited" Switching on is possible.	
7	Alarm active	1	Alarm active The drive is operational again. No acknowledgement necessary. The active alarms are stored in the alarm buffer.	BO: r2139.7
		0	No alarm active No active alarm in the alarm buffer.	

Bit	Meaning	Remarks		Parameter
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 undershoot for t < t_{max} permissible, e.g. n = n_{set}± f = f_{set}±, etc., t_{max} can be parameterized	BO: r2197.7
		0	Setpoint/actual value monitoring not within tolerance band	
9	Control request to PLC	1	Control requested 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
		0	I, M or P limit reached or exceeded	
12	Holding brake open	1	Holding brake opened	BO: r0899.12
		0	Holding brake closed	
13	No motor overtemperature alarm	1	Motor overtemperature alarm not active	BO: r2135.14
		0	Motor overtemperature alarm active	
14	Reserved	-	-	-
15	Reserved	-	-	-

ZSW2_BM (status word 2, metal industry)

See function diagram [2429].

Table 10- 26 Description of ZSW2_BM (status word 2, metal industry)

Bit	Meaning	Remarks		Parameter
0	Reserved	-	-	-
1	Reserved	-	-	-
2	Reserved	-	-	-
3	Reserved	-	-	-
4	Reserved	-	-	-
5	Alarm class bit 0	–	Bits 5-6: Alarm stage of SINAMICS drives, transferred as attribute in alarm message value = 0: Alarm (previous alarm stage) value = 1: Alarm class A value = 2: Alarm class B value = 3: Alarm class C	BO: r2139.11
6	Alarm class bit 1	–		BO: r2139.12
7	Reserved	-	-	-
8	Reserved	-	-	-
9	Limit speed setpoint	1	Speed setpoint limited	r1407.11
		0	Speed setpoint not limited	
10	Upper torque limit	1	Upper torque limit reached	r1407.8
		0	Upper torque limit not reached	
11	Lower torque limit	1	Lower torque limit reached	r1407.9
		0	Lower torque limit not reached	
12	Reserved	-	-	-
13	Safe Stop 1	1	Normalized signal according to PROFIdrive on PROFIsafe	r9773.2
14	Safe Torque Off active (safe stop)	1	Normalized signal according to PROFIdrive on PROFIsafe	r9773.1
15	Controller sign of life toggle bit	1	Toggle bit communication active	r2093.15
		0	Toggle bit communication not active	

ZSW2_ENC (status word 2 encoder)

See function diagram [2434].

Table 10- 27 Description of ZSW2_ENC (status word 2 encoder)

Bit	Meaning	Remarks		Parameter
0...2	Reserved	–	–	–
3	Fault active	1	Fault active The drive is faulty and, therefore, out of service. The drive switches to "switching on inhibited" once the fault has been acknowledged and the cause has been remedied. The active faults are stored in the fault buffer.	BO: r2139.3
		0	No fault active No active fault in the fault buffer.	
4...9	Reserved	–	–	–
10	Control request to PLC	1	Control requested 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	
11	Reserved	–	–	–
12	DO sign-of-life bit 0			
13	DO sign-of-life bit 1			
14	DO sign-of-life bit 2			
15	DO 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.

E_DIGITAL
E_DIGITAL1
MT_ZSW
MT_n_ZS_F/MT_n_ZS_S
CU_ZSW1

These process data are part of the central process data.

IAIST

Absolute current actual value.

IAIST_GLATT

The absolute current actual value smoothed with p0045 is displayed.

ITIST_GLATT

The actual current value smoothed with p0045 is displayed.

MIST

Actual torque value.

MIST_GLATT

The actual torque value smoothed with p0045 is displayed.

PIST_GLATT

The active power smoothed with p0045 is displayed.

NIST_A_GLATT

The actual speed value smoothed with p0045 is displayed.

MSOLL_GLATT

The torque setpoint smoothed with p0045 is displayed.

AIST_GLATT

Torque utilization smoothed with p0045 is displayed.

MELDW (message word)

See function diagram [2456]

Table 10- 28 Description of MELDW (message word)

Bit	Meaning	Remarks		Parameter
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
		1/0	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.	
		0	Ramp-function generator active • The ramp-up procedure is still active once the speed setpoint has been changed.	
		0/1	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 delay time (p2166) has elapsed.	
1	Torque utilization < p2194	1	Torque utilization < p2194 • The current torque utilization is less than the set torque utilization threshold (p2194), or • Ramp-up is not yet complete.	BO: r2199.11
		0	Torque utilization > p2194 • The current torque utilization is greater than the set torque utilization threshold (p2194).	
	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).			

<table>
<tr><th>Bit</th><th>Meaning</th><th colspan="2">Remarks</th><th>Parameter</th></tr>
<tr><td rowspan="3">2</td><td rowspan="2">|n_act| < 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="3">3</td><td rowspan="2">|n_act| ≤ 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>
<tr><td colspan="4">Note:
The message is parameterized as follows:
p2155 Threshold value
p2140 Hysteresis
Application:
Speed monitoring.</td></tr>
<tr><td>4</td><td>Reserved</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Variable signaling function</td><td>1</td><td>The monitored signal of a SERVO axis has exceeded the specified threshold value.</td><td rowspan="2">BO: r3294</td></tr>
<tr><td>0</td><td>The monitored signal of a SERVO axis is within the specified threshold value or the signaling function is not active</td></tr>
<tr><td rowspan="3">6</td><td rowspan="2">No motor overtemperature alarm</td><td>1</td><td>No motor overtemperature alarm
The temperature of the motor is within the permissible range.</td><td rowspan="2">BO: r2135.14</td></tr>
<tr><td>0</td><td>Alarm, motor overtemperature
The temperature of the motor is greater than the set motor temperature threshold (p0604).</td></tr>
<tr><td colspan="4">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.</td></tr>
</table>

Bit	Meaning	Remarks		Parameter
7	No thermal overload in power unit alarm	1	No thermal overload in power unit alarm The temperature of the heat sink in the power unit is within the permissible range.	BO: r2135.15
		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.	
9,10	Reserved	-	-	-
11	Controller enable	1	Controller enable	BO: r0899.8
12	Drive ready	1	Drive ready	BO: r0899.7
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.			
14,15	Reserved	-	-	-

MELD_NAMUR

Display of the NAMUR message bit bar.

AKTSATZ

See function diagram [3650].

Table 10- 29 Description of AKTSATZ (active traversing block/MDI active)

Bit	Meaning	Remarks		Parameter
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	

POS_ZSW

See function diagram [3645].

Table 10- 30 Description of POS_ZSW (status word, positioning mode)

Bit	Meaning	Remarks		Parameter
0	Tracking mode active	1	Tracking mode active	BO: r2683.0
		0	Tracking mode not active	
1	Velocity limiting active	1	Active	BO: r2683.1
		0	Not active	
2	Setpoint static	1	Setpoint static	BO: r2683.2
		0	Setpoint not static	
3	Position setpoint reached	1	Position setpoint reached	BO: r2683.3
		0	Position setpoint not reached	
4	Axis moves forwards	1	Axis moves forwards	BO: r2683.4
		0	Axis stationary or moves backwards	
5	Axis moves backwards	1	Axis moves backwards	BO: r2683.5
		0	Axis stationary or moves forwards	
6	Minus software limit switch actuated	1	Minus SW limit switch actuated	BO: r2683.6
		0	Minus SW limit switch not actuated	
7	Plus software limit switch actuated	1	Plus SW limit switch actuated	BO: r2683.7
		0	Plus SW limit switch not actuated	
8	Position actual value ⇐ cam switching position 1	1	Position actual value ⇐ cam switching position 1	BO: r2683.8
		0	Cam switching position 1 passed	
9	Position actual value ⇐ cam switching position 2	1	Position actual 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: r2683.14
		0	Travel to fixed stop not active	
15	Reserved	–	–	–

POS_ZSW1 (status word 1, positioning mode, r0108.4 = 1)

See function diagram [2466].

Table 10- 31 Description of POS_ZSW1 (status word 1, positioning mode, r0108.4 = 1)

Bit	Meaning	Remarks		Parameter
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	Reserved	–	–	–
7	Reserved	–	–	–
8	STOP cam minus active	1	–	BO: r2684.13
9	STOP cam plus active	1	–	BO: r2684.14
10	Jog active	1	Jog active	BO: r2094.0 BO: r2669.0
		0	Jog not active	
11	Reference point approach active	1	Reference point approach active	BO: r2094.1 BO: r2669.1
		0	Reference point approach not active	
12	Flying referencing	1	Flying referencing	BO: r2684.1
		0	Flying referencing not active	
13	Traversing blocks active	1	Traversing blocks active	BO: r2094.2 BO: r2669.2
		0	Traversing blocks not active	
14	Set-up active	1	Set-up active	BO: r2094.3 BO: r2669.4
		0	Set-up not active	
15	MDI active	1	MDI active	BO: r2670.15
		0	MDI not active	

POS_ZSW2 (status word 2, positioning mode, r0108.4 = 1)

See function diagram [2467].

Table 10- 32 Description of POS_ZSW2 (status word 2, positioning mode, r0108.4 = 1)

Bit	Meaning	Remarks		Parameter
0	Tracking mode active	1	Tracking mode active	BO: r2683.0
		0	Tracking mode not active	
1	Velocity limiting active	1	Active	BO: r2683.1
		0	Not active	
2	Setpoint static	1	Setpoint static	BO: r2683.2
		0	Setpoint not static	
3	Print index outside outer window	1	Flying / passive referencing not active	BO: r2684.3
		0	Flying / passive referencing active	
4	Axis moves forwards	1	Axis moves forwards	BO: r2683.4
		0	Axis stationary or moves backwards	
5	Axis moves backwards	1	Axis moves backwards	BO: r2683.5
		0	Axis stationary or moves forwards	
6	Minus software limit switch actuated	1	Minus SW limit switch actuated	BO: r2683.6
		0	Minus SW limit switch not actuated	
7	Plus software limit switch actuated	1	Plus SW limit switch actuated	BO: r2683.7
		0	Plus SW limit switch not actuated	
8	Position actual value ⇐ cam switching position 1	1	Position actual value ⇐ cam switching position 1	BO: r2683.8
		0	Cam switching position 1 passed	
9	Position actual value ⇐ cam switching position 2	1	Position actual 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: r2683.14
		0	Travel to fixed stop not active	
15	Traversing command active	1	Axis traversing	BO: r2684.15
		0	Axis stationary	

XIST_A

Actual position value is displayed

Normalization: 1 corresponds to 1 LU

SP_ZSW

Clamping system, status word

SP_XIST_A

Clamping system: Position (analog actual value)

SP_XIST_D

Clamping system: Position (digital measuring information)

SP_KONFIG

Clamping system: Sensor configuration

S_ZSW1B

Safety Info Channel: Status word

Table 10- 33 Description S_ZSW1B

Bit	Meaning	Remarks		Parameter
0	STO active	1	STO active	r9734.0
		0	STO not active	
1	SS1 active	1	SS1 active	r9734.1
		0	SS1 not active	
2	SS2 active	1	SS2 active	r9734.2
		0	SS2 not active	
3	SOS active	1	SOS active	r9734.3
		0	SOS not active	
4	SLS active	1	SLS active	r9734.4
		0	SLS not active	
5	SOS selected	1	SOS selected	r9734.5
		0	SOS deactivated	
6	SLS selected	1	SLS selected	r9734.6
		0	SLS not selected	
7	Internal event	1	Internal event	r9734.7
		0	No internal event	
8…11	Reserved	–	–	–
12	SDI positive selected	1	SDI positive selected	r9734.12
		0	SDI positive not selected	
13	SDI negative selected	1	SDI negative selected	r9734.13
		0	SDI negative not selected	
14	Emergency retraction requested	1	Emergency retraction requested	r9734.14
		0	Emergency retraction not requested	
15	Safety message effective	1	Safety message effective	r9734.15
		0	No Safety message effective	

S_V_LIMIT_B

SLS speed limit with a 32-bit resolution with sign bit.

- The SLS speed limit is available in r9733[2].
- Bit 31 determines the sign of the value:
  - Bit = 0 → positive value
  - Bit = 1 → negative value
- The SLS speed limit is standardized via p2000.

  S_V_LIMIT_B = 4000 0000 hex ≙ speed in p2000

WARN_CODE

Display of the alarm code (see function diagram 8065).

FAULT_CODE

Display of the fault code (see function diagram 8060).

E_ZSW1 (status word for infeed)

See function diagram [2457].

Table 10- 34 Description of E_ZSW1 (status word for infeed)

Bit	Meaning	Remarks		Parameter
0	Ready for switching on	1	Ready for switching on	BO: r0899.0
		0	Not ready for switching on	
1	Ready for operation	1	Ready for operation DC link pre-charged, pulses inhibited	BO: r0899.1
		0	Not ready for operation	
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	Switching on inhibited	1	Switching on inhibited Fault active	BO: r0899.6
		0	No "switching on inhibited" active	
7	Reserved	–	–	–
8	Reserved	–	–	–
9	Control request to PLC	1	Control requested 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	–	–	–

E_ZSW1_BM (status word for infeeds, metal industry)

See function diagram [2430].

Table 10- 35 Description of E_ZSW1_BM (status word for infeeds, metal industry)

Bit	Meaning	Remarks		Parameter
0	Ready for switching on	1	Ready for switching on	BO: r0899.0
		0	Not ready for switching on	
1	Ready for operation	1	Ready for operation DC link pre-charged, pulses inhibited	BO: r0899.1
		0	Not ready for operation	
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	Switching on inhibited	1	Switching on inhibited Fault active	BO: r0899.6
		0	No "switching on inhibited" active	
7	Alarm active	1	Alarm active	BO: r2139.7
		0	No alarm	
8	Reserved	–	–	–
9	Control request to PLC	1	Control requested 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
13..14	Reserved	–	–	–
15	Controller sign of life toggle bit	1	Toggle bit communication active	r2090.15
		0	Toggle bit communication not active	

10.1.3.4 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_STW 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

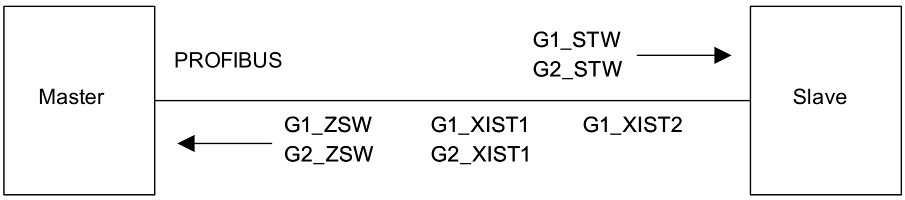


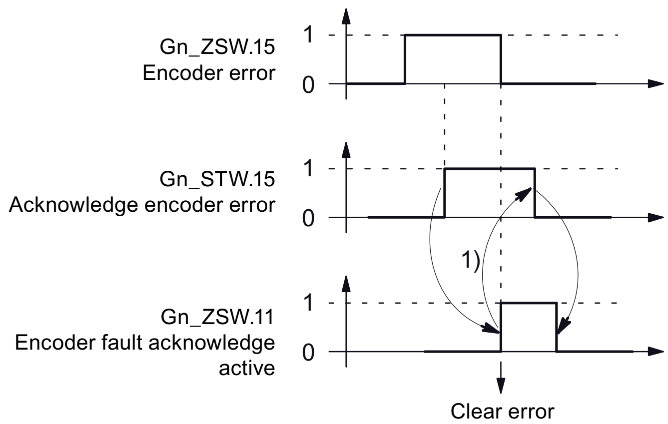
Figure 10-7 Example of encoder interface (encoder-1: two actual values, encoder -2: one actual value)

Encoder n control word (Gn_STW, n = 1, 2, 3)

The encoder control word controls the encoder functions.

Table 10- 36 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 (ZSW.0/.1/.2/.3 "0" signal again). • Find reference mark It is possible to search for a reference mark. • Equivalent zero mark • Flying 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	Flying measurement (fine resolution via p0418)	
			0	Find reference mark (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	

Bit	Name	Signal status, description	
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
			 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 marks (function 1/function 2)
- Position control with encoder 1

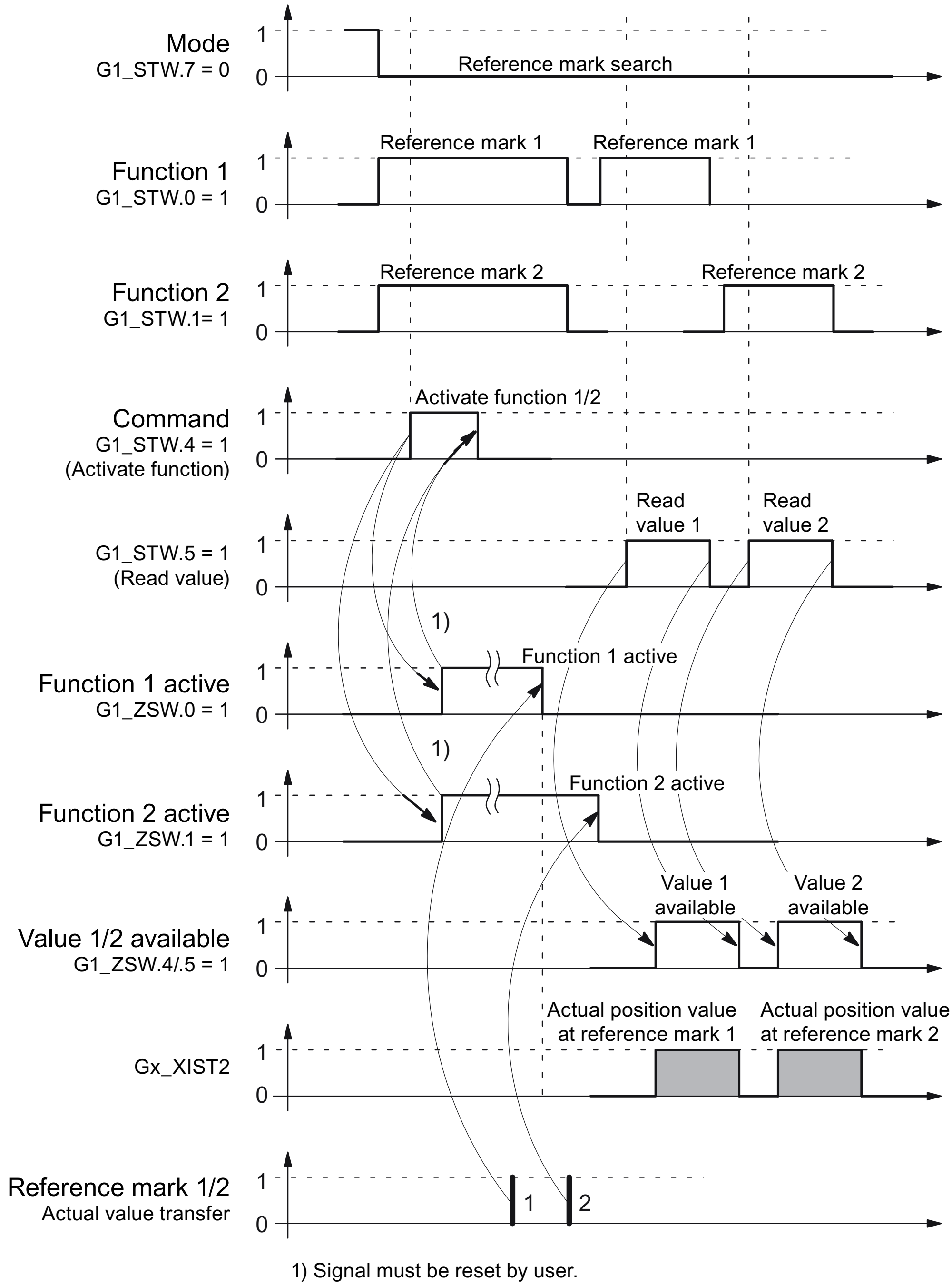


Figure 10-8 Sequence chart for "Find reference mark"

Example 2: Flying measurement

Assumptions for the example:

- Measuring probe with rising edge (function 1)
- Position control with encoder 1

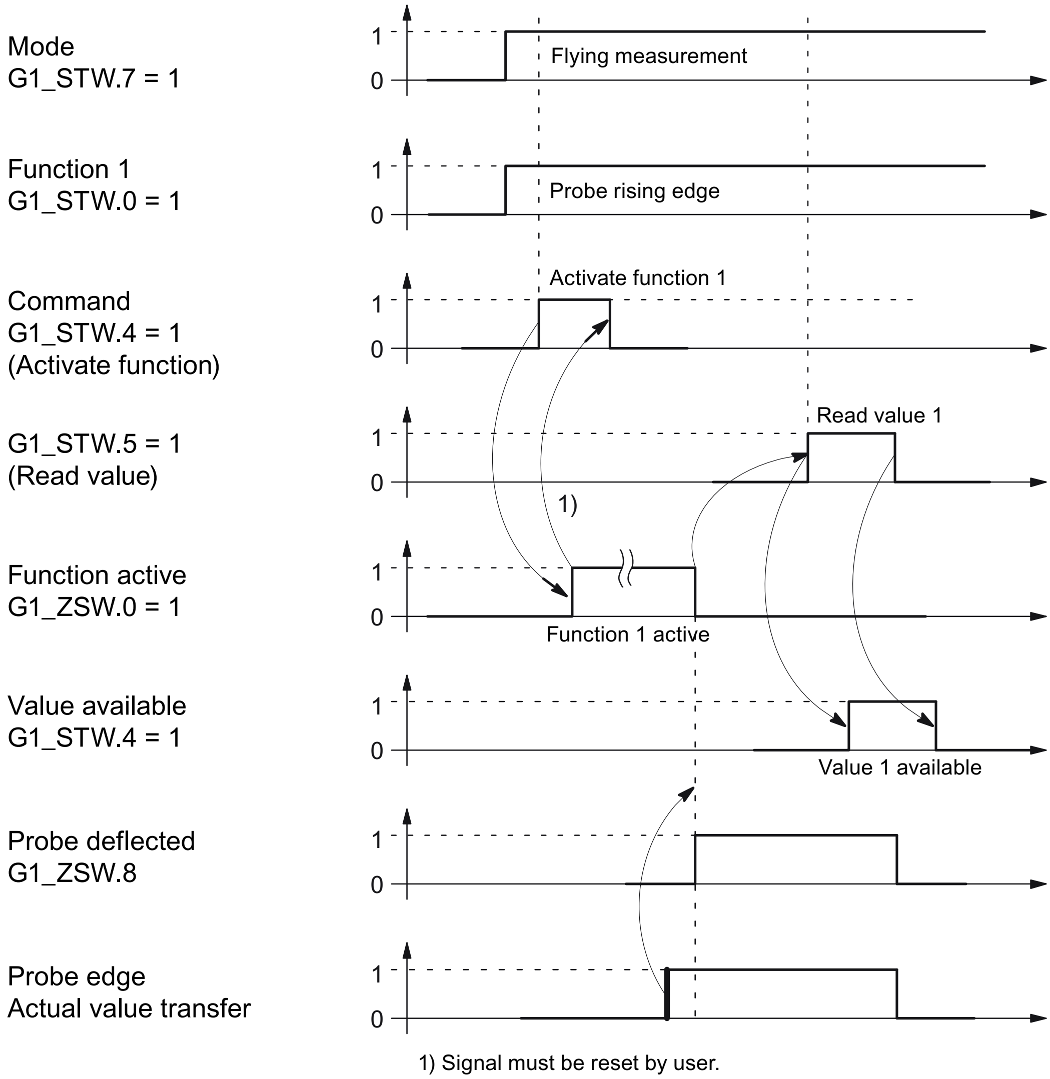


Figure 10-9 Sequence chart for "Flying measurement"

Encoder 2 control word (G2_STW)

- see G1_STW

Encoder n status word (Gn_ZSW, n = 1, 2)

The encoder status word is used to display states, errors and acknowledgements.

Table 10- 37 Description of the individual signals in Gn_ZSW

<table>
<tr><th>Bit</th><th colspan="2">Name</th><th colspan="3">Signal status, description</th></tr>
<tr><td rowspan="6">0
1
2
3</td><td rowspan="13">"Find reference mark" or "Flying measurement"</td><td rowspan="6">Status:
Function 1 - 4 active</td><td colspan="3">Valid for "Find reference mark" and "Flying measurement"</td></tr>
<tr><td>Bit</td><td colspan="2">Meaning</td></tr>
<tr><td>0</td><td>Function 1</td><td>Reference mark 1
Probe 1 rising edge</td></tr>
<tr><td>1</td><td>Function 2</td><td>Reference mark 2
Probe 1 falling edge</td></tr>
<tr><td>2</td><td>Function 3</td><td>Reference mark 3
Probe 2 rising edge</td></tr>
<tr><td>3</td><td>Function 4</td><td>Reference mark 4
Probe 2 falling edge</td></tr>
<tr><td></td><td></td><td colspan="3">Note:
• Bit x = 1 function active
Bit x = 0 function inactive</td></tr>
<tr><td rowspan="7">4
5
6
7</td><td rowspan="7">Status:
Value 1 - 4 available</td><td colspan="3">Valid for "Find reference mark" and "Flying measurement"</td></tr>
<tr><td>Bit</td><td colspan="2">Meaning</td></tr>
<tr><td>4</td><td>Value 1</td><td>Reference mark 1
Probe 1 rising edge</td></tr>
<tr><td>5</td><td>Value 2</td><td>Probe 1 falling edge</td></tr>
<tr><td>6</td><td>Value 3</td><td>Probe 2 rising edge</td></tr>
<tr><td>7</td><td>Value 4</td><td>Probe 2 falling edge</td></tr>
<tr><td colspan="3">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.</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">Probe 1 deflected</td><td>1</td><td colspan="2">Probe deflected (high signal)</td></tr>
<tr><td>0</td><td colspan="2">Probe not deflected (low signal)</td></tr>
<tr><td rowspan="2">9</td><td colspan="2" rowspan="2">Probe 2 deflected</td><td>1</td><td colspan="2">Probe deflected (high signal)</td></tr>
<tr><td>0</td><td colspan="2">Probe not deflected (low signal)</td></tr>
<tr><td>10</td><td colspan="2">Reserved</td><td colspan="3">-</td></tr>
<tr><td rowspan="2">11</td><td colspan="2" rowspan="2">Encoder fault acknowledge active</td><td>1</td><td colspan="2">Encoder fault acknowledge active
Note:
See under STW.15 (acknowledge encoder error)</td></tr>
<tr><td>0</td><td colspan="2">No acknowledgement active</td></tr>
</table>

Bit	Name	Signal status, description	
12	Reserved	-	
13	Transmit absolute value cyclically	1	Acknowledgement for Gn_STW.13 (request absolute value cyclically) **Note:** Cyclic transmission of the absolute value can be interrupted by a function with higher priority. • See Gn_XIST2
		0	No acknowledgement
14	Parking encoder	1	Parking encoder active (i.e. parking encoder switched off)
		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_XIST2.
		0	No error is active.

Encoder 1 actual position value 1 (G1_XIST1)

- 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.

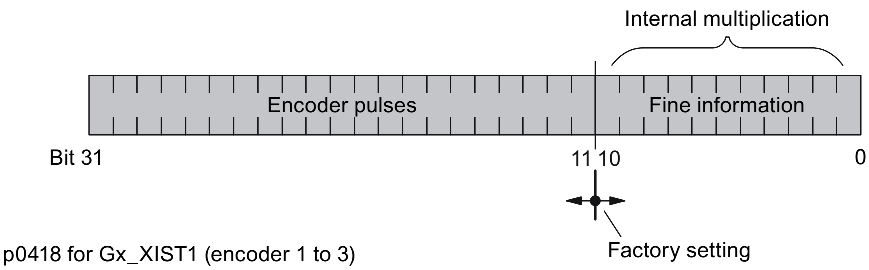


Figure 10-10 Subdivision and settings for Gx_XIST1

- 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_XIST2)

Different values are entered in Gx_XIST2 depending on the function.

- Priorities for Gx_XIST2

The following priorities should be considered for values in Gx_XIST2:

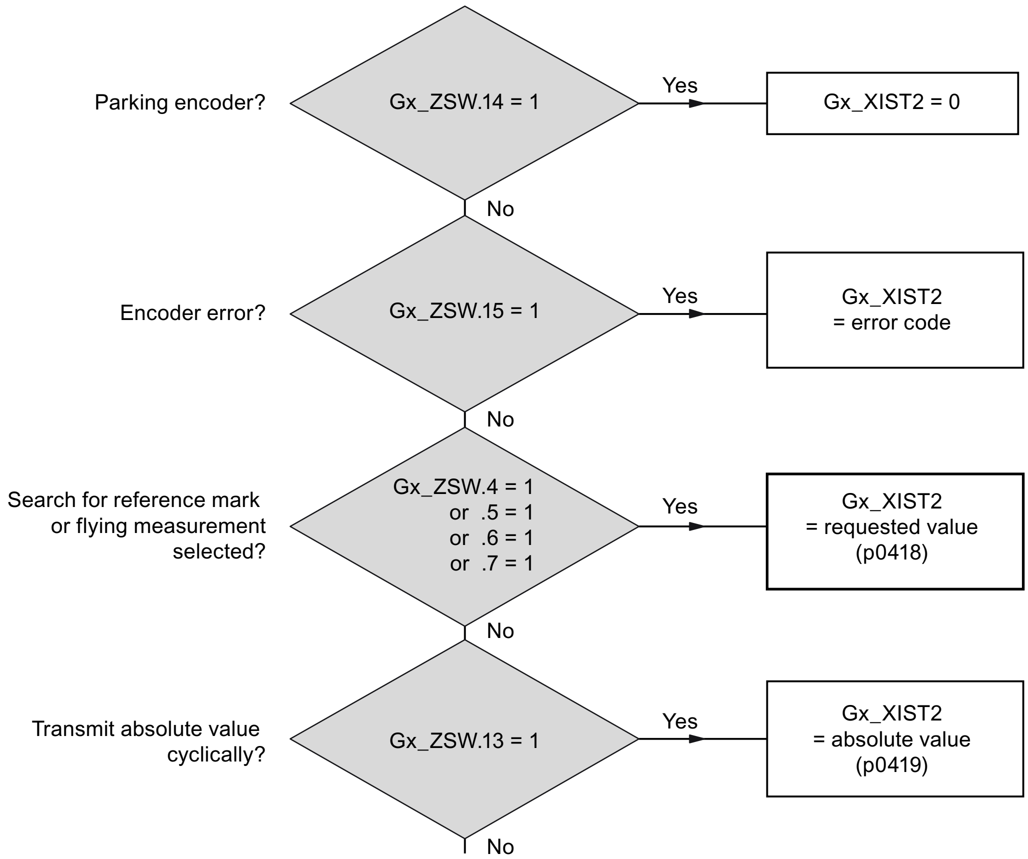


Figure 10-11 Priorities for functions and Gx_XIST2

- Resolution: Encoder pulses • 2n

  n: fine resolution, no. of bits for internal multiplication

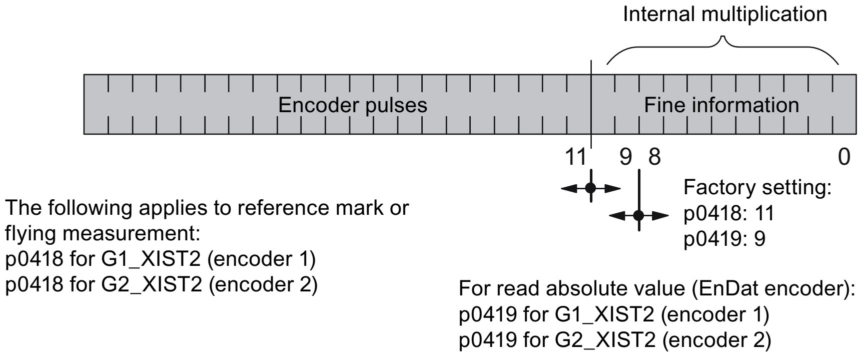


Figure 10-12 Subdivision and settings for Gx_XIST2

- 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- 38 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 mark monitoring	–
3	Abort parking sensor	• Parking drive object already selected.
4	Abort find reference mark	• A fault exists (Gn_ZSW.15 = 1) • Encoder has no zero mark (reference mark) • reference mark 2, 3 or 4 is requested • Switchover to "Flying measurement" during search for reference mark • Command "Read value x" set during search for reference mark • Inconsistent position measured value with distance-coded reference marks.
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_ZSW)

- See Gn_ZSW

Encoder 2 actual position value 1 (G2_XIST1)

- See Gn_XIST1

Encoder 2 actual position value 2 (G2_XIST2)

- See Gn_XIST2

Function diagrams (see SINAMICS S120/S150 List Manual)

- 4720 Encoder interface, receive signals, encoders n
- 4730 Encoder interface, send signals, encoders n
- 4735 Find reference mark with equivalent zero mark, encoders n
- 4740 Measuring probe evaluation, measured value memory, encoders n

Overview of important parameters (see SINAMICS S120/S150 List Manual)

Adjustable parameter drive, CU_S parameter is marked

- p0418[0...15] Fine resolution Gx_XIST1
- p0419[0...15] Fine resolution Gx_XIST2
- 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)

Display 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

10.1.3.5 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 are available:

Receive signals:

- CU_STW1 Control Unit control word
- A_DIGITAL digital outputs
- A_DIGITAL_1 digital outputs
- MT_STW probe control word

Transmit signals:

- CU_ZSW1 Control Unit status word
- E_DIGITAL digital inputs
- E_DIGITAL_1 digital inputs
- MT_ZSW Probe status word
- MTn_ZS_F Probe n measuring time, falling edge (n = 1-6)
- MTn_ZS_S Probe n measuring time, rising edge (n = 1-6)

CU_STW1 (control word for Control Unit, CU)

See function diagram [2495].

Table 10- 39 Description of CU_STW1 (control word for Control Unit)

Bit	Meaning	Remarks		Parameter
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...9	Reserved	-	-	-
10	Control transferred	0	The CU has control Once the propagated faults have been acknowledged on all DOs, the fault is also implicitly acknowledged on the DO1 (CU).	p3116
		1	External controller has control The propagated faults must be acknowledged on all DOs and must also be explicitly acknowledged on the DO1 (CU).	
11	Reserved	–		-
12	Master sign-of-life bit 0	–	Master sign of life	CI: p2045
13	Master sign-of-life bit 1	–		
14	Master sign-of-life bit 2	–		
15	Master sign-of-life bit 3	–		

A_DIGITAL (digital outputs)

This process data can be used to control the Control Unit outputs.
See function diagram [2497]

Table 10- 40 Description of A_DIGITAL (digital outputs)

Bit	Meaning	Remarks		Parameter
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
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- 41 Description of MT_STW (control word for Control Unit)

Bit	Meaning	Remarks		Parameter
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_ZSW1 (status word of the DO1 telegram (telegrams 39x))

See function diagram [2496].

Table 10- 42 Description of CU_ZSW1 (status word of the CU)

Bit	Meaning	Remarks		Parameter
0	Reserved	-	-	-
1	Reserved	-	-	-
2	Reserved	-	-	-
3	Fault active	1	The active faults are stored in the fault buffer	BO: r2139.3
	No fault present	0	There are no faults in the fault buffer	
4	Reserved	-	–	-
5	Reserved	-	-	-
6	Reserved	-	-	-
7	Alarm active	1	The active alarms are stored in the alarm buffer	BO: 2139.7
	No alarm active	0	There are no alarms in the alarm buffer	
8	SYNC	SYNC bit of TM17 indicates that the slave is synchronized.		BO: r0899.8
		1	Slave synchronized	
		0	Slave not synchronized	
9	Alarm is active	1	There is no alarm in the module line-up.	BO: r3114.9
		0	There is an alarm in the module line-up.	
10	Fault pending	1	No group bit for fault in the module line-up.	BO: r3114.10
		0	Group bit for fault in the module line-up present.	
11	Safety Integrated module line-up fault	1	Group bit for SI fault is active, ORed across all drive DOs including the CU of the module line-up, plus propagations.	BO: r3114.11
		0	No group bit for SI fault	
12	Slave sign-of-life bit 0	1-15	Cyclic advance	Implicitly interconnected
		0	Initialization, no sign of life available	
13	Slave sign-of-life bit 1	1-15	Cyclic advance	
		0	Initialization, no sign of life available	
14	Slave sign-of-life bit 2	1-15	Cyclic advance	
		0	Initialization, no sign of life available	
15	Slave sign-of-life bit 3	1-15	Cyclic advance	
		0	Initialization, no sign of life available	

E_DIGITAL (digital inputs)

See function diagram [2498].

Table 10- 43 Description of E_DIGITAL (digital inputs)

Bit	Meaning	Remarks		Parameter
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
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- 44 Description of MT_ZSW (status word for the "central probe" function)

Bit	Meaning	Remarks		Parameter
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 CU_STW1 and the CU_ZSW1.
  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.

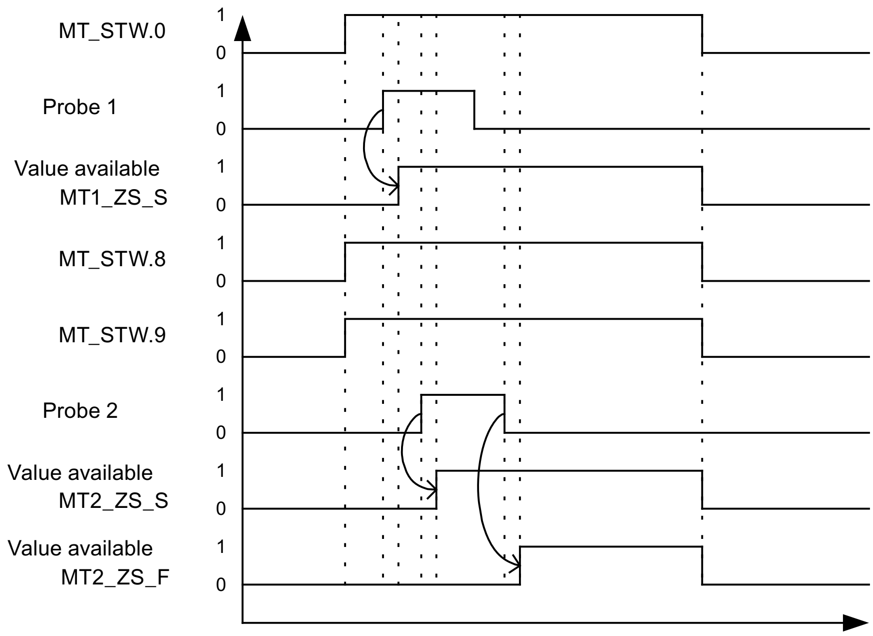


Figure 10-13 Sequence chart for central probe example

10.1.3.6 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. HWConfig 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. HWConfig) supports:
  - High number of drives per slave/drive unit → longer cycle
  - Large number of slaves/drive units → longer 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.

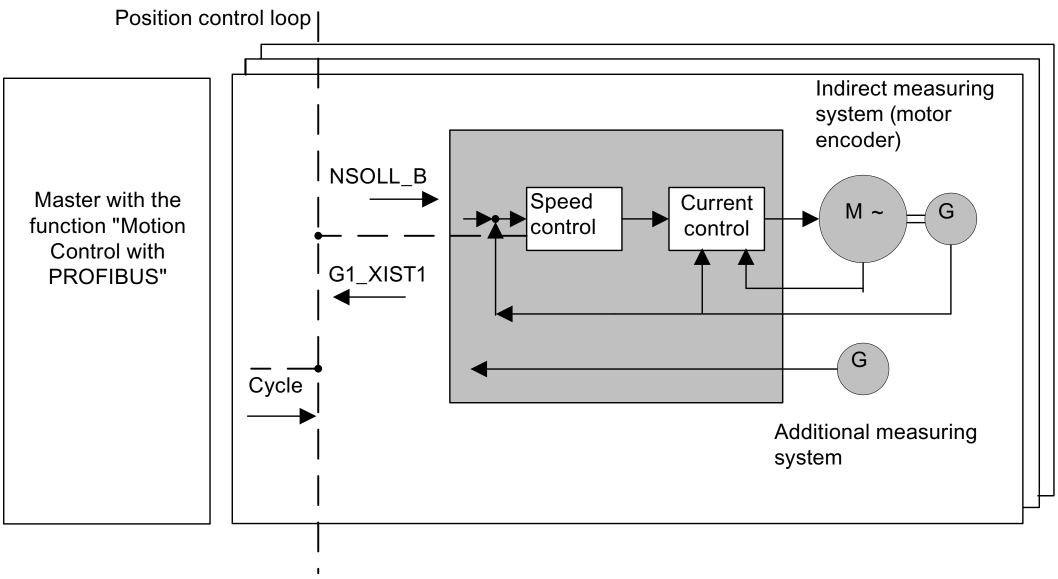


Figure 10-14 Overview of "Motion Control with PROFIBUS" (example: master and 3 slaves)

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

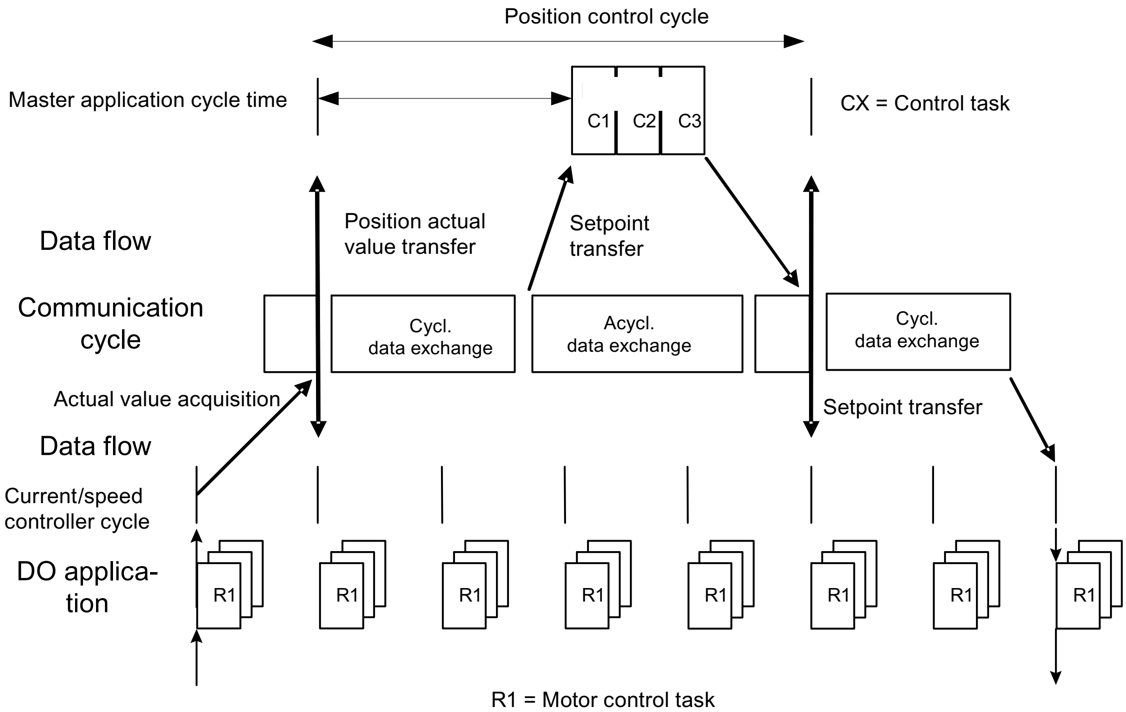


Figure 10-15 Isochronous drive link/Motion Control with PROFIdrive

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 the online mode via PROFIBUS.
- PROFIdrive parameter channel with the following data sets:
  - PROFIBUS: Data block 47 (0x002F)

    The DPV1 services are available for master class 1 and class 2.
  - PROFINET: Data block 47 and 0xB02F al global access, data set 0xB02E as local access

> **Note**
>
> Please refer to the following documentation for a detailed description of acyclic communication:
> Reference: PROFIdrive Profile V4.1, May 2006, Order No: 3.172
>
> 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.

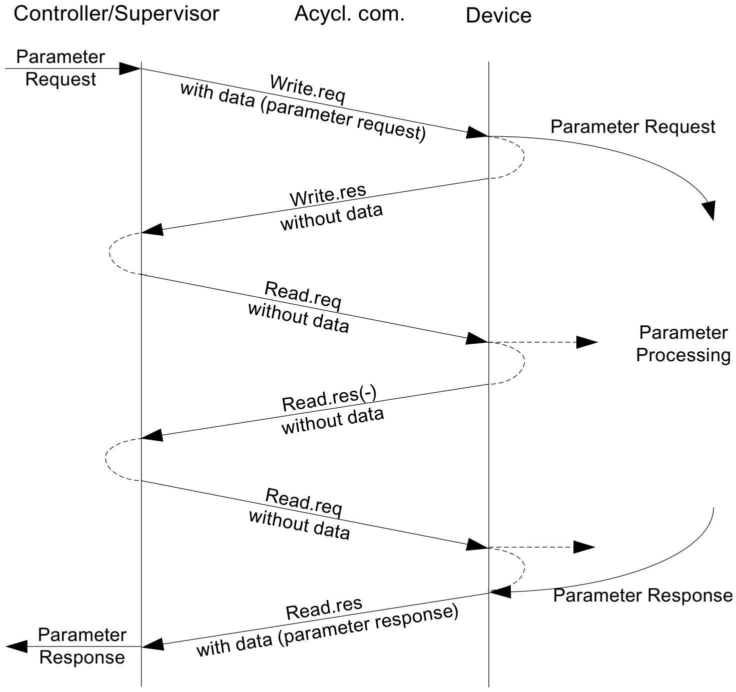


Figure 10-16 Reading and writing data

Characteristics of the parameter channel

- One 16-bit address each for parameter number and subindex.
- Concurrent access by several additional 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	Remark
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
	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.		

Field	Data type	Values	Remark
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
	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- 45 Error values in DPV1 parameter responses

Error value	Meaning	Remark	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
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).	–	–

Error value	Meaning	Remark	Additional info
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.	–	–
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).	–	–

Error value	Meaning	Remark	Additional info
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

Requirements

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 actual fault incident with 8 faults is to be read.
- Parameter number:

  945 dec → p0945 (fault code) is read.
- Subindex:

  0 dec → Reading starts at index 0.

1. Initiate parameter request.

   If ZSW1.3 = "1" → Initiate parameter request

2. 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 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 the 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)

Requirements

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.

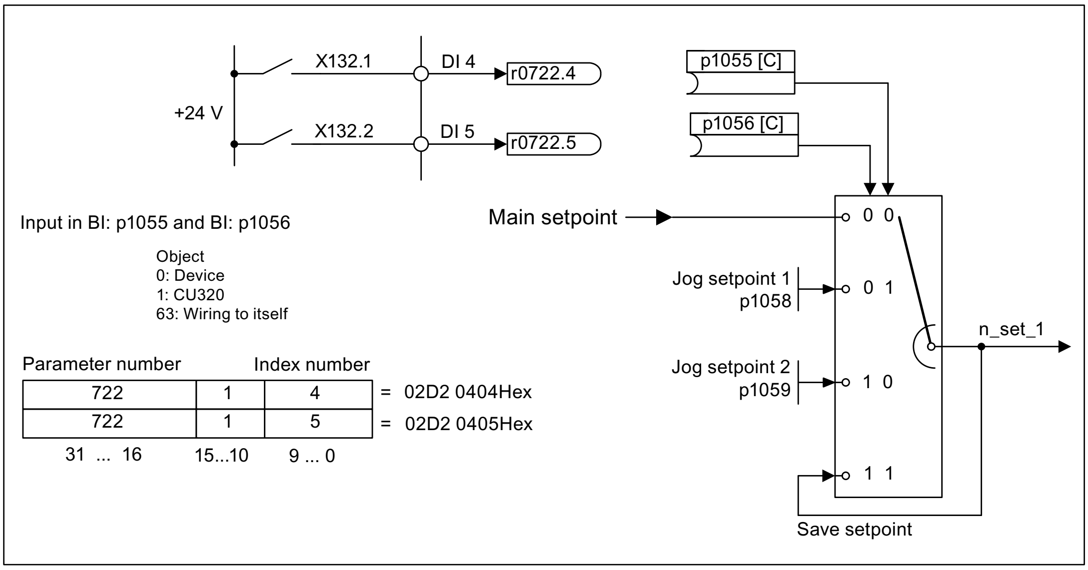


Figure 10-17 Task description for multi-parameter request (example)

Basic procedure

1. Create a request to write the parameters.
2. Invoke the request.
3. Evaluate the response.

Activity

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
	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 CU320-2 and other CAN bus nodes may be destroyed.

Master and slave

- Master and slave properties

Table 10- 46 Master and slave properties

Properties	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...24] 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 the online mode under → **Drive unit** → **Communication→ Telegram configuration**.

When you create the configuration on the master side (e.g. HWConfig), 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:

- Active Infeed (A_INF)
- Basic Infeed (B_INF)
- Control Unit (CU_S)
- ENCODER
- Smart Infeed (S_INF)
- SERVO
- Terminal Board 30 (TB30)
- Terminal Module 15 (TM15DI_DO)
- Terminal Module 31 (TM31)
- Terminal Module 41 (TM41)
- Terminal Module 120 (TM120)
- VECTOR

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.

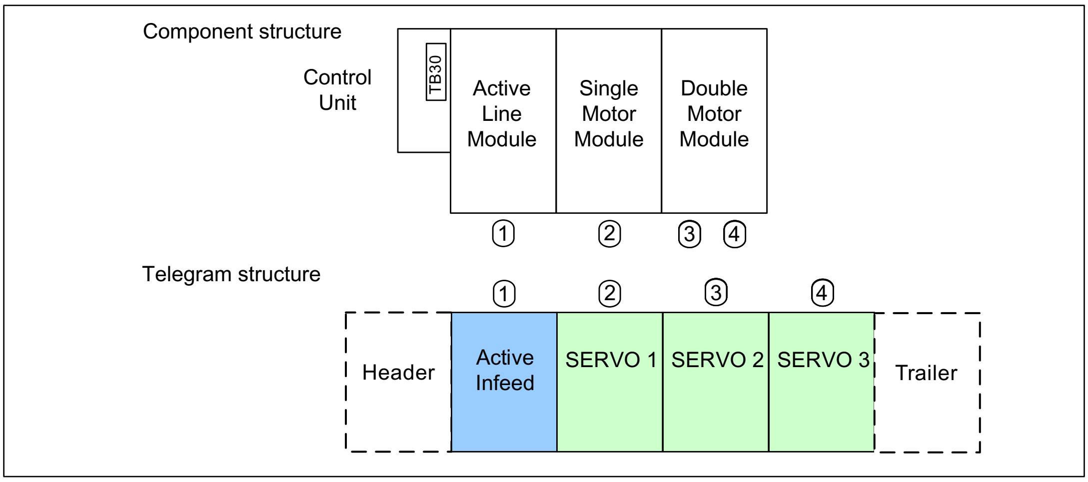


Figure 10-18 Component and telegram structure

You can check and change the sequence of the telegrams via p0978[0...15].

Configuration settings (e.g. HWConfig 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

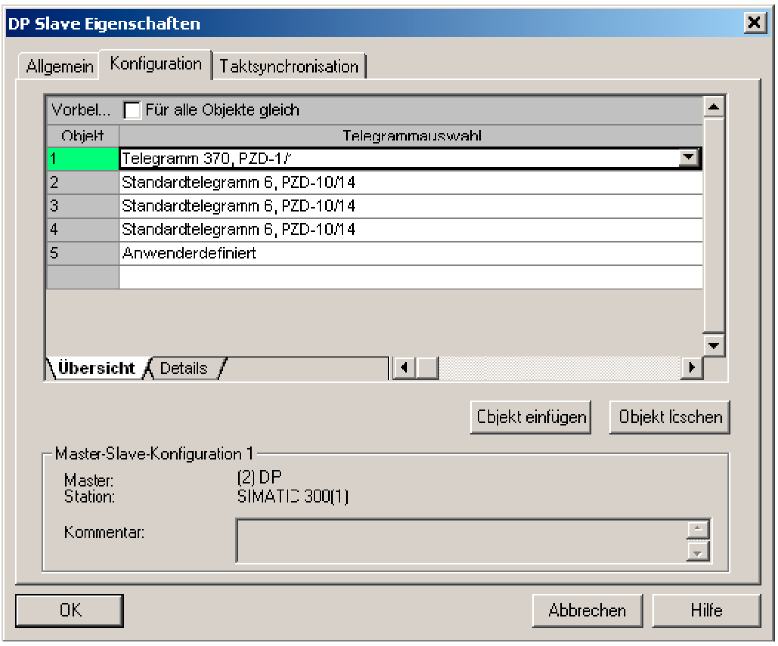


Figure 10-19 Slave properties – overview

When you click "Details", the properties of the configured telegram structure are displayed (e.g. I/O addresses, axis separator).

DP slave properties – details

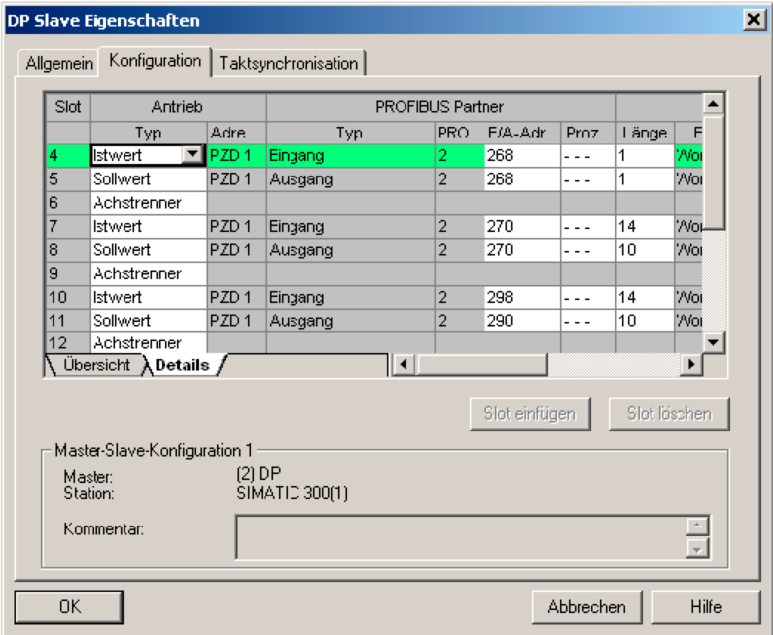


Figure 10-20 Slave properties – details

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

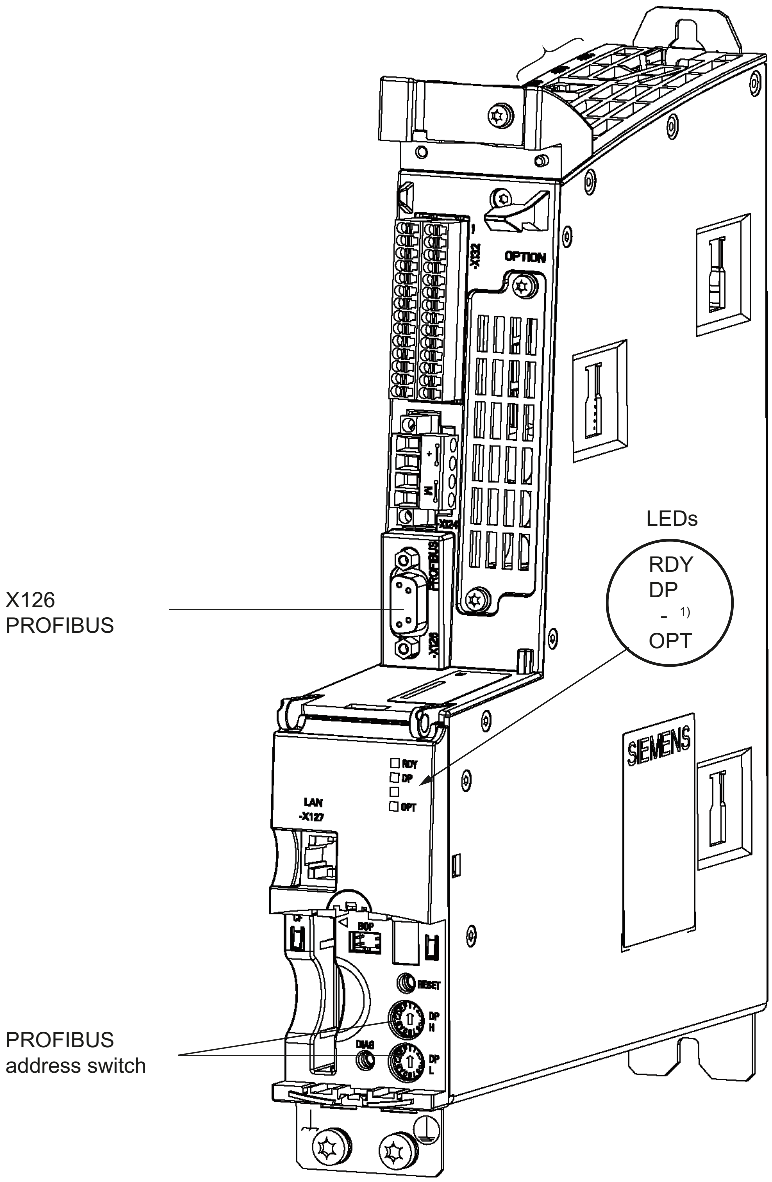
etc.

10.2.2 Commissioning PROFIBUS

10.2.2.1 Setting the PROFIBUS interface

Interfaces and diagnostic LED

A PROFIBUS interface with LEDs and address switches is available as standard on the Control Unit.



1) LED reserved

Figure 10-21 Interfaces and diagnostic LED

- PROFIBUS interface

  The PROFIBUS interface is described in the following documentation:

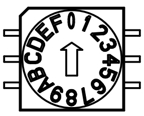
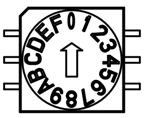
  Reference: SINAMICS S120 Equipment Manual for Control Units and Additional System Components
- PROFIBUS diagnostic LED

Note

A teleservice adapter can be connected to the PROFIBUS interface (X126) for remote diagnostics purposes.

On the CU320-2, the PROFIBUS address is set as a hexadecimal value via two rotary coding switches. Values between 0_{dec} (00_{hex}) and 127_{dec} ($7F_{hex}$) can be set as the address. The upper rotary coding switch (H) is used to set the hexadecimal value for 16^1, and the lower rotary coding switch (L) is used to set the hexadecimal value for 16^0.

Table 10- 47 PROFIBUS address switch

Rotary coding switches	Significance	Examples		
		21_{dec}	35_{dec}	126_{dec}
		15_{hex}	23_{hex}	$7E_{hex}$
 DP H	$16^1 = 16$	1	2	7
 DP L	$16^0 = 1$	5	3	E

Setting the PROFIBUS address

The factory setting for the rotary coding switches is 0_{dec} (00_{hex}).

There are two ways to set the PROFIBUS address:

1. Via p0918
   – To set the bus address for a PROFIBUS node using STARTER, first set the rotary code switches to 0_{dec} (00_{hex}) and 127_{dec} ($7F_{hex}$).
   – Then use parameter p0918 to set the address to a value between 1 and 126.
2. Via the PROFIBUS address switches on the Control Unit
   – The address is set manually to values between 1 and 126 using the rotary coding switches. In this case, p0918 is only used to read the address.

The address switch is behind the blanking plate. The blanking plate is part of the scope of supply.

Note

Address 126 is used for commissioning. Permitted PROFIBUS addresses are 1 ... 126.

If more than one CU is connected to a 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 selectively setting parameter p0918. The setting can be made by connecting the 24 V supply step by step and reparameterizing parameter 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.

Note

Only values from 1 to 126 ($7E_{hex}$) are valid for PROFIBUS addressing. If values above 127 are set, then the set value is interpreted as "0". If a value "0" or "127" is set, the value in parameter p0918 defines the PROFIBUS address.

10.2.2.2 PROFIBUS interface in operation

Generic station description file

A generic station description 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://support.automation.siemens.com/WW/llisapi.dll?func=cslib.csinfo2&aktprim=99&lang=de, then search for GSD files using the index search.
- On the CD for the STARTER commissioning tool

  Order no. 6SL3072-0AA00-0AGx
- On the memory card in directory

  \\SIEMENS\SINAMICS\DATA\CFG\

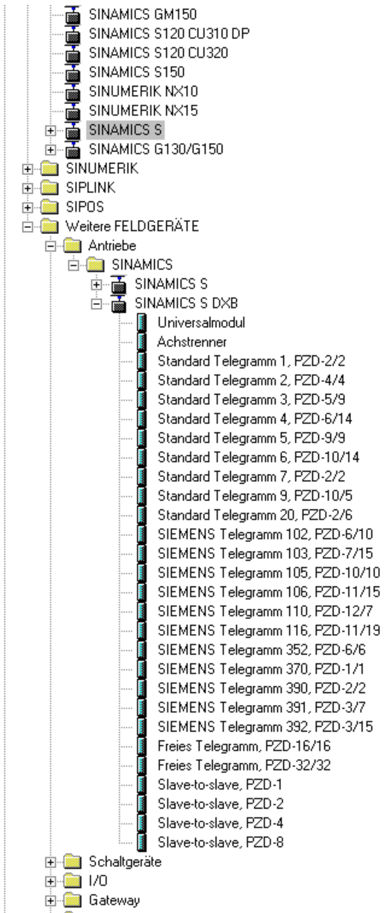


Figure 10-22 Hardware catalog of the generic station description file with slave-to-slave communication functionality

The SINAMICS S DXB GSD file contains among other things 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 separator after each drive object to compose a telegram for the drive unit.

The processing of a GSD file in the bus configuration tool (e.g. HW Config) is part of the documentation of the particular bus configuration tool (here: SIMATIC documentation).

Note for 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.

Device identification

An identification parameter for individual slaves facilitates diagnostics 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 off 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.

  Reference: /GH1/ SINAMICS S120 Equipment Manual for Control Units and Additional System Components

10.2.2.3 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 HWConfig:
   - 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.

10.2.2.4 Diagnostics options

The standard slave diagnostics can be read online in the HW config.

10.2.2.5 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- 48 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- 49 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 sub-index bit 15 ... 10: Drive object No. 0 ... 63 bit 9 ... 0: Sub-index 0 ... 1023 or expressed differently DBW = 1024 * drive object No. + sub-index
Length	Not activated
Acquisition cycle	Any
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.

10.2.2.6 Monitoring: telegram failure

Description

When monitoring telegram failure, SINAMICS differentiates between two cases:

1. Telegram failure with a bus fault

   After a telegram failure and the additional 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 a quick stop, for example.

   Once the delay time p2044 has elapsed, fault F01910 is output. Fault F01910 triggers fault response OFF2 (pulse inhibit) for the infeed and OFF3 (quick 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.

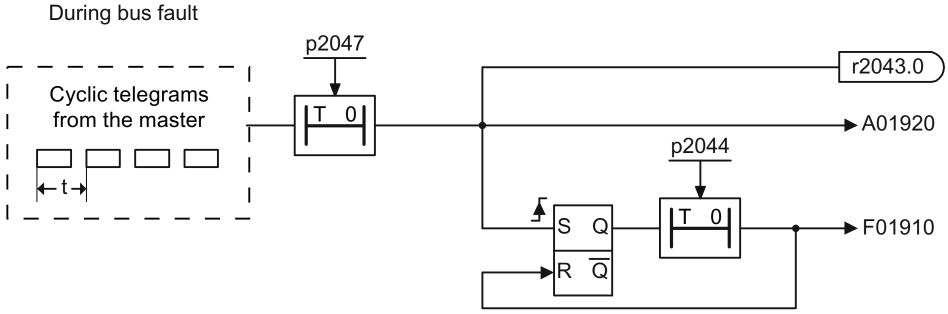


Figure 10-23 Monitoring telegram failure with a bus fault

2. Telegram failure with a CPU stop

   After telegram failure, bit r2043.0 is set to "1". Binector output r2043.0 can be used for a quick stop, for example.

   Once the delay time p2044 has elapsed, fault F01910 is output. Fault F01910 triggers fault response OFF2 (pulse inhibit) for the infeed and OFF3 (quick 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.

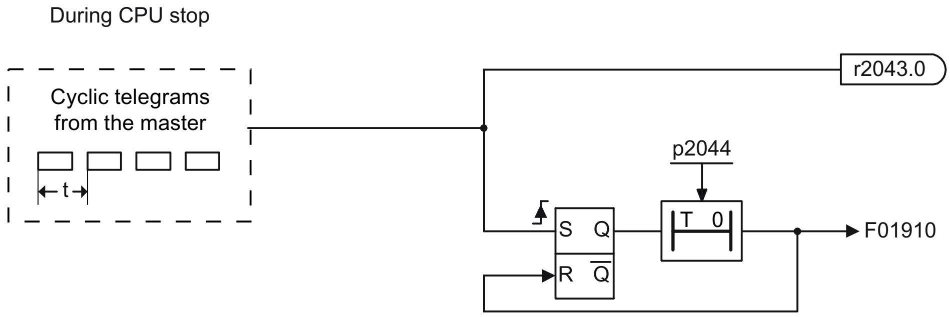


Figure 10-24 Monitoring telegram failure for a CPU stop

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 a ramp-down time (p1135) of two seconds, the drive is at a standstill.

Settings:

- CU p2047 = 20 ms
- A_INF p2044 = 2 ms
- VECTOR p2044 = 0 ms

Sequence:

Following a telegram failure and once the additional monitoring time (p2047) has elapsed, 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 two-second delay time (p2044), fault F01910 is output on the infeed and triggers OFF2.

Note

The additional monitoring time parameter p2047 is only useful for cyclic communication. During isochronous communication, a telegram failure should be recorded without delay, in order to respond as quickly as possible.

10.2.3 Motion Control with PROFIBUS

Motion Control /Isochronous drive link with PROFIBUS

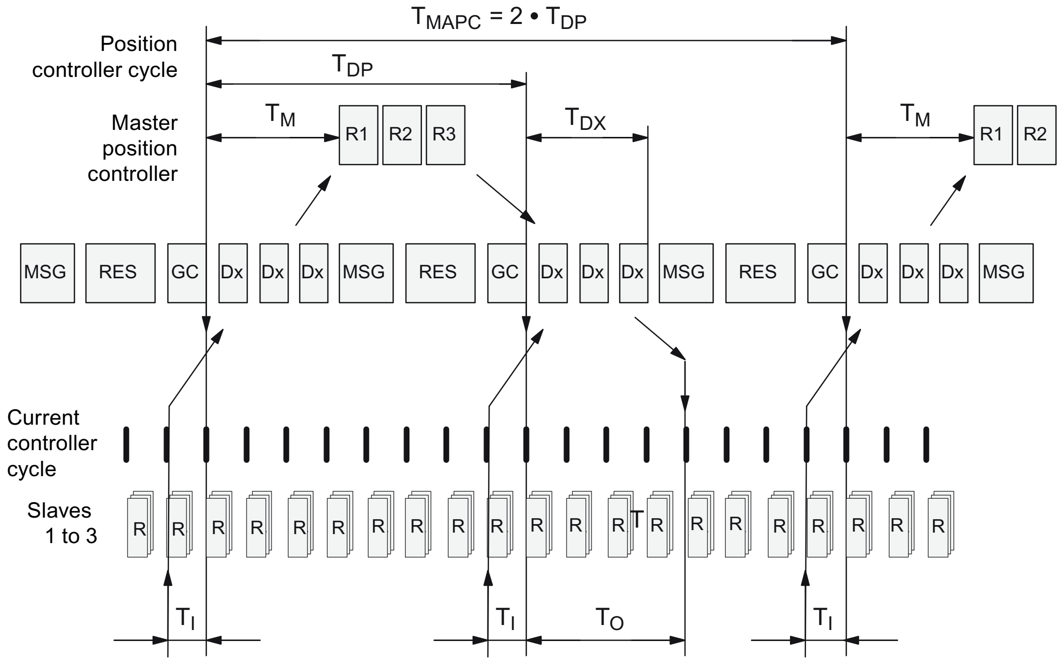


Figure 10-25 Motion Control/Isochronous drive link with PROFIBUS, optimized cycle with T_{MAPC} = 2 • T_{DP}

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- 50 Time settings and meanings

Name	Limit value	Description
T_{BASE_DP}	250 µsec	Time base for T_{DP}
T_{DP}	$T_{DP} \geq T_{DP\_MIN}$ $T_{DP\_MIN} \leq T_{DP} \leq T_{DP\_MAX}$	DP cycle time T_{DP} = Dx + MSG + RES + GC T_{DP} = multiple integer • T_{BASE_DP} T_{DP_MIN} = 1 ms T_{DP_MAX} =32 ms
T_{MAPC}		Master application cycle time This is the time frame in which the master application generates new setpoints (e.g. in the position controller cycle). T_{MAPC} = integer multiple * T_{DP}
T_{BASE_IO}	125 µsec	Time base for T_I, T_O
T_I	$T_{I\_MIN} \leq T_I < T_{DP}$	Time of actual-value sensing This is the time at which the actual position value is sensed before the start of each cycle. T_I = integer multiple of T_{BASE_IO} T_{I_MIN} corresponds to the longest current controller cycle (p0115[0]) of a drive object (SERVO/VECTOR) in the drive unit, minimum 125 µs.
T_O	$T_{DX} + T_{O\_MIN} \leq T_O < T_{DP}$	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} T_{O_MIN} corresponds to the longest speed controller cycle (p0115[1]) of a drive object (SERVO/VECTOR) in the drive unit, minimum 125 µsec
T_{DX}	$T_{DX} < T_{DP}$	Data exchange time This is the time required within one cycle for transferring process data to all available slaves.
T_{PLL_W}	-	PLL window
T_{PLL_D}	-	PLL delay time
GC		Global Control Telegram (Broadcast Telegram)
Dx		Data_Exchange This service is used to implement user data exchange between master and slave 1 - n.
MSG		Acyclic service This service is used to implement user data exchange between master and slave 1 - n on an acyclical basis.
RES		Reserve: "Active pause" until the isochronous cycle has expired
R		Computation time, speed or position controller in the master or slave
T_M		Master time Start of the closed-loop master control

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 $T_{DP} > T_O$

    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 parameter p0972 = 1 (reset drive unit) must be set.

- T_I and T_O
  - Setting the times in T_I and T_O as short as possible reduces the dead time in the position control loop.
  - $T_O > T_{DX} + T_{Omin}$
- Settings and optimization can be done using a tool (e.g. HW Config in SIMATIC S7).

Minimum times for reserves

Table 10- 51 Minimum times for reserves

Data	Time required [µs]
Basic load	300
Per slave	20
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 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}).

Example: SINAMICS vector drives with SIMOTION D4x5 and/or CX modules

To determine what the cycles in the SINAMICS drive unit will be after a project has been downloaded, dependable cycle values should be set initially in HW Config.

The following settings and sequences are recommended:

1. T_{DP} = 3.0 ms (T_{DP} = DP cycle time)
2. $T_I = T_o$ = 1.5 ms (T_I = time of actual value acquisition, T_o = time of setpoint transfer)
3. T_{MAPC} = 6.0 ms (T_{MAPC} = master application cycle time)

After successful download, all current and speed controller cycles can be determined. These cycles can be optimized in HW Config if necessary.
The cycles are set in HW Config under the DP slave properties of the SINAMICS drive unit (slave, master e.g. SIMOTION D4x5) on the "Clock synchronization" tab.

10.2.4 Slave-to-slave communication

10.2.4.1 General information

Description

With 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 communication" function without direct involvement from the master.

The following terms are used for the functions described here:

- Slave-to-slave communication
- Data Exchange Broadcast (DXB.req)
- Slave-to-slave communication (is used in the following)

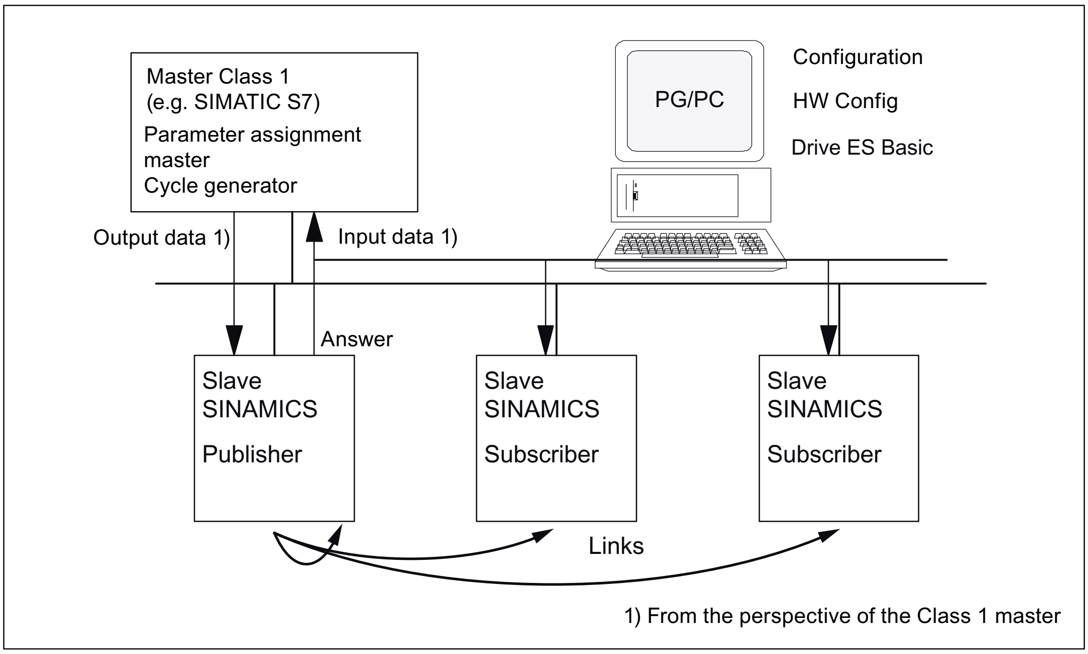


Figure 10-26 Slave-to-slave communication with the publisher-subscriber model

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 are 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 (connections to publisher) contain the following information:

- From which publisher is input data received?
- Which input data are there?
- Where do the additional setpoints come in?

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 supplementary conditions

The following supplementary conditions should be observed for the "slave-to-slave communication" function:

- Drive ES Basic V5.3 SP3
- Number of process data, max. per drive
- Number of links to publishers
- Number of taps per link

Note

The "slave-to-slave communication" function is not available for the CU310-2 PN.

Applications

For example, the following applications can be implemented using the "slave-to-slave communication" function:

- Axis couplings (this is practical for isochronous mode)
- Specifying binector connections from another slave

10.2.4.2 Setpoint assignment in the subscriber

Setpoints

Information about setpoints:

- Number of setpoint

  When bus communication 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 are determined using the local process data configuration for the "SINAMICS slave".
- Operation as "standard" slave

  The drive unit (slave) only receives its setpoints as 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.

10.2.4.3 Activating/parameterizing slave-to-slave communications

The "slave-to-slave communication" 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 during bus startup.

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 via the bus configuration tool (e.g. HW Config).

Activation in the Subscriber

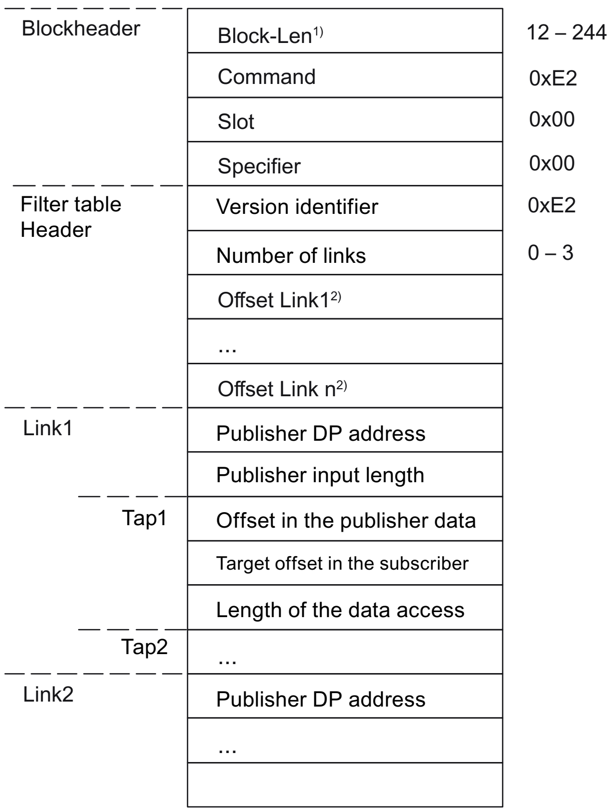
The slave, which is to be used as Subscriber, requires a filter table. The slave must know which setpoints are received from the master and which are received from a publisher.

The filter table is created automatically via the bus configuration tool (e.g. HW Config).

The following diagram shows the information contained in the filter table.

Parameterizing telegram (SetPrm)

The filter table is transferred, as dedicated block from the master to the slave with the parameterizing telegram when a bus communication is established.



1) Specification in bytes
2) Calculated from Version ID

Figure 10-27 Filter block in the parameterizing telegram (SetPrm)

Configuration telegram (ChkCfg)

Using the configuration telegram, a slave knows how many setpoints are to be received from the master and how many actual values are to be sent to the master.

For slave-to-slave communication, a special space ID is required for each tap. The PROFIBUS configuration tool (e.g. HW Config) generates this ID. The ID is then transferred with the ChkCfg into the drive devices that operate as subscribers.

10.2.4.4 Commissioning of the PROFIBUS slave-to-slave communication

The commissioning of slave-to-slave communication between two SINAMICS drive devices using the additional Drive ES Basic package is described below in an example.

Settings in HW Config

The project below is used to describe the settings in HW Config, using the example "Standard telegrams".

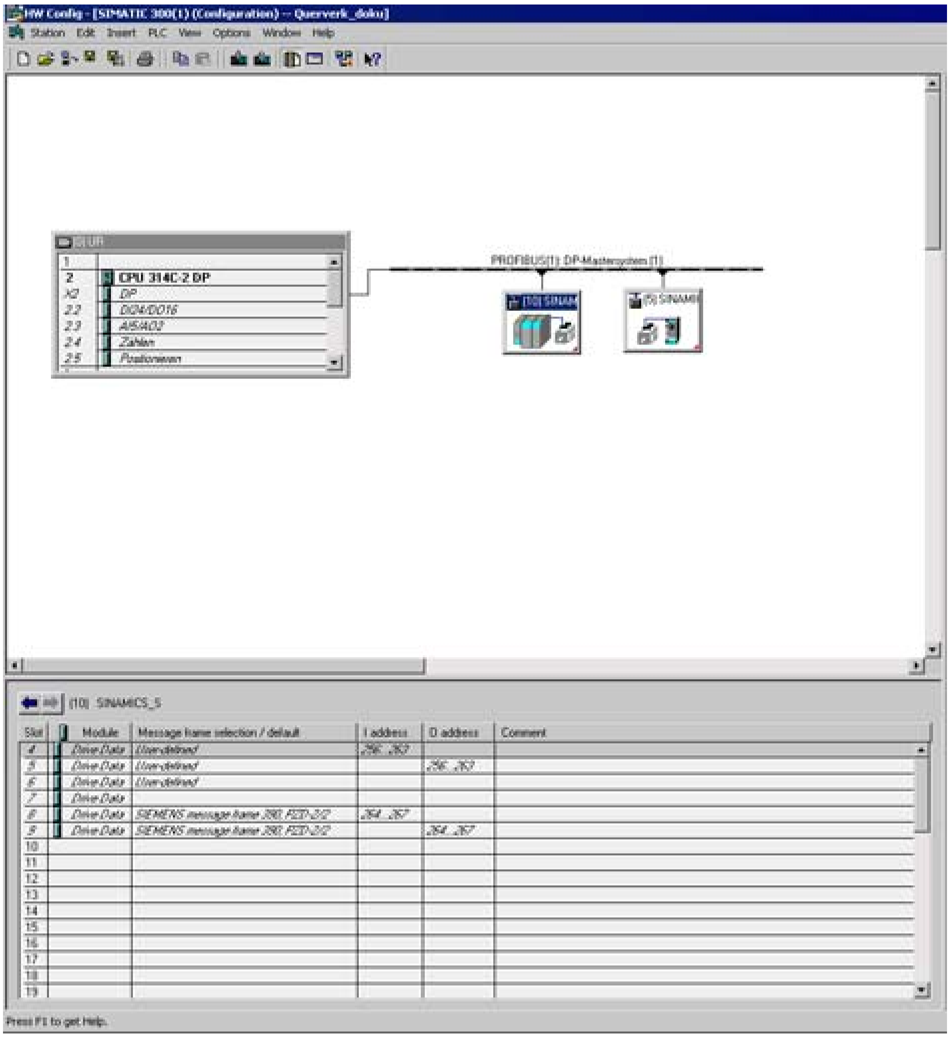


Figure 10-28 Example project of a PROFIBUS network in HW Config

Procedure

1. Select a slave (e.g. SINAMICS S) and use its properties to configure the telegram for the connected drive object.
2. Select a SINAMICS S as a slave and use its properties dialog to configure the telegram portions for the individual drive objects.

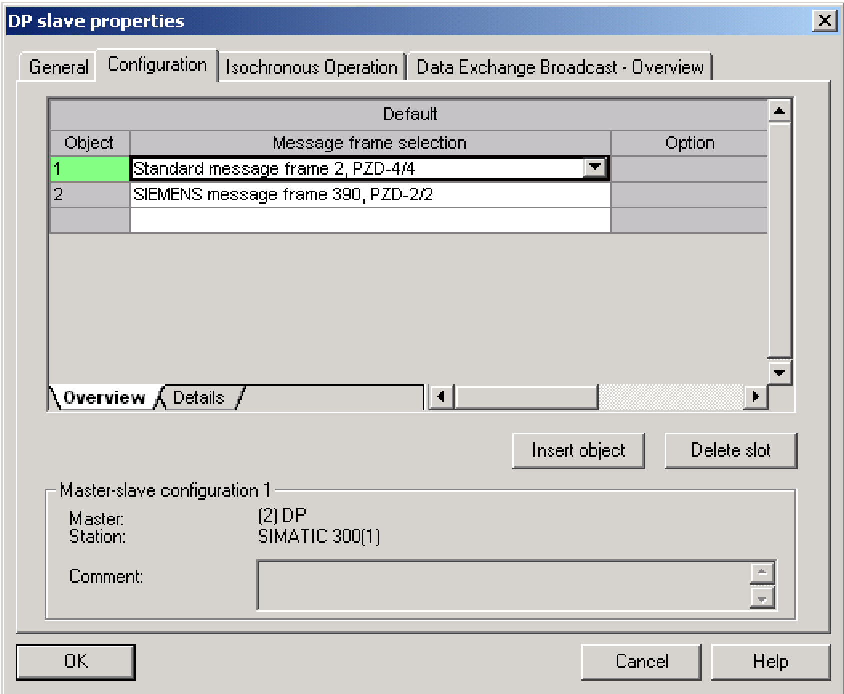


Figure 10-29 Telegram selection for drive object

3. Then switch to the detailed view.
   Slots 4/5 contain the actual and setpoint values for the first drive object, e.g. SERVO.
   Slots 7/8 are the telegram portion for the actual and setpoint values for the second drive object, e.g. CU.

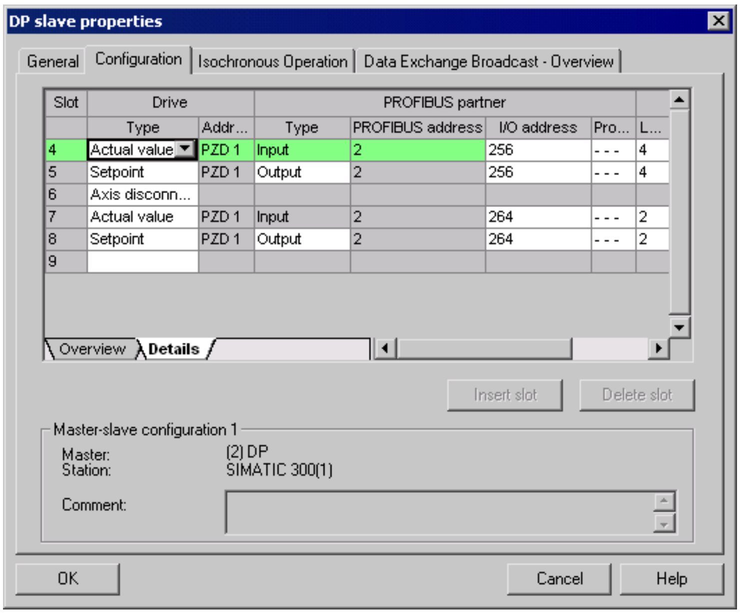


Figure 10-30 Detail view of slave configuration

4. The "Insert slot" button is used to create a new setpoint slot for the first drive object behind the existing setpoint slot.

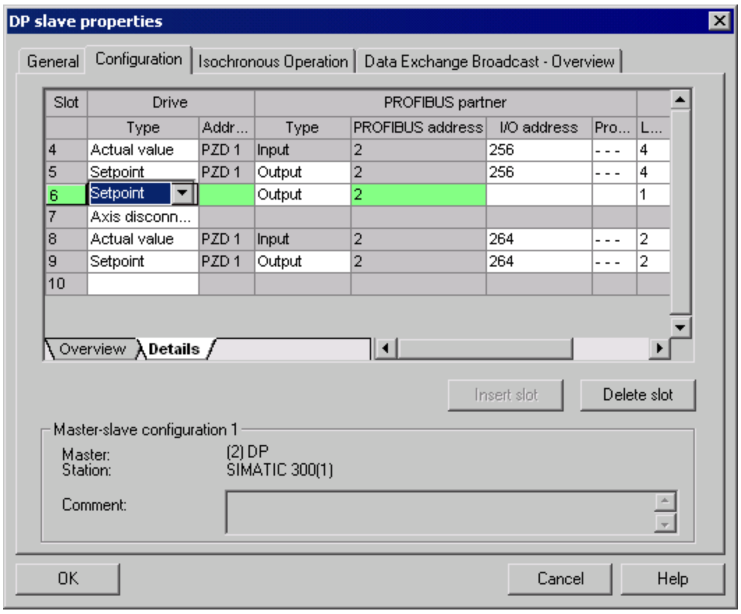


Figure 10-31 Insert new slot

5. Assign the setpoint slot the type "slave-to-slave communication".

6. In the column, select the PROFIBUS DP address of the publisher.
   This displays all PROFIBUS 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 device.
7. The "I/O address" column displays the start address for every drive object.
   Select the start address of the data of the drive object 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 drive object telegram portion.

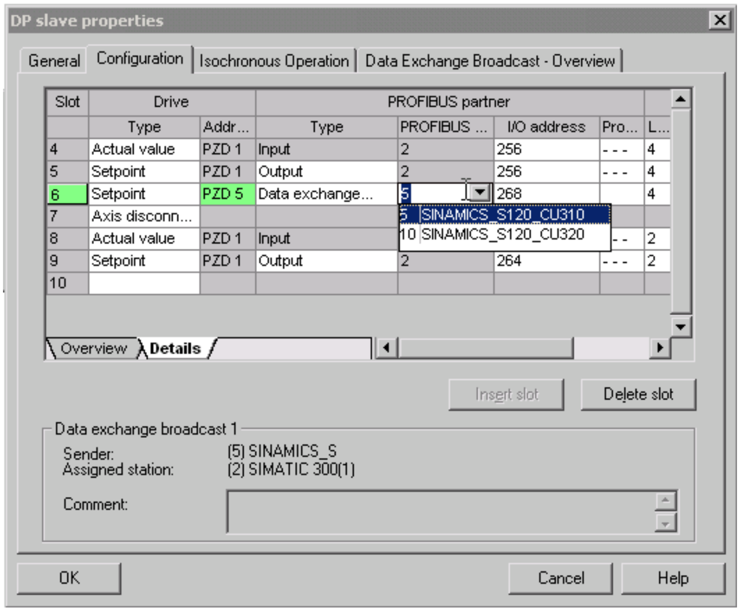


Figure 10-32 Configuring the slave-to-slave communication nodes

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.

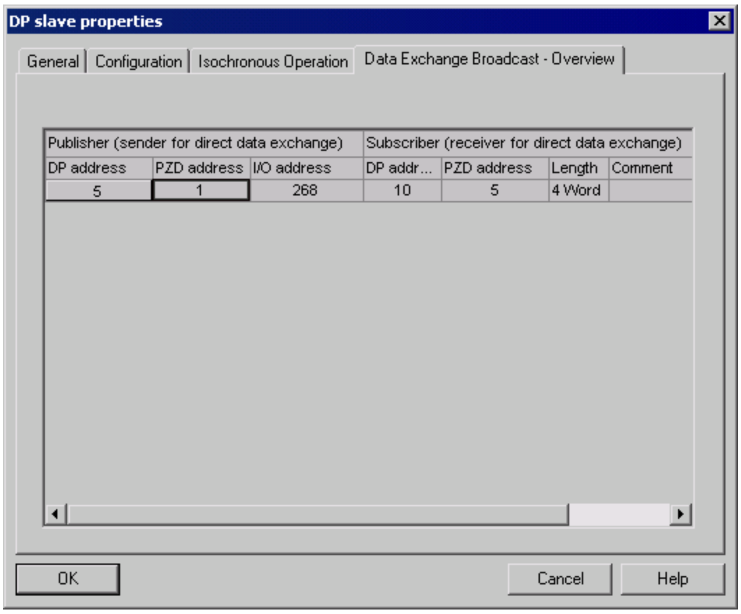


Figure 10-33 Data Exchange Broadcast - Overview

9. After the slave-to-slave communication link has been created, instead of showing "Standard telegram 2" for the drive object, "User-defined" appears in the configuration overview.

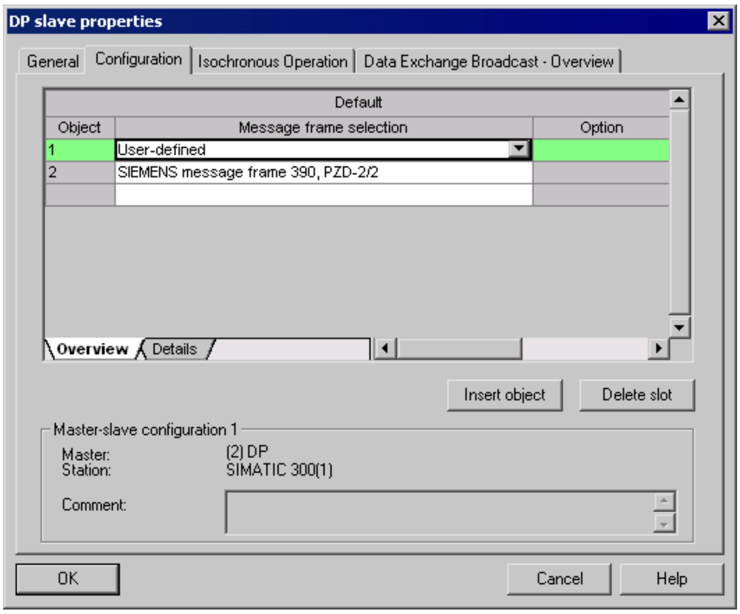


Figure 10-34 Telegram assignment for slave-to-slave communication

10. The details after creation of the slave-to-slave communication link for a drive object of the SINAMICS S drive device are as follows:

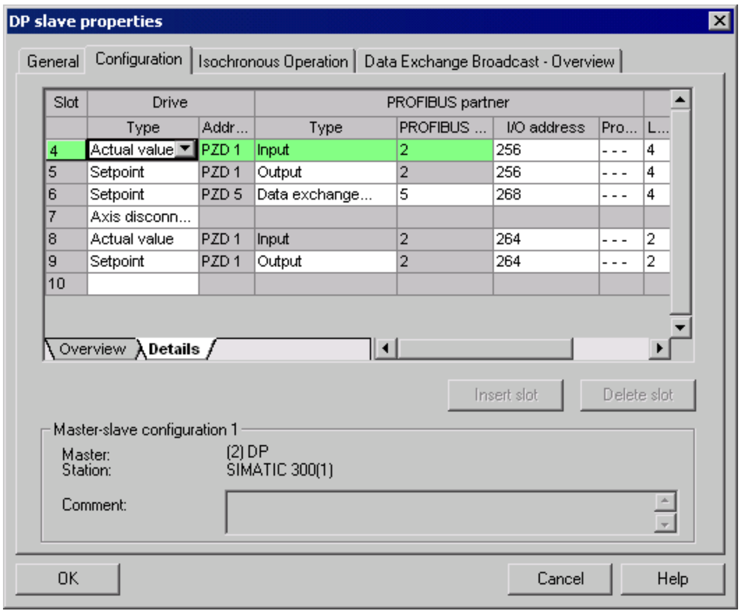


Figure 10-35 Details after the creation of the slave-to-slave communication link

11. You need to adjust the telegrams accordingly for each drive object of the selected drive device which is to actively participate in slave-to-slave communication.

Commissioning in STARTER

Slave-to-slave communication is configured in HWConfig and is simply an extension of an existing telegram. Telegrams can be extended in STARTER (p0922 = 999).

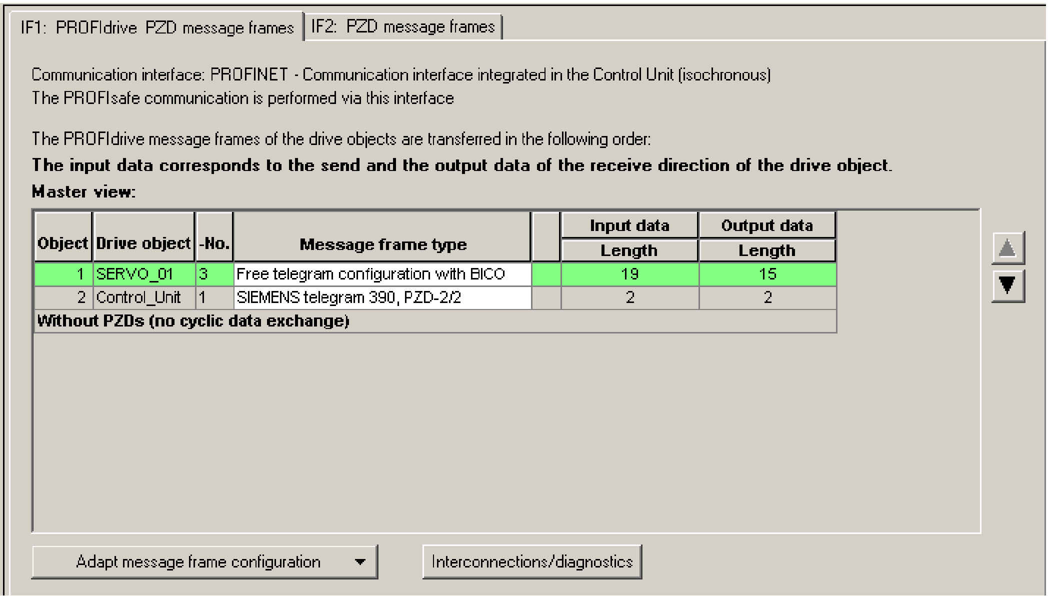


Figure 10-36 Configuring the slave-to-slave communication links in STARTER

To complete the configuration of slave-to-slave communication for the drive objects, the telegram portions of the drive objects in STARTER must be matched to those in the HW Config and extended. The configuration is made centrally via the configuration of the respective drive device.

Procedure

1. In the overview for the PROFIBUS telegram, you can access the telegram portions of the drive objects, here SERVO_01. Select the telegram type "Free telegram configuration with BICO" 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 consists of the telegram portion of the master and the slave-to-slave communication data.
3. Then, in the telegram selection, set the telegram portion to the "Standard telegram" (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.

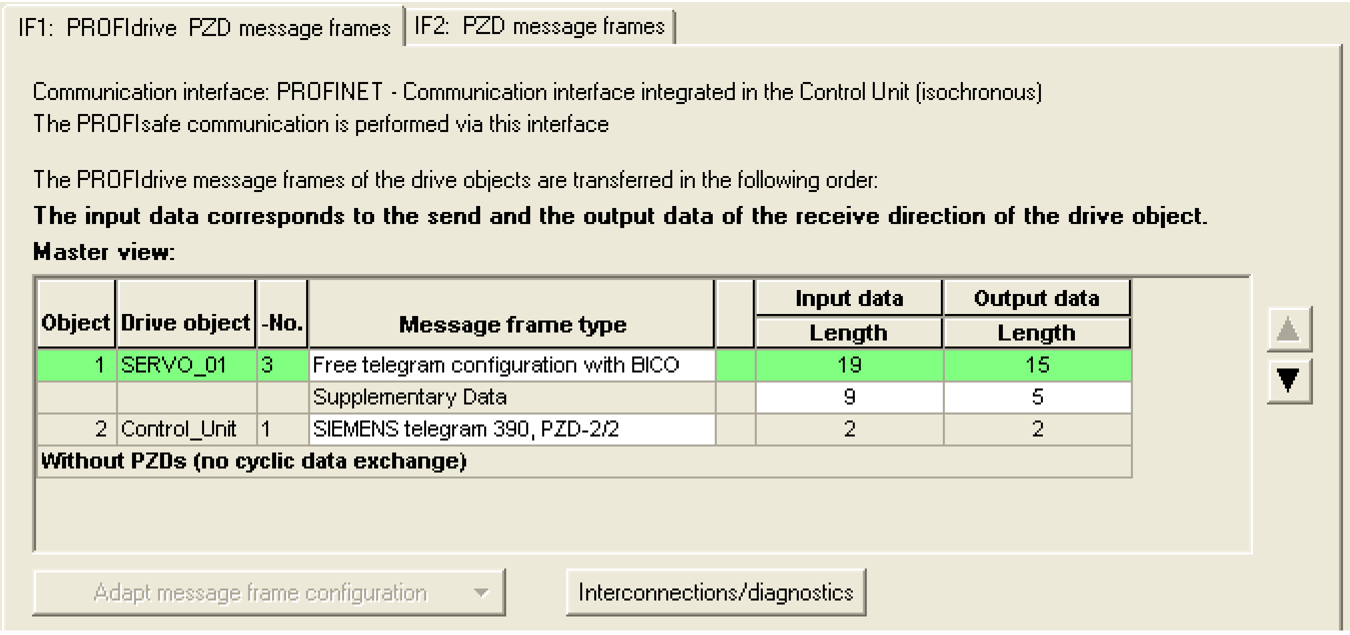


Figure 10-37 Display of the telegram extension

By selecting the item "Communication → PROFIBUS" for the drive object "SERVO_01" in the project navigator, you get the structure of the PROFIBUS telegram in the receive and send direction.
The telegram extension from PZD5 is the portion for slave-to-slave communication.

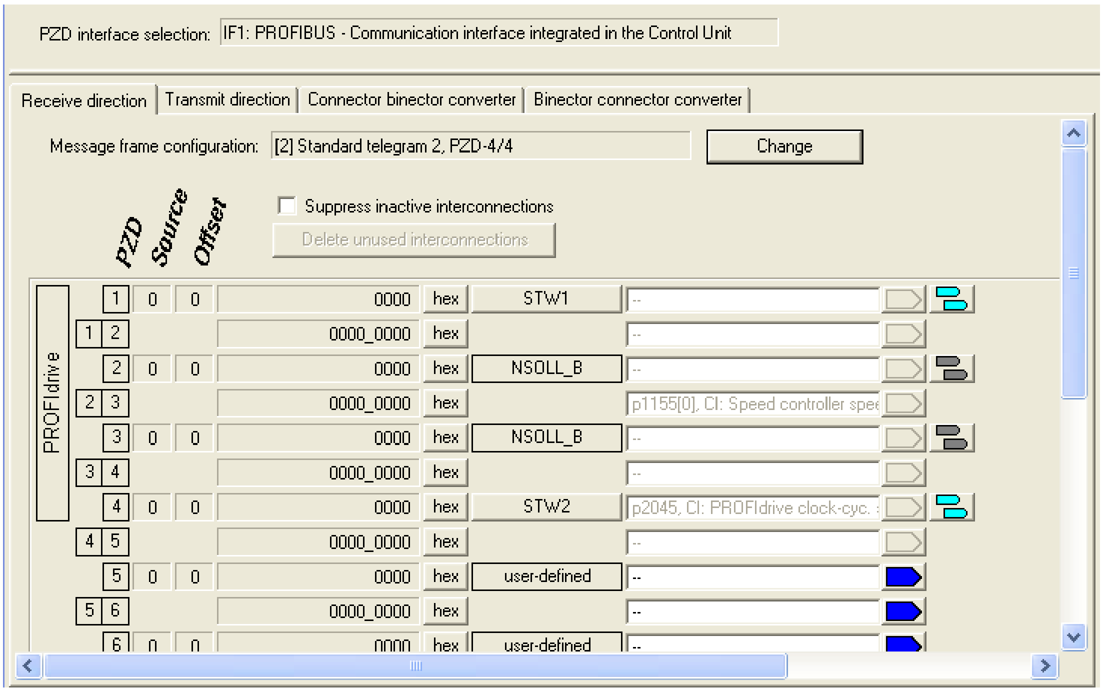


Figure 10-38 Configuring the PROFIBUS slave-to-slave communication in STARTER

To connect the drive objects to the process data which is received via slave-to-slave communication, you also need to connect the appropriate connectors to the corresponding signal sinks. A list for the connector shows all signals that are available for interconnection.

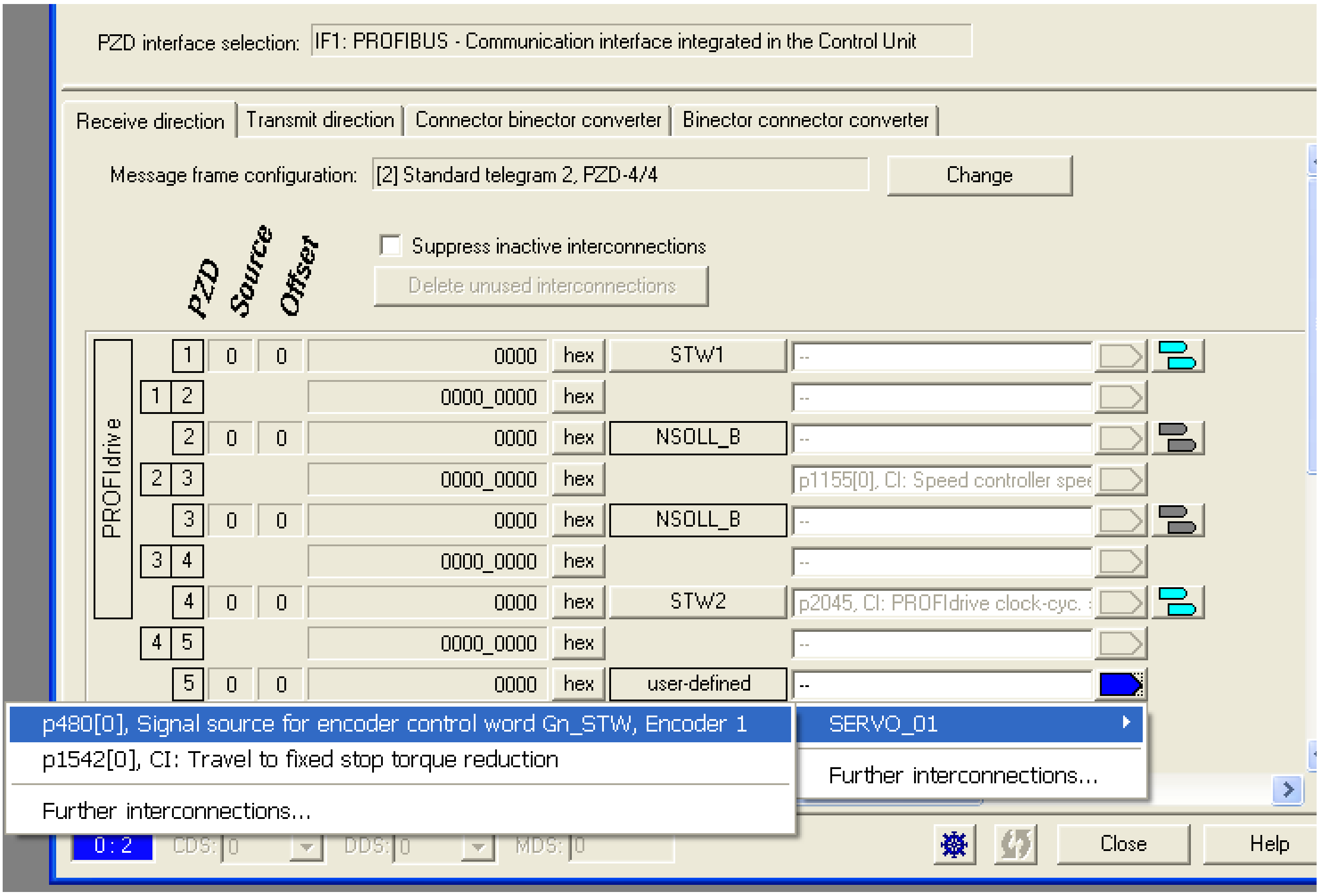


Figure 10-39 Combinding the PZDs for slave-to-slave communication with external signals

10.2.4.5 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 (A01920, F01910). 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, send 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.

Faults and alarms with PROFIBUS slave-to-slave communication

The alarm A01945 signals that the connection to a least one Publisher of the drive device is missing or has failed. Any interruption to the Publisher is also reported by the fault F01946 at the affected drive object. A failure of the Publisher will therefore only affect the respective drive objects.

More detailed information on the messages can be found in

References: SINAMICS S120/150 List Manual

10.3 Communication 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.

Signal processing in real time and determinism is important in industrial networks. PROFINET IO satisfies these requirements.

The following standards ensure open, multi-vendor systems:

- International standard IEC 61158

PROFINET IO is optimized for high-speed, time-critical data transfers at field level.

PROFINET IO

Within the context of Totally Integrated Automation (TIA), PROFINET IO is the systematic development of the following systems:

- PROFIBUS DP, the established field bus, and
- Industrial Ethernet, the communications bus for the cell level.

Experience gained from both systems was and is being integrated into PROFINET IO. As an Ethernet-based automation standard defined by PROFIBUS International (PROFIBUS user organization), PROFINET IO is a manufacturer-independent communication and engineering model.

PROFINET IO defines every aspect of the data exchange between IO controllers (devices with so-called "master functionality" and the IO devices (those with so-called "slave functionality") as well as parameterization and diagnostic processes. An IO system is configured by virtually the same method used for PROFIBUS.

A PROFINET IO system is assembled from the following devices:

- The IO controller controls automation tasks.
- An IO device is controlled and monitored by an IO controller. An IO device consists of several modules and submodules.
- IO supervisor is an engineering tool typically based on a PC that is used to parameterize and diagnose individual IO devices (drive units).

IO device: Drive units with PROFINET interface

- SINAMICS S120 with CU320-2 DP and inserted CBE20
- SINAMICS S120 with CU320-2 PN
- SINAMICS S120 with CU310-2 PN

Cycle communication using PROFINET IO with IRT or using RT is possible on all drive units equipped with a PROFINET interface. This means that problem-free communication using other standard protocols is guaranteed within the same network.

Note

PROFINET for drive technology is standardized and described in the following document:

PROFIBUS Profile PROFIdrive – Profile Drive Technology

Version V4.1, May 2006,

PROFIBUS User Organization e. V.

Haid-und-Neu-Straße 7,

D-76131 Karlsruhe

http://www.profibus.com,

Order no. 3.172, spec. Chapter 6

- IEC 61800-7

CAUTION
The cyclic PZD channel for PROFIBUS DP is initially deactivated when the CBE20 is plugged in and for the CU320 2 DP. It can however be activated again with parameter (p8839) (see chapter "Parallel operation of communication interfaces").

10.3.1.2 Real-time (RT) and isochronous real-time (IRT) communication

Real-time communication

When communication takes place via TCP/IP, the resultant transmission times may be too long and non-deterministic to meet production automation requirements. When communicating time-critical IO user data, PROFINET IO therefore uses its own real-time channel, rather than TCP/IP.

Determinism

Determinism means that a system will react in a predictable ("deterministic") manner. With PROFINET IO, it is possible to precisely determine (predict) transmission times.

PROFINET IO with RT (Real Time)

Real time means that a system processes external events over a defined period.

Process data and alarms are always transmitted in real time (RT) within the PROFINET IO system. RT communication provides the basis for data exchange with PROFINET IO. Real-time data are treated as a higher priority than TCP(UDP)/IP data. Transmission of time-critical data takes place at guaranteed time intervals.

PROFINET IO with IRT (Isochronous Real Time)

Isochronous Real Time Ethernet: Real time property 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 between the IO controller and IO device (drive unit). This is also known as time-scheduled communication whereby knowledge about the network structure is utilized. IRT requires special network components that support planned data transfer.

Cycle times of minimum 500 μs and a jitter accuracy of less than 1 μs can be achieved when this transmission method is implemented.

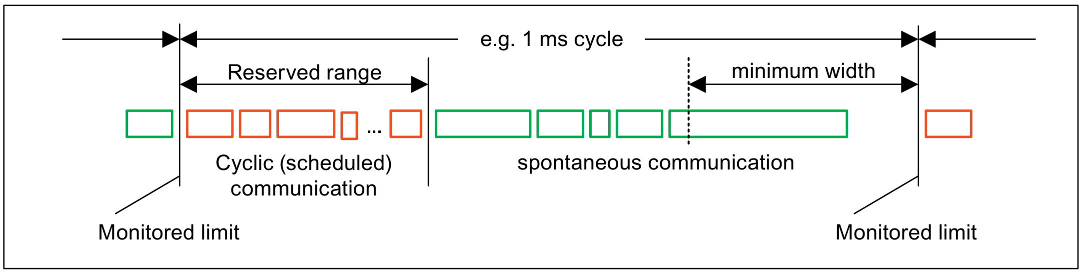


Figure 10-40 Bandwidth distribution/reservation, PROFINET IO

10.3.1.3 Addresses

MAC address

Every Ethernet and PROFINET interface 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 printed on a label (CBE20) or specified on the type plate (CU320-2PN and CU310-2PN), e.g.: 08-00-06-6B-80-C0.

The SINAMICS S120 Control Units CU320-2PN or CU310-2PN have three onboard interfaces:

- One Ethernet interface
- Two PROFINET interfaces

The MAC address of the onboard Ethernet interface is stamped on the type plate. The MAC address then comes from the so-called PN device. This is the switch, which routes data between the two PROFINET interfaces. The MAC addresses of the onboard PROFINET interfaces are then received continuously. A CU320-2PN or CU310-2PN has a total of 4 MAC addresses.

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. In this case, the IP address is not stored permanently. The IP address entry is lost after POWER ON/OFF. If the IP address is to be stored in a non-volatile memory, the address must be assigned using the Primary Setup Tool (PST).

This can also be performed with HW Config of 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 (IP address) from your network administrator.

Device name (NameOfStation)

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 stored retentively using either STARTER, the Primary Setup Tool (PST) or with HW Config of STEP 7.

Note

You can enter the address data for the internal PROFINET ports X150 P1 and P2 in STARTER in the expert list using parameters p8920, p8921, p8922 and p8923.

You can enter the address data for the ports of the optional CBE20 module in STARTER in the expert list using parameters p8940, p8941, p8942 and p8943.

Replacing the Control Unit CU320-2DP/PN and the CU310-2PN (IO device)

If the IP address and device name are stored in non-volatile memory, these data are also forwarded with the memory card of the Control Unit.

If a complete Control Unit needs to be replaced due to a device or module defect, the new Control Unit automatically parameterizes and configures using the data on the memory card. Following this, cyclic exchange of user data are restarted. The memory card allows module exchange without an IO supervisor when a fault occurs in a PROFINET device.

10.3.1.4 Data transfer

Properties

The PROFINET interface on a drive unit supports the simultaneous operation of:

- IRT – isochronous real-time Ethernet
- RT – real-time Ethernet
- Standard Ethernet services (TCP/IP, LLDP, UDP and DCP)

PROFIdrive telegram for cyclic data transmission, acyclic 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 unit. These acyclic services can be utilized by the IO supervisor or IO controller.

Sequence of drive objects in cyclic data transmission

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).

10.3.1.5 PROFINET: Address parameters

Overview of important parameters (see the SINAMICS S120/S150 List Manual)

For integrated PROFINET interface

- p8920[0...239] PN Name of station
- p8921[0...3] PN IP Address of station
- p8922[0...3] PN Default gateway of station
- p8923[0...3] PN Subnet mask of station
- p8925 PN interface configuration
- p8929 PN Number of remote controllers
- r8930[0...239] PN Name of station active
- r8931[0...3] PN IP Address of station active
- r8932[0...3] PN Default gateway of station active

- r8933[0...3] PN Subnet mask of station active
- r8935[0...5] PN MAC address of station
- r8936[0...1] PN State of the cyclical connections
- r8937[0...5] PN Diagnostics

For the integrated PROFINET interface

- p8920[0...239] PN Name of Station
- p8921[0...3] PN IP Address of Station
- p8922[0...3] PN Default Gateway of Station
- p8923[0...3] PN Subnet Mask of Station
- p8925 PN interfaces configuration
- p8929 PN Remote Controller number
- r8930[0...239] PN Name of Station active
- r8931[0...3] PN IP Address of Station active
- r8932[0...3] PN Default Gateway of Station active
- r8933[0...3] PN Subnet Mask of Station active
- r8935[0...5] PN MAC Address of Station
- r8936[0...1] PN State of the cyclic connections
- r8937[0...5] PN diagnostics

For CBE20

- p8829 CBE20 Remote Controller number
- p8940 CBE20 Name of Station
- p8941 CBE20 IP Address of Station
- p8942 CBE20 Default Gateway of Station
- p8943 CBE20 Subnet Mask of Station
- p8944 CBE20 DHCP Mode
- p8945 CBE20 interfaces configuration
- r8950 CBE20 Name of Station active
- r8951 CBE20 IP Address of Station active
- r8952 CBE20 Default Gateway of Station active
- r8953 CBE20 Subnet Mask of Station active
- r8954 CBE20 DHCP Mode active
- r8955 CBE20 MAC Address of Station
- r8959 CBE20 DAP ID

10.3.2 Hardware setup

10.3.2.1 Configuring SINAMICS drives with PROFINET

PROFINET interface for CU310-2PN and CU320-2 DP/PN

The Control Units CU310-2PN and CU320-2PN have an integrated PROFINET interface with 2 ports.

The CBE20 option board can be additionally inserted in the option slot of the CU320-2 DP/PN. The CBE20 is equipped with a PROFINET interface with 4 ports that can be used to connect the PROFINET subnet.

NOTICE
PROFINET interfaces of the CU320-2PN with CBE20
The integrated PROFINET interface of the CU320-2PN is independent of the optionally inserted CBE20 module. The two PROFINET interfaces are not connected with each other. Routing is not provided between the two PROFINET interfaces.

Note

The ports must not be interconnected in such a way that a ring topology is created.

References

- The integration of a SINAMICS S120 with CU310-2PN/CU320-2DP/PN in a PROFINET IO system is described in detail in the System Manual "SIMOTION SCOUT Communication".
- For an example of how to link a SINAMICS S120 to a SIMATIC S7 via PROFINET IO, please refer to the FAQ "PROFINET IO communication between an S7-CPU and SINAMICS S120" on the Internet.
- For a description of the CBE20 and how you can use it in the drive, please refer to document: SINAMICS S120 Equipment Manual Control Units.
- The PROFINET interface on the CU310-2PN unit is described in the reference: SINAMICS S120 Manual for AC Drives.

Clock generation via PROFINET IO (isochronous communication)

The SINAMICS S120 with CU310-2PN/CU320-2DP/PN can only assume the role of a synchronization slave within a PROFINET IO network.

The following applies to a CU310-2PN / CU320-2DP/PN with CBE20 module:

- Transmission type IRT, IO device is synchronization slave and isochronous, send clock cycle is applied to bus: Control Unit synchronizes with the bus and the send clock cycle becomes the cycle for the Control Unit.
- RT or IRT (option drive unit "not isochronous") has been configured. The SINAMICS does not use a local clock (clock configured in SINAMICS).

The following applies to a CU320-2DP/PN for which a CBE20 is configured, but does not exist:

- SINAMICS uses the local clock (clock configured in SINAMICS); if there is no data exchange via PROFINET, alarm A01487 is output ("Topology: Comparison option slot components missing in the actual topology").
  Access via PROFINET is not available.

Telegrams

PROFIdrive telegrams are available for implementing cyclic communication via PROFINET IO (see section "Communication according to PROFIdrive", cyclic communication).

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 with CU310-2 PN and a CU320-2DP/PN with inserted 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 CU310-2PN or SINAMICS S120 with CU320-2DP with inserted 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 2 Hz, green/orange or red/orange) on the CU310-2PN/CU320-2DP.

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.

Connect a PG/PC with STARTER commissioning tool

There are various connection options in order to commission a Control Unit with a PG/PC using the STARTER commissioning tool. The Ethernet interface X127, which is integrated in all SINAMICS S120 Control Units from firmware 4.x, is specifically intended for commissioning and diagnostics. You require a crosslink cable to establish the connection between the PG/PC and the Control Unit.

Communication with the controls can be established via PROFIBUS or PROFINET, depending on the selected integrated interfaces. Examples of possible topologies are provided in the diagram below:

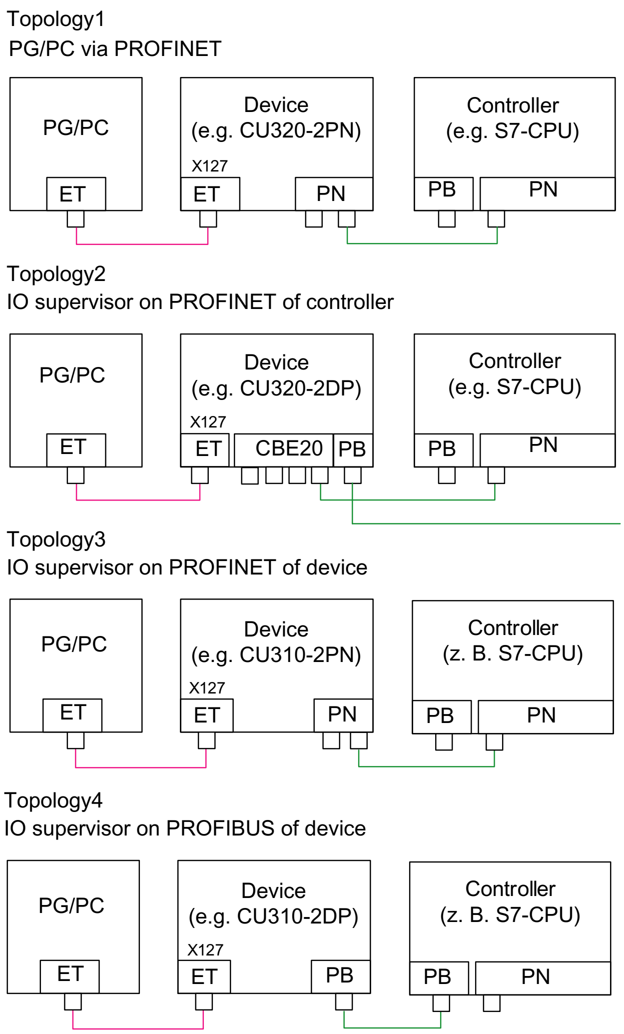


Figure 10-41 Topology PROFINET with PG/PC,

Commissioning using the STARTER tool via the integrated Ethernet interface.

10.3.3 RT classes for PROFINET IO

PROFINET IO is a scalable realtime communication system based on Ethernet technology. The scalable approach is expressed with three realtime classes.

RT

RT communication is based on standard Ethernet. The data are transferred via prioritized Ethernet telegrams. Because standard Ethernet does not support any synchronization mechanisms, isochronous operation is not possible with PROFINET IO with RT! The real-time capability is comparable with the present PROFIBUS DP solutions with 12 MBaud, i.e. a sufficiently large bandwidth portion is available for the parallel transmission of IT services on the same line.

The real update cycle in which cyclic data are exchanged depends on the bus load, the devices used and the quantity framework of the I/O data. The update cycle is a multiple of the send cycle.

IRT

Two options are available with this RT class:

- IRT "high flexibility"
- IRT "high performance".

Software preconditions for configuring IRT:

- STEP 7 5.4 SP4 (HW Config)

> **Note**
>
> For further information about configuring the PROFINET interface for the I/O controller and I/O device, please refer to the following document: SIMOTION SCOUT Communication System Manual.

IRT "high flexibility"

The telegrams are sent cyclically in a deterministic cycle (Isochronous Real Time). The telegrams are exchanged in a bandwidth reserved by the hardware. One IRT time interval and one standard Ethernet time interval are created for each cycle.

> **Note**
>
> IRT "high flexibility" cannot be used for isochronous applications.

IRT "high performance"

In addition to the bandwidth reservation, the telegram 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 with respect to IRT "high flexibility".

In addition to the isochronous data transfer provided by IRT, even the application itself (position control cycle, IPO cycle) can be isochronous in the devices. This is an essential requirement for closed-loop axis control and synchronization via the bus. 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.

The RT classes IRT "high flexibility" and IRT "high performance" can be selected as options in the synchronization settings configuration area of HW Config. In the description below, both these classes are simply referred to as "IRT".

In contrast to standard Ethernet and PROFINET IO with RT, the telegrams for PROFINET IO with IRT are transmitted according to a schedule.

Comparison between RT and IRT

Table 10- 52 Comparison between RT and IRT

RT class	RT	IRT "high flexibility"	IRT "high performance"
Transfer mode	Switching based on the MAC address; prioritization of the RT telegrams possible using Ethernet-Prio (VLAN tag)	Switching using the MAC address; bandwidth reservation by reserving an IRT "high flexibility" interval in which only IRT "high flexibility" frames are transferred but, for example, no TCP/IP frames	Path-based switching according to a topology-based plan; no transmission of TCP/IP frames and IRT "high flexibility" frames in the IRT "high performance" interval.
Isochronous application in the IO controller	No	No	Yes
Determinism	Variance of the transmission duration by started TCP/IP telegrams	Guaranteed transmission of the IRT "high flexibility" telegrams in the current cycle by the reserved bandwidth.	Exactly planned transfer; times for transmission and receiving are guaranteed for any topologies.
Reload the network configuration after a change	Not relevant	Only when the size of the IRT "high flexibility" interval needs to be modified (reservation of position is possible)	Whenever the topology or the communication relationships change
Maximum switching depth (number of switches in one line)	10 at 1 ms	61	32
For possible send cycles, see subitem "Send cycles and update cycles for RT classes" in table "Adjustable send cycles and update cycles"			

Set the RT class

The RT class is set by means of the properties of the controller interface of the IO controller. If RT class IRT "high performance" is set, it is not possible to operate any IRT "high flexibility" devices on the IO controller and vice versa. IO devices with RT can always be operated, regardless of the IRT class setting.

You can set the RT class in the HW Config for the associated PROFINET device.

1. In HW Config, double-click on item PROFINET interface in the module.

   The "Properties" dialog box is opened.
2. Select the RT class under RT class on the "Synchronization" tab.
3. Once you have selected "IRT", you can also choose between option "high flexibility" and "high performance".
4. Confirm with "OK".

Synchronization domain

The sum of all devices to be synchronized form a synchronization domain. The whole domain must be set to a single, specific RT class (real-time class) for synchronization, Different synchronization domains can communicate with one another via RT.

For IRT, all IO devices and IO controllers must be synchronized with a common synchronization master.

RT allows an IO controller to communicate with a drive unit outside a synchronization domain or "through" another synchronization domain. As of version 5.4 SP1, STEP 7 supports multiple synchronization domains on a single Ethernet subnet.

Example:

- Synchronization domain IRT : SIMOTION 2 with SINAMICS
- SINAMICS, which is assigned to the IO system of SIMOTION 1, is arranged in the topology in such a way that its RT communication must be conducted through the IRT synchronization domain.

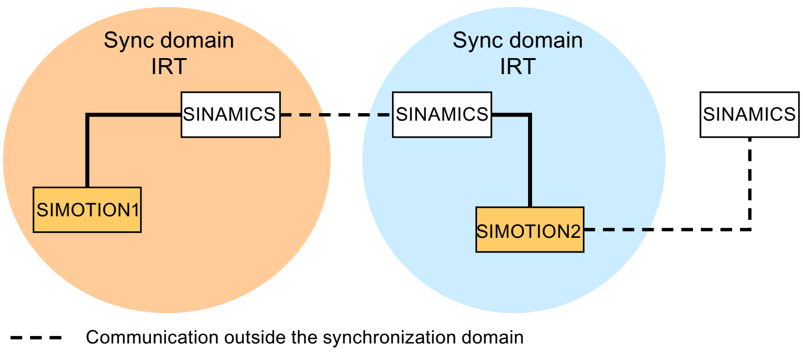


Figure 10-42 RT communication across the limits of synchronization domains

Update cycles and send cycles for RT classes

Definition of update time/send cycle:
If we take a single IO device in the PROFINET IO system as an example, this device has been supplied with new data (outputs) by the IO controller and has transferred new data (inputs) to the IO controller within the update time. The send cycle is the shortest possible update cycle.

All cyclic data are transferred within the send cycle. The actual send cycle that can be set depends on various factors:

- Bus load
- Type of devices used
- Computing capacity available in the IO controller
- Supported send clocks in the participating PROFINET devices of a synchronization domain A typical send cycle is e.g. 1 ms

The table below specifies the reduction ratios which can be set between the send cycle and the update times for IRT "high performance", IRT "high flexibility", and RT.

Table 10- 53 Settable send cycles and update cycles

Send cycle		Reduction ratio between update and send cycles	
		RT IRT "high flexibility" 4)	IRT "high performance"
Range "even" 1)	250, 500, 1000 µs	1,2,4,8,16,32,64,128,256,512	1,2,4,8,16 2)
	2000 µs	1,2,4,8,16,32,64,128,256	1,2,4,8,16 2)
	4000 µs	1,2,4,8,16,32,64,128	1,2,4,8,16 2)
Range "uneven" 3)	375, 625, 750, 875, 1125, 1250 µs ... 3875 µs (increment 125 µs)	not supported 5)	1

Note

There is no intersection between the send cycles for the "even" and "uneven" ranges!

Explanations for the above table:

1) It is only possible to set send cycles from the "even" range when IO devices with RT class "RT" are assigned to a synchronization domain. Likewise, only the reduction ratios from the "even" range can be set for a send cycle setting from the "even" range.

2) It is generally only possible to set a reduction ratio of 1:1 between the update time and send cycle for IO devices (ET200S IM151-3 PN HS, SINAMICS S) which are operated in isochronous mode. In this case, the update cycle mode must always be set to "fixed factor" (under I/O device properties, "IO cycle" tab, "Mode" pulldown menu). This means that STEP 7 will not automatically adjust the update cycle and thus the update cycle will always correspond to the send cycle.

3) The send cycles from the "uneven" range can be set only if a synchronization domain does not include any IO devices with RT class "RT". Likewise, only the reduction ratios from the "uneven" range can be set for a send cycle setting from the "uneven" range.

4) Isochronous operation is not compatible with IRT "high flexibility".

5) Uneven send cycles can be used only if the IO systems assigned to the synchronization domain do not include any RT or IRT "high flexibility" devices.

Furthermore, the send cycles which can actually be set are determined by the intersection of the send cycles supported by all the devices in the synchronization domain.

The reduction ratio between the update cycle of an IO device and the send cycle is set in the "Properties" of the PROFINET interface for the relevant device.

Send cycles for SINAMICS drive units

A SINAMICS drive unit with PROFINET interface which supports IRT permits send cycle settings of between 0.5 ms and 4.0 ms in a 250 μs time frame.

Topology rules

Topology rules for RT

- A topology can be, but need not be configured for RT. If a topology has been configured, the devices must be wired in accordance with the topology.
- Otherwise, the wiring between devices is entirely optional.

Topology rules for IRT

- Mixed operation is not supported by STEP 7 V5.4 SP4, i.e. IRT "high performance" cannot be combined with IRT "high flexibility" in the same synchronization domain.
- A synchronization domain with IRT "high performance" can contain a maximum of one IRT "high performance" island. "Island" means that the devices must be interconnected to match the configured topology. A synchronization master must be positioned in the relevant island.
- IRT "high flexibility" is subject to the same topology rules as IRT "high performance", the only exception being that a topology does not need to be configured. However, if a topology has been configured, the devices must be wired to match the topology.

Device selection in HW Config

Hardware catalog:
The drive unit from the appropriate unit family entry in the hardware catalog must be configured. For the RT class IRT, these are all entries with the end identification ...PN-V2.2.
GSD:
The names of GSD files for devices which contain IRT end in …PN-V2.2.

10.3.4 Selecting the CBE20 firmware version

Only one of the possible PROFINET versions of the CBE20 can be loaded into the Control Unit as firmware. All firmware files provided for different PROFINET variants are stored on the Control Unit's memory card.

The PROFINET versions of the CBE20 required are each stored in a separate UFW file on the memory card. The required file is selected using parameter p8835. POWER ON must then be executed to activate the change in variant. During the subsequent system boot, the corresponding UFW file is loaded.

Table 10- 54 UFW files and selected in the pointer file

UFW file and folder on memory card	Functionality	Pointer file content
/SIEMENS/SINAMICS/CODE/CB/CBE20_1.UFW	PROFINET device	CBE20=1
/SIEMENS/SINAMICS/CODE/CB/CBE20_2.UFW	PN_Gate	CBE20=2
/SIEMENS/SINAMICS/CODE/CB/CBE20_3.UFW	SINAMICS Link	CBE20=3
/OEM/SINAMICS/CODE/CB/CBE20.UFW	Customized	CBE20=99

The factory setting for the parameter is p8835 = 1 (PROFINET device).

Setting values of of p8835:
1 = PROFINET device
2 = PN Gate
3 = SINAMICS Link
99 = customer-specific

The versions can be switched between by modifying the parameter. A POWER ON must then be performed to activate the change.

Identification of the firmware version:
The loaded firmware version of the PROFINET interface can be clearly identified using the COMM BOARD diagnostics channel, parameter r8858.

10.3.5 PROFINET GSD

To integrate a SINAMICS S into a PROFINET network, SINAMICS S120 supports two different PROFINET GSD versions (device master file):

- PROFINET GSD for compact modules
- PROFINET GSD with subslot configuring

PROFINET GSD for compact modules

With the PROFINET GSD known up until now, you can precisely configure a complete module, which corresponds to a drive object. Each of these modules involves two subslots: The Parameter Access Point (PAP) and a PZD telegram for transferring process data. You can identify the PROFINET GSD for compact modules by the following structure of the file name:
GSDML-V2.2-Siemens-Sinamics_S_CU3x0-20090101.xml (example)

PROFINET GSD with subslot configuring

PROFINET GSD with subslot configuring allows standard telegrams to be combined with a PROFIsafe telegram - and if required, a telegram extension. Each of the modules has four subslots: The Module Access Point (MAP), the PROFIsafe telegram, a PZD telegram to transfer process data and where relevant, a telegram for PZD extensions. You can identify the PROFINET GSD with subslot configuring by the following structure of the file name:
GSDML-V2.2-Siemens-Sinamics_S_CU3x0-20090101.xml (example)

The following table shows the possible submodules depending on the particular Drive Object.

Table 10- 55 Submodules depending on the particular Drive Object

Module	Subslot 1 MAP	Subslot 2 PROFIsafe	Subslot 3 PZD telegram	Subslot 4 PZD extension	Max. number of PZD
Servo	MAP	Telegram 30	Telegrams: 1...220 free PZD-16/16	PZD-2/2, -2/4, -2/6	20/28
Vector	MAP	Telegram 30	Telegrams: 1...352 free PZD-16/16, 32/32	PZD-2/2, -2/4, -2/6	32/32
Infeed	MAP	Reserved	Telegrams: 370 free PZD-4/4	PZD-2/2, -2/4, -2/6	5/8
Encoder	MAP	Reserved	Telegrams: 81, 82, 83 free PZD-4/4	PZD-2/2, -2/4, -2/6	4/12
TB30, TM31, TM15 DI_DO, TM120	MAP	Reserved	Telegrams: no free PZD-4/4	Reserved	5/5
TM41	MAP	Reserved	Telegrams: 3 free PZD-4/4, 16/16	Reserved	20/28
Control Unit	MAP	Reserved	Telegrams: 390, 391, 392, 393, 394, free PZD-4/4	Reserved	4/21
TM15/TM17	Not supported.				

Note:

The telegrams in subslots 2, 3 and 4 can be freely configured, i.e. they can also remain empty.

Configuring

Configuring the three versions is only briefly sketched out in the following:

- Compact modules (as before):
  - Insert a module "DO Servo/Vector/...".
  - Assign the I/O addresses.
- Subslot configuring without new functionality:
  - Insert a module "DO with telegram xyz".
  - Insert a submodule "PZD telegram xyz".
  - Assign the I/O addresses.
- Subslot configuring with optional PROFIsafe and PZD extension:
  - Insert a module "DO Servo/Vector/...".
  - Insert the optional submodule "PROFIsafe telegram 30".
  - Insert a submodule "PZD telegram xyz".
  - Insert the optional submodule "PZD extension".
  - Assign the I/O addresses for the module and the submodules.

You will find a detailed description for processing a GSD file in HW Config in the SIMATIC documentation.

10.3.6 Motion Control with PROFINET

Motion Control/Isochronous drive link with PROFINET

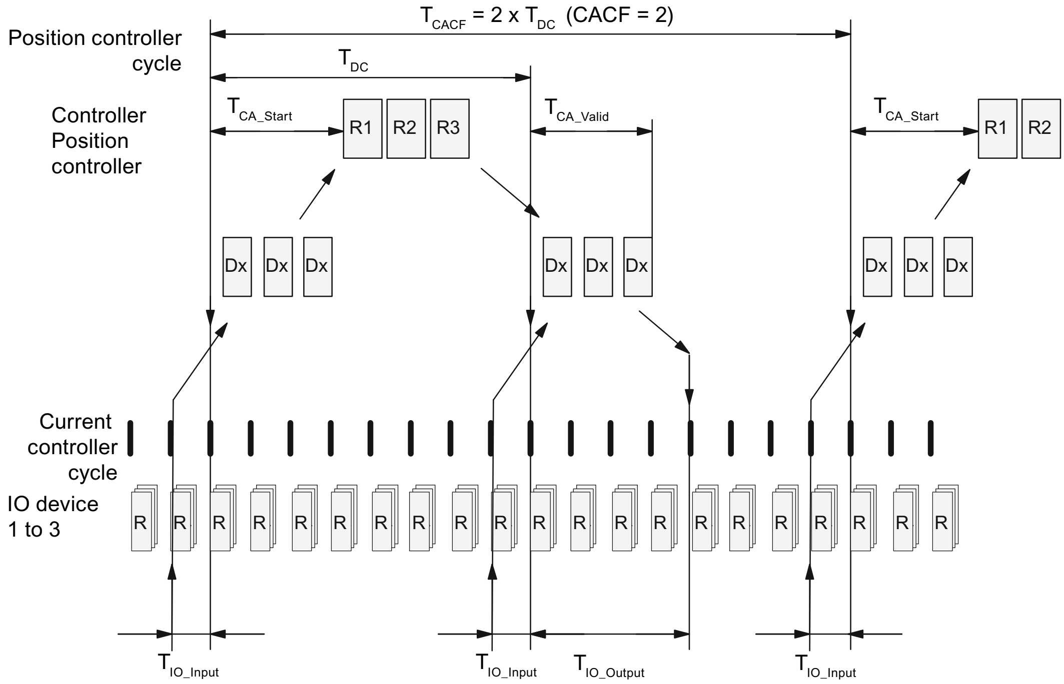


Figure 10-43 Motion Control/Isochronous drive link with PROFINET, optimized cycle with CACF = 2

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- 56 Time settings and meanings

Name	Limit value	Description
T_{DC_BASE}	-	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 ≤ 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}		Time base for T_{IO_Input}, T_{IO_Output} T_{IO_BASE} =T_IO_BASE • 1 ns= 125000 • 1 ns = 125 µs
T_{IO_Input}	T_IO_InputMIN ≤ T_IO_Input < T_DC	Time of actual value acquisition This is the time at which 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_Output_valid + 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
	T_IO_Output_valid	The time after which the new control output data (setpoints) are available for the drive object.
Dx		Data_Exchange This service is used to implement user data exchange between the IO controller and IO device 1 - n.
R or Rx		Computation time, current or position controller

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.
- 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. HWConfig 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 as the IO controller sign of life.
  - The IO controller sign-of-life counter is incremented in 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
  - ZSW2.12 ... ZSW2.15 are used as the IO device sign of life.
  - The IO device sign-of-life counter is incremented in each DC cycle (T_{DC}).

10.3.7 PROFINET with 2 controllers

10.3.7.1 Settings for SINAMICS S

SINAMICS S120 allows an automation control (A-CPU) and a safety control (F-CPU) to be simultaneously connected to a Control Unit via PROFINET.

SINAMICS S for this communication only supports the standard telegram 30 of the safety control.

The following diagram shows the principle structure of this connection version using a CU320-2PN or CU310-2PN as an example.

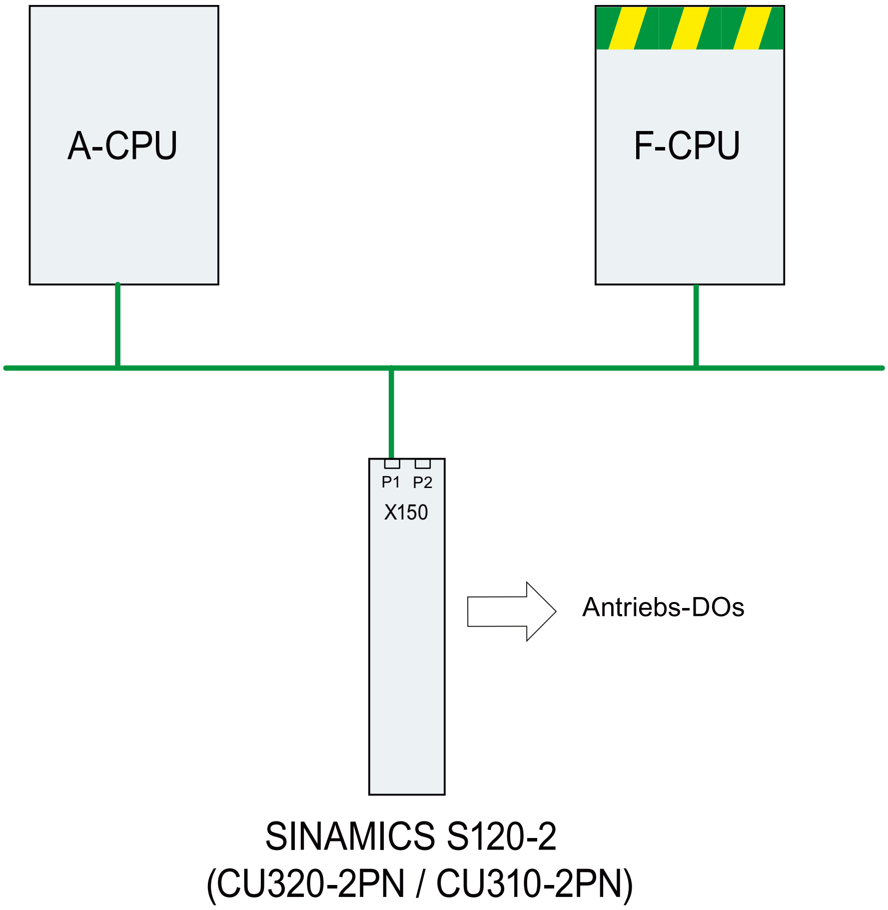


Figure 10-44 PROFINET topology overview

Example

The following diagram shows a configuration example of a SINAMICS S120 with 3 axes. The A-CPU sends standard telegram 105 for axis 1 and standard telegram 102 for axis 2. The F-CPU sends PROFIsafe telegram 30 for axis 1 and axis 3.

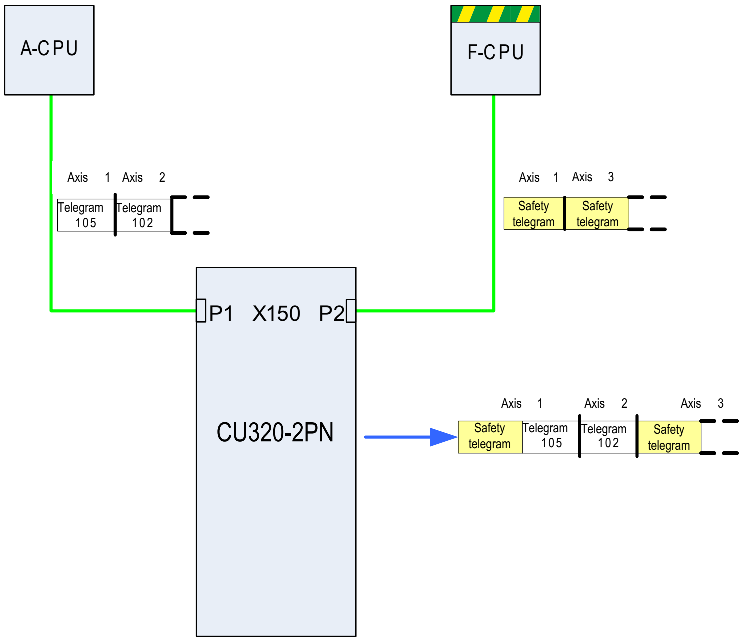


Figure 10-45 Example, communication sequence

Configuration

To configure the connection, proceed as follows:

- Using parameter p8929 = 2, define that data from 2 control systems should be received via the PROFINET interface.
- Using parameters p9601.3 = p9801.3 = 1, enable PROFIsafe for axes 1 and 2.
- Configure the PROFINET communication in **HW Config** (see Section "Configuring the controls").
- When the system boots, using p8929 = 2, SINAMICS S identifies that PROFINET telegrams are expected from 2 control systems, and establishes the communication corresponding to the configuration in **HW Config**.

Note

When booting, SINAMICS S first requires the configuration data of A-CPU and then establishes a cyclic communication to this CPU taking into account the PROFIsafe telegrams expected.

As soon as SINAMICS S has received the configuration data of the F-CPU, then cyclic communication is also established here and PROFIsafe telegrams are taken into consideration.

CAUTION

CPU failure

Communication with the other CPU is not interrupted if a CPU fails. Communication via the two channels functions independently of one another.

Communication with the other CPU is not interrupted and continues to operate undisturbed if a CPU fails. Error messages are output regarding the components that have failed. Resolve the fault and acknowledge the messages; communication to the CPU that failed is then automatically restored.

10.3.7.2 Configuring the open-loop controls

In **HW Config** you have two options when configuring the two controls A-CPU and F-CPU: You configure

- both controls, utilizing the shared device function, in a common project or
- each control in a separate project.

Note

- Detailed information on configuring with **HW Config** is provided in the STEP7 documentation.
- For SINAMICS devices here you **must** utilize configuring via GSDML.

Both controls in a common project

- Both controls are in a common project:

Figure 10-46 Both CPUs in one STEP7 project

- Attach a SINAMICS PROFINET device with GSDML in the A-CPU. Configure the subslots according to the data to be transferred.

Note

You must ensure that the configuration of the A-CPU and the F-CPU correspond to the required communication behavior.

- You can see the result for our particular example in the following diagram:

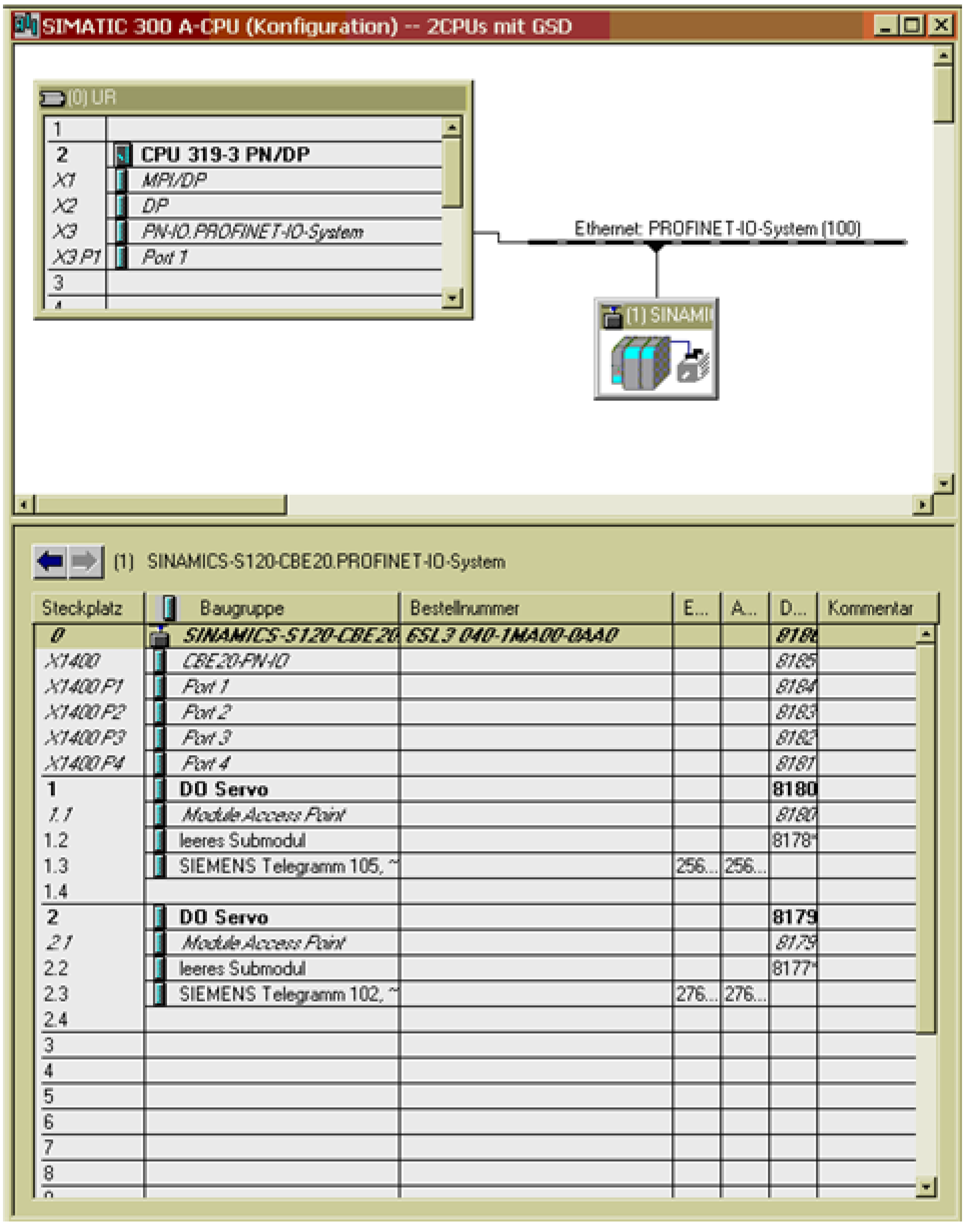


Figure 10-47 One project: Configuring the A-CPU

- Copy the SINAMICS PROFINET device and attach it to the F-CPU as shared device. Configure a DO without data, and then 2 servo DOs, which only contain the subslot for PROFIsafe telegram 30. You can see the result for our particular example in the following diagram:

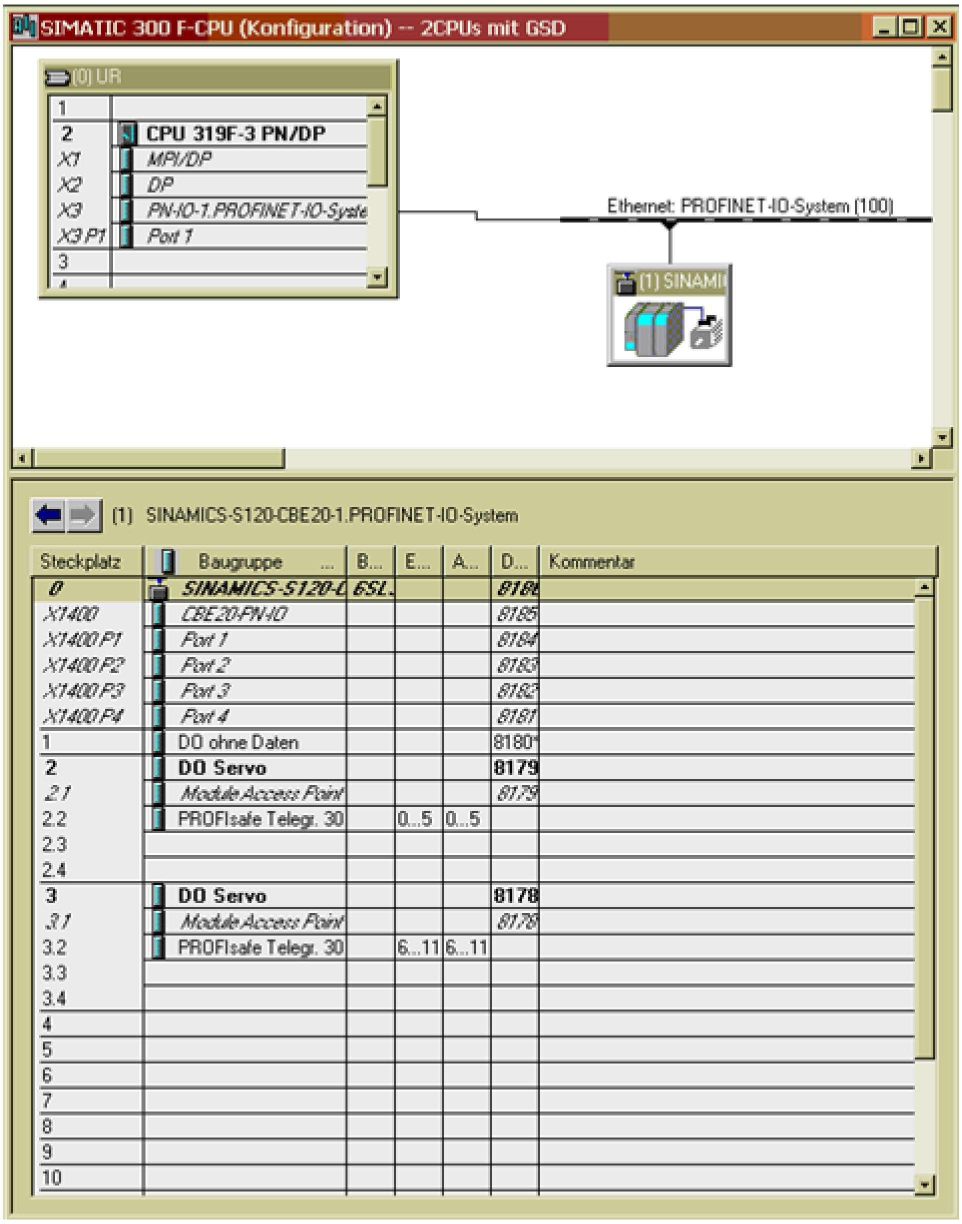


Figure 10-48 One project: Configuring the F-CPU

Each control in a separate project

- Each control is in its own separate project:
- Attach a SINAMICS PROFINET device with GSDML in the A-CPU. Configure the subslots according to the data to be transferred.

Note

You must ensure that the configuration of the A-CPU and the F-CPU correspond to the required communication behavior.

- You can see the result for our particular example in the following diagram:

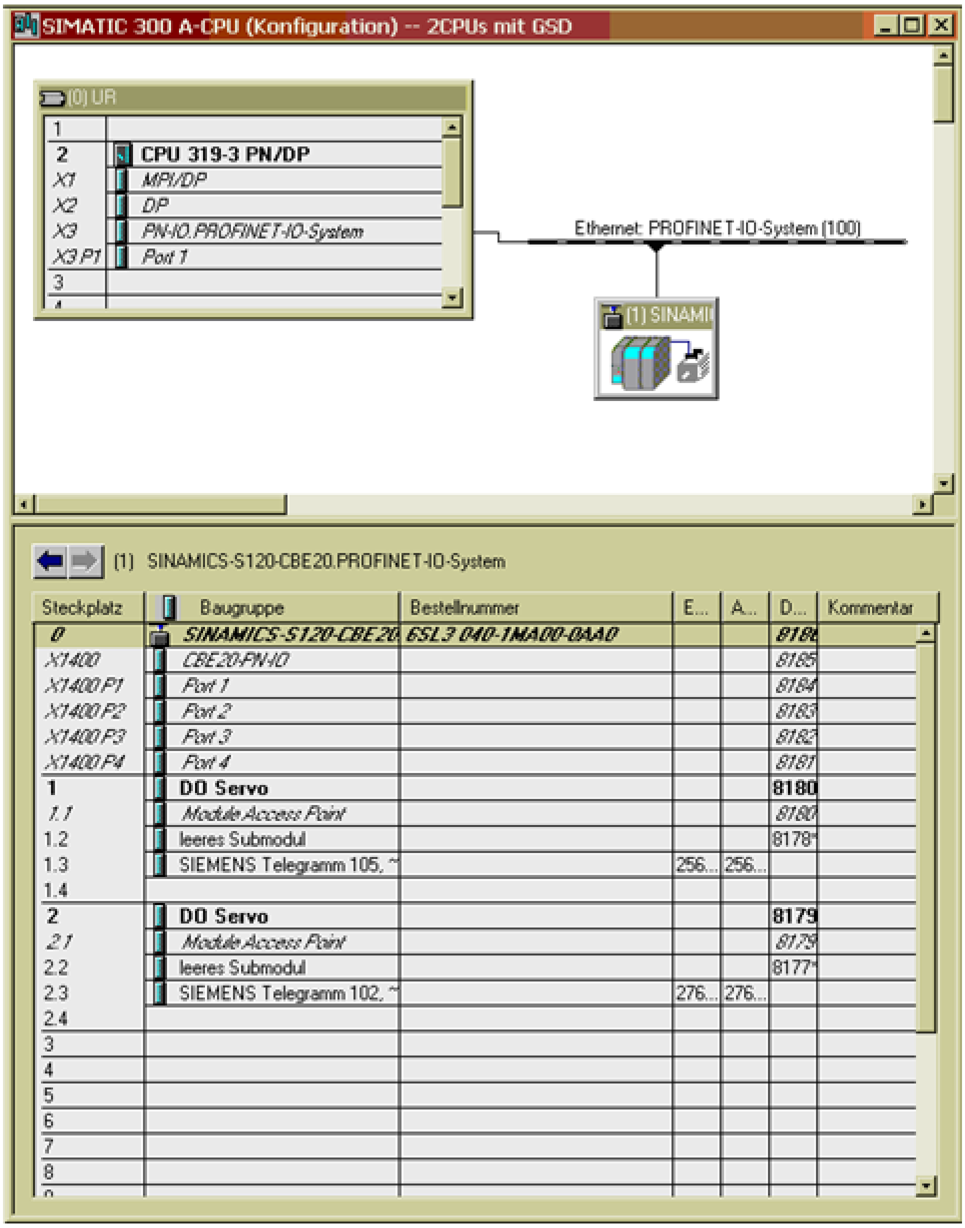


Figure 10-49 Two projects: Configuring the A-CPU

- Attach a SINAMICS PROFINET device with GSDML in the F-CPU.
- Configure a DO without data, and then 2 servo DOs, which only contain the subslot for PROFIsafe telegram 30. You can see the result for our particular example in the following diagram:

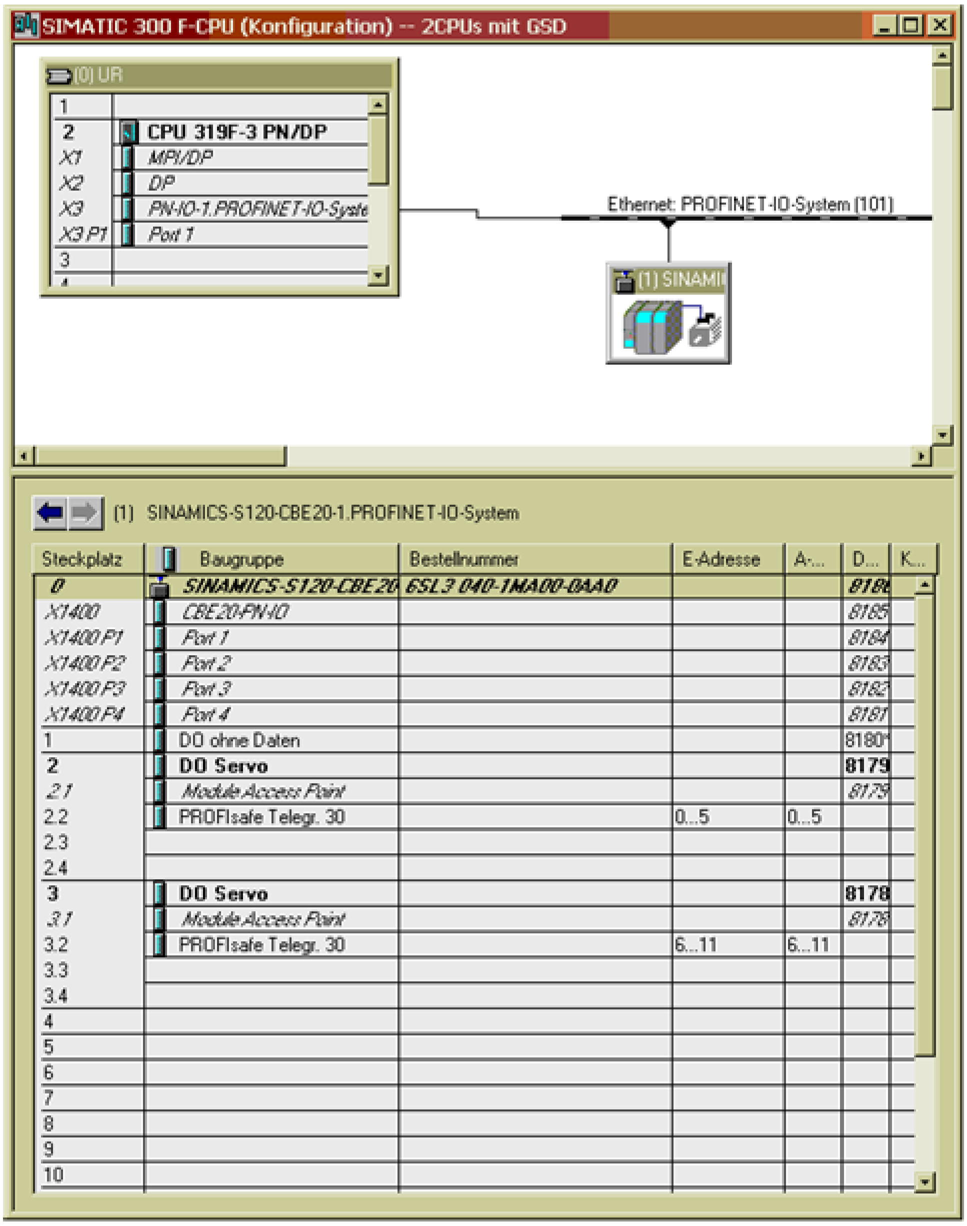


Figure 10-50 Two projects: Configuring the F-CPU

10.3.7.3 Overview of important parameters

Overview of important parameters (see the SINAMICS S120/S150 List Manual)

- p8929 PN Remote Controller number
- p9601 SI enable, functions integrated in the drive (Control Unit)
- p9801 SI enable, functions integrated in the drive (Motor Module)

10.4 Communication via SINAMICS Link

10.4.1 Basic principles of SINAMICS Link

SINAMICS Link enables data to be directly exchanged between several Control Units CU320-2 PN and CU320-2DP or CUD, which for this purpose must be equipped with the CBE20 supplementary module. Other nodes cannot be integrated into this communication. Possible applications include e.g.:

- Torque distribution for n drives
- Setpoint cascading for n drives
- Load distribution of drives coupled through a material web
- Master/slave function for infeed units
- Links between SINAMICS DC-MASTER and SINAMICS S120

Note

The "SINAMICS Link" function is not available for any CU310-2 version.

Send and receive data

The most frequently used node comprises a drive unit with a CU and a number of connected drive objects (DOs). A SINAMICS Link telegram has space retainers for 16 process data (PZD). Each PZD is precisely one word long. Slots that are not required are filled with zeros

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

SINAMICS Link

Every node can send a telegram with 16 PZD. A drive object can receive up to 16 PZD from every other DO of the connected nodes as long as the transferred data within a telegram does not exceed 16 words. Single words and double words can be sent and received. Double words require 2 consecutive PZDs. It is not possible to read in your own send data.

Transmission time

A transmission time of 3.0 ms is possible when using SINAMICS Link (for a controller cycle, max. 0.5 ms; bus cycle, 2.0 ms).

10.4.2 Topology

Only a line topology with the following structure is permitted for SINAMICS Link.

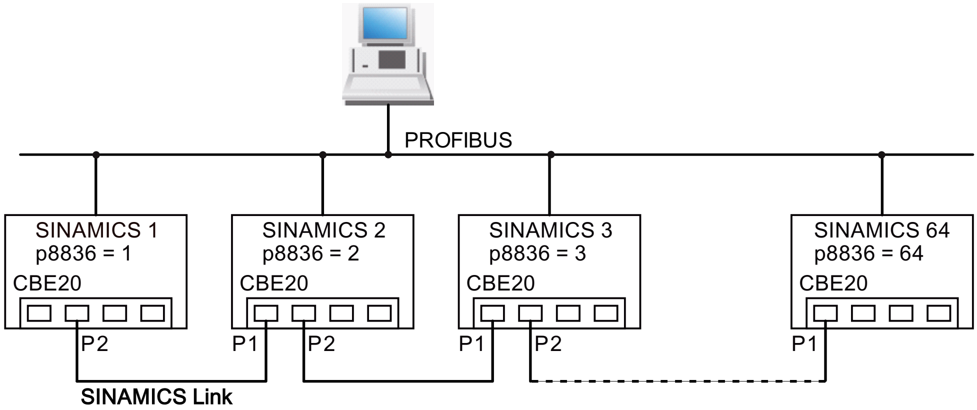


Figure 10-51 Maximum topology

- The numbers of the various nodes are entered into parameter p8836 in ascending order.
- Gaps in the numbering are not permitted.
- The node with the number 1 is automatically the sync master of the communication link.
- When configuring the communication, the NameOfStation (SINAMICSxLINKx001 … SINAMICSxLINKx064) and the IP address (169.254.123.001 … 169.254.123.064) of the particular node are automatically set up by allocating the node number and cannot be changed.
- For the CBE20 connection, the ports must be used as shown in the diagram above – this is mandatory. This means that Port 2 (P2) of node n is always connected with Port 1 (P1) of node n+1.

10.4.3 Configuring and commissioning

Commissioning

When commissioning, proceed as follows for the Control Unit:

- Set parameter p8835 to 3 (SINAMICS Link).
- Using parameter p8836, assign node numbers to the nodes (the first CU is always assigned the number 1). Observe the specifications under "Topology". Node number 0 means that SINAMICS Link is shut down.
- Then execute a "Copy RAM to ROM".
- Perform a POWER ON (switch-off/switch-on).

Sending data

Proceed as follows to send data:

- In parameter p2051[x], for each drive object, define which data (PZDs) should be sent. p2061[x] must be used for double word quantities.
- In parameter p8871, for each drive object, assign the send parameter to the send slot of its own node. Double words (e.g. 2+3) are assigned two consecutive send slots, e.g. p8871[1] = 2 and p8871[2] = 3.

Receiving data

Proceed as follows to receive data:

Note

The first word of the receive data must be a control word, where bit 10 is set. If this is not the case, then you must deactivate the evaluation of bit 10 using p2037 = 2.

- Received data are saved in parameter r2050[x]/r2060[x].
- The address of the node from which the relevant PZD is to be read is defined in parameter p8872[0 … 15] (0 ≙ nothing is read in).
- In parameter p8870[0 … 15], the PZD is defined, which is read from the sent telegram and is to be stored in its own receive slot, r2050 for PZD or r2060 for double PZD (0 ≙ no PZD selected).

Note

For double words, 2 PZD must be read; e.g.: Read in a 32-bit setpoint, which is located on PZD2+PZD3 for node 5 and map this to PZD2+PZD3 of its own node: p8872[1] = 5, p8870[1] = 2, p8872[2] = 5, p8870[2] = 3

Activation

To activate SINAMICS Link connections, perform a POWER ON for all nodes. The assignments of p2051[x]/2061[x] and the links of the read parameters r2050[x]/2060[x] can be changed without a POWER ON.

10.4.4 Example

Task

Configure SINAMICS Link for two nodes (here, in example 2, SINAMICS S120) and transfer the following values:

- Send data from node 1 to node 2
  - r0898 CO/BO: Control word, drive object 1 (1 PZD), in the example PZD1
  - r0079 CO: Total torque setpoint (2 PZD), in the example PZD2
  - r1150 CO: Ramp-function generator speed setpoint at the output (2 PZD) in the example, PZD3
- Send data from node 2 to node 1
  - r0899 CO/BO: Status word, drive object 1 (1 PZD), in the example PZD1

Procedure

1. For all nodes, set the SINAMICS Link mode:
   p8835 = 3
2. Assign node numbers for the two devices:
   - Node 1: p8836 = 1 and
   - Node 2: p8836 = 2
3. Define the send data (node 1)
   - For node 1/DO VECTOR, define the PZD to be sent:
     p2051.0 = Drive1:r0898, p2061.1 = Drive1:r0079, p2061.3 = Drive1:r1150
   - Assign this PZD to the send buffer (p8871) of its own DO:
     p8871.0 = 1, p8871.1 = 2, p8871.2 = 3, p8871.3 = 4, p8871.4 = 5

     This means that you have defined the position of the data in the 16-word telegram of the drive unit.
4. Define the send data (node 2)
   - For node 2/DO VECTOR, define the PZD to be sent:
     p2051.0 = Drive1:r0898
   - Assign this PZD1 to send buffer 0 (p8871) of its own DO:
     p8871.0 = 1
5. Define the receive data (node 1)
   - Define that receive buffer 0 should be filled with data from node 2:
     p8872.0 = 2
   - Define that PZD1 of node 2 should be saved in this buffer:
     p8870.0 = 1
   - r2050.0 now contains the value of PZD1 of node 2.

6. Define the receive data (node 2)
   - Define that receive buffers 0 to 4 should be filled with data from node 1:
     p8872.0 = 1, p8872.1 = 1, p8872.2 = 1, p8872.3 = 1, p8872.4 = 1
   - Define that PZD1, PZD2 and PZD3 of node 1 should be saved in these buffers:
     p8870.0 = 1, p8870.1 = 2, p8870.2 = 3, p8870.3 = 4, p8870.4 = 5
   - r2050.0, r2060.1 and r2060.3 now contain the values from PZD1, PZD2 and PZD3 of node 1.
7. Perform a "Copy RAM to ROM" for both nodes to save the data.
8. For both nodes, perform a POWER ON in order to activate the SINAMICS Link connections.

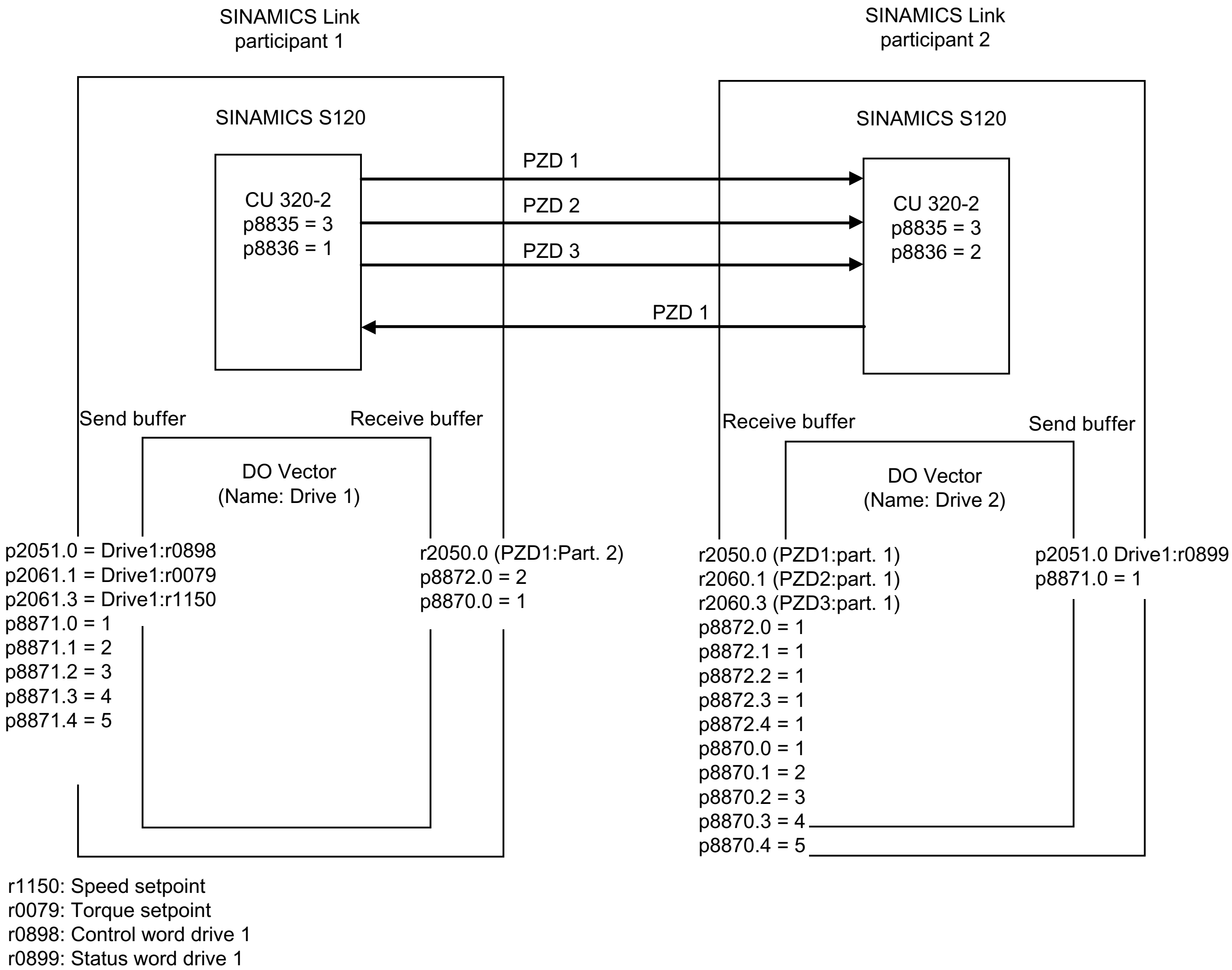


Figure 10-52 SINAMICS Link: Configuration example

10.4.5 Diagnostics

Communication failure when booting or in cyclic operation

If at least one sender does not correctly boot after commissioning or fails in cyclic operation, then alarm A50005 is output to the other nodes: "Sender was not found on the SINAMICS Link."
The message contains the number of the faulted node. After you have resolved the fault at the node involved and the system has identified the node, the system automatically withdraws the alarm.

If several nodes are involved, the message occurs a multiple number of times consecutively with different node numbers. After you have resolved all of the faults, the system automatically withdraws the alarm.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- r2050[0...19] CO: IF1 PROFIdrive PZD receive word
- p2051[0...14] CI: IF1 PROFIdrive PZD send word
- r2060[0...18] CO: IF1 PROFIdrive PZD receive double word
- p2061[0...26] CI: IF1 PROFIdrive PZD send double word
- p8835 CBE20 firmware selection
- p8836 SINAMICS Link address
- p8870 SINAMICS Link telegram word PZD receive
- p8871 SINAMICS Link telegram word PZD send
- p8872 SINAMICS Link address PZD receive

Applications 11

11.1 Switching on a drive object X_INF using a VECTOR drive object

Description

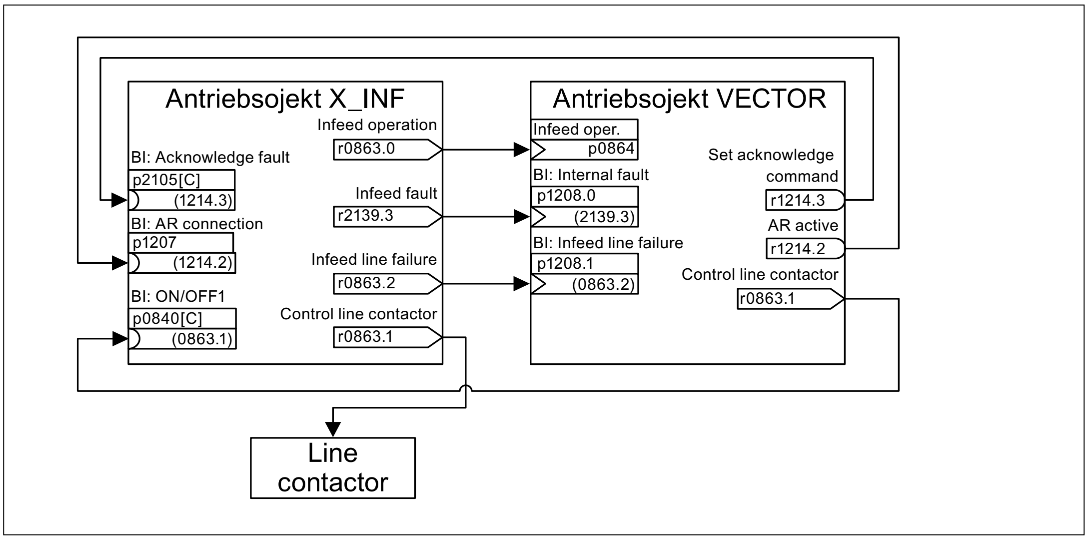


Figure 11-1 BICO interconnection

Using this BICO interconnection, a drive object (DO) X_INF1) can be switched-in using a VECTOR drive object. This switch-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 VECTOR drive object (p1210).
- In addition to the WEA function:
  - The flying restart function (p1200) must be activated on the VECTOR drive object if a restart is to be made while a motor is still rotating
  - The supply voltage must be reliably available at the infeed module (before the switch-on command, an existing line contactor or motor relay must have closed).

Individual steps when restarting:

- After the line supply returns and the electronics has booted, the faults that have occurred at the VECTOR drive object as a result of its automatic restart are acknowledged depending on the settings in p1210.
- The faults of the X_INF drive object are acknowledged via the BICO connection from r1214.3 to p2105.

- The ON command (p0840) for the infeed is generated via the binector output "control line contactor" of the VECTOR drive object (p0863.1).
- The switch-on attempt is interrupted if a fault occurs on the X_INF drive object during the new switch-on sequence. The fault is communicated to the VECTOR drive object via the BICO connection from p1208.0 to r2139.3 shown above.
- The automatic restart of the X_INF drive object has absolutely no significance for the described switch-on version.

1) X_INF stands for all drive objects "Infeed"; i.e.: A_INF, B_INF, S_INF

11.2 Parallel operation of communication interfaces

General information

Cyclic process data (setpoints/actual values) are processed using interfaces IF1 and IF2. The following interfaces are used:

- Onboard interfaces for PROFIBUS DP or PROFINET
- An additional interface (COMM board) for PROFINET (CBE20) or CANopen (CBE10) as option

The parallel use of the onboard interfaces and COMM board in the SINAMICS system is set using parameter p8839, and assigned to the functionality of interfaces IF1 and IF2.

For example, the following applications are conceivable:

- 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)
- SINAMICS Link via IF2 (CBE20); standard telegrams and PROFISafe via IF1
- Operation 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).

Depending on their type (PROFIBUS DP, PROFINET or CANopen) the communication interfaces are assigned to one of the cyclic interfaces (IF1, IF2) by the factory setting of p8839.

For the parallel operation of the communication interfaces, the assignment to the cyclic interfaces can essentially be defined as required by the 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 (p0922)	Yes	No
Clock cycle synchronization (isochronous mode) possible (p8815[0])	Yes	Yes
PROFIsafe possible (p8815[1])	Yes	Yes
Slave-to-slave communication (PROFIBUS only)	Yes	Yes
List of drive objects (p0978)	Yes	Yes
Max. PZD (16bit) setpoint / actual value SERVO	20 / 28	20 / 28
Max. PZD (16bit) setpoint / actual value vector	32 / 32	32 / 32
Max. PZD (16bit) setpoint / actual value infeeds	5 / 8	5 / 8
Max. PZD (16bit) setpoint / actual value encoder	4 / 12	4 / 12
Max. PZD (16bit) setpoint / actual value TM41	20 / 28	20 / 28
Max. PZD (16bit) setpoint / actual value TM31	5 / 5	5 / 5
Max. PZD (16bit) setpoint / actual value TM15DI_DO	5 / 5	5 / 5
Max. PZD (16bit) setpoint / actual value TM120	5 / 5	5 / 5
Max. PZD (16bit) setpoint / actual value TB30	5 / 5	5 / 5
Max. PZD (16bit) setpoint / actual value CU (device)	5 / 21	5 / 21

Table 11- 2 Implicit assignment of hardware to cyclic interfaces for p8839[0] = p8839[1] = 99

Plugged hardware interface	IF1	IF2
No option, only onboard interface (PROFIBUS, PROFINET or USS)	Onboard	--
CU320-2 DP with PROFINET option (CBE20)	COMM board	Onboard PROFIBUS or onboard USS
CU320-2 PN with PROFINET option (CBE20)	PROFINET onboard	COMM board PROFINET
CAN option (CBC10)	Onboard	COMM board

For parallel operation of the hardware interfaces and the explicit assignment to the cyclic interfaces IF1 and IF2, the parameter p8839[0,1] "PZD Interface hardware assignment" exists for the device DO in the expert list.

The object sequence for process data exchange via IF2 depends on the object sequence from IF1; see "List of drive objects" (p0978).

The factory 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

Clock cycle synchronous applications can only run via one of the two interfaces IF1 or IF2 (p8815). With an additional PROFINET module inserted in the CU320-2 DP, 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

---

Parameters for IF2

The following parameters are available to be able to better use the IF2 for a PROFIBUS / PROFINET interface:

- Receive and send process data:
  r8850, p8851, r8853, r8860, p8861, r8863 1)
- Diagnostic parameters:
  r8874, r8875, r8876 1)
- Binector-connector converter
  p8880, p8881, p8882, p8883, p8884, r8889 1)
- Connector-binector converter
  r8894, r8895, p8898, p8899 1)

1) Significance of 88xx identical to 20xx

Note

It is not possible in the HW Config configuration tool to represent a PROFIBUS / PROFINET slave with two interfaces. In parallel operation, SINAMICS will therefore appear twice in the project or in two projects although there is only one physical device.

Interrelationship, clock cycle synchronism, PROFIsafe and SINAMICS Link

Table 11- 3 Interrelationship, clock cycle synchronism, PROFIsafe and SINAMICS Link

Variant	Interface	Clock cycle synchronization	PROFIsafe	SINAMICS Link possible
1	IF1	No	No	No
	IF2	No	No	No
2	IF1	No	No	No
	IF2	No	Yes	No
3	IF1	No	Yes	No
	IF2	No	No	No
4	IF1	No	No	No
	IF2	Yes	No	Yes (for CBE20 as IF2)
5	IF1	No	No	No
	IF2	Yes	Yes	No
6	IF1	No	Yes	No
	IF2	Yes	No	Yes (for CBE20 as IF2)
7	IF1	Yes	No	Yes (for CBE20 as IF1)
	IF2	No	No	No
8	IF1	Yes	Yes	No
	IF2	No	No	No
9	IF1	Yes	No	Yes (for CBE20 as IF1)
	IF2	No	Yes	No

Parameter

p8839	PZD Interface hardware assignment
Description:	Assigning the hardware for cyclic communication via PZD interface 1 and interface 2.
Values:	0: not active
	1: Communication interface integrated in the Control Unit
	2: Option board
	99: Automatic

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, factory setting), the assignment will be made on the basis of the hardware being used. 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'.
- If a CAN module is being used (CBC10), an entry of p8839[0] = 2 is not permissible (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 supplied from the onboard interface. Message A08550 is output instead.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0922 IF1 PROFIdrive telegram selection
- p0978[0...24] List of drive objects
- p8815[0...1] Selects the functionality IF1/IF2
- p8839[0...1] PZD Interface hardware assignment
- p9601 SI enable, functions integrated in the drive (Control Unit)

11.3 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 changeover)
- 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

Applicable to "Vector" drive type:
To switch to a 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.

Example of a motor changeover for four motors (encoderless)

Preconditions

- First commissioning has been completed.
- 4 motor data sets (MDS), p0130 = 4
- 4 drive data sets (DDS), p0180 = 4
- 4 digital outputs for controlling the auxiliary contactors
- 4 digital inputs for monitoring 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 contacts, 1 NO contact)
- 4 motors, 1 Control Unit, 1 infeed, and 1 Motor Module

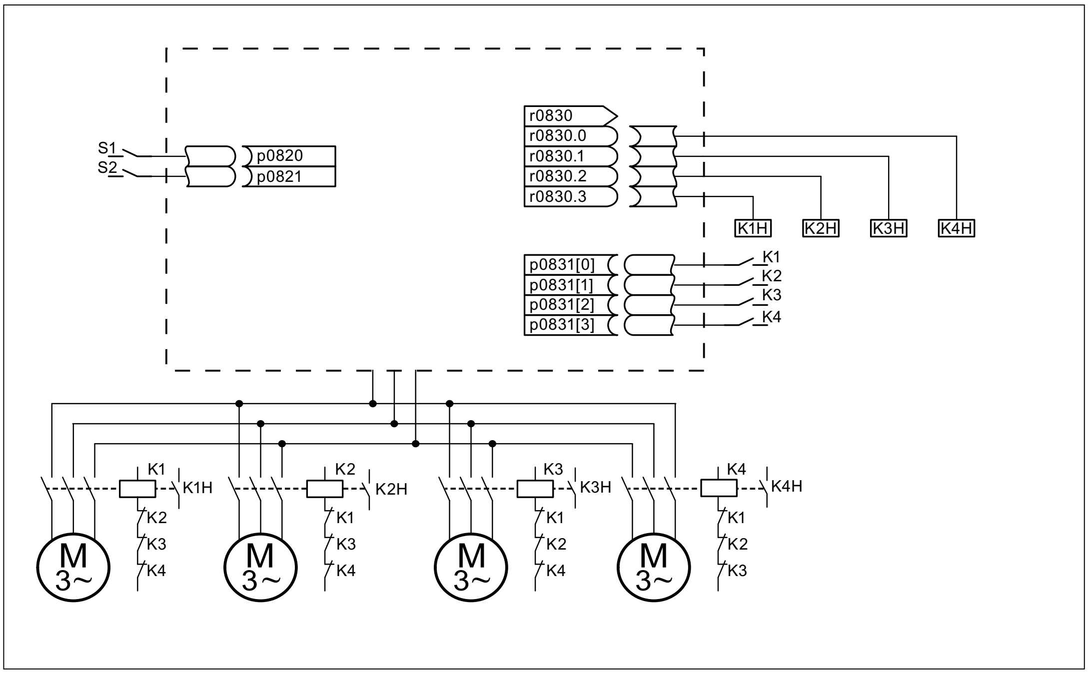


Figure 11-2 Example of motor changeover

Table 11- 4 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 changeover via DDS selection are selected. Binary coding is used (p0820 = bit 0 etc.).
p0822 to p0824	0	
p0826[0...3]	0, 1, 2, 3	Different numbers indicate a different thermal model
p0827[0...3]	0, 1, 2, 3	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.
p0830.0 to p0830.3	Digital outputs, contactors	The digital outputs for the 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.
p0833.0..2	0, 0, 0	The drive controls the contactor circuit and pulse inhibition. Parking bit (Gn_ZSW14) is set.

Procedure for changeover between motor data sets

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 from exceeding the terminal voltage.

2. Pulse inhibit:

   The pulses are inhibited after a new drive data set is selected with 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.

Example of a star/delta changeover (via speed threshold; encoderless)

Preconditions

- First commissioning has been completed.
- 2 motor data sets (MDS), p0130 = 2
- 2 drive data sets (DDS), p0180 = 2
- 2 digital outputs for controlling the auxiliary contactors
- 2 digital inputs for monitoring the auxiliary contactors
- 1 free speed monitoring (p2155)
- 2 auxiliary contactors with auxiliary contacts (1 NO contact)

- 2 motor contactors with positively-driven auxiliary contacts (1 NC contact, 1 NO contact)
- 1 motor, 1 Control Unit, 1 infeed, and 1 Motor Module

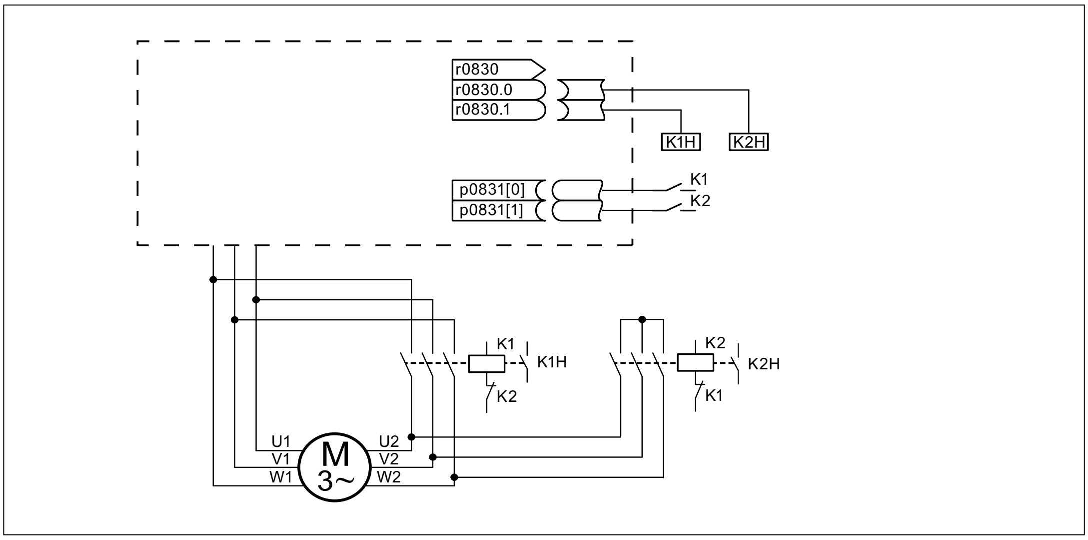


Figure 11-3 Example: star/delta changeover

Table 11- 5 Settings for the example

Parameter	Settings	Remark
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	Changeover 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]	0, 1	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.
p0830.0 and p0830.1	Digital outputs, contactors	The digital outputs for the contactors are assigned to the bits.
p0831[0...1]	Digital inputs, auxiliary contacts	The digital inputs for the feedback signal of the motor contactors are assigned.
p0833.0..2	0, 0, 0	The drive controls the contactor circuit and pulse inhibition. Parking bit (Gn_ZSW14) is set.
p2155.0...1	Changeover speed	Sets the speed at which circuit is to be changed over to delta. **Note:** Using p2140, you can define an additional hysteresis for the changeover (refer to SINAMICS S120/150 List Manual, function diagram 8010).

Procedure for star/delta changeover

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:

   The pulses are suppressed after the changeover speed (p2155) is reached.
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 changeover is complete.

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8565 Drive Data Sets (DDS)
- 8570 Encoder Data Sets (EDS)
- 8575 Motor Data Sets (MDS)

Overview of important parameters (see SINAMICS S120/S150 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 changeover motor number
- p0827 Motor changeover status bit number
- p0828 BI: Motor changeover feedback
- p0830 CO/BO: Motor changeover status
- p0831 BI: Motor changeover contactor feedback
- p0833 Data set changeover configuration

11.4 Application examples with DMC20

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:

- Implementation of a distributed topology via a DRIVE-CLiQ cable
- Hot plugging (a DRIVE-CLiQ connection is withdrawn in operation)

DME20

DME20 offers the same functions as the DMC20. However, the difference is that it has a different enclosure with degree of protection IP67 for mounting outside a control cabinet.

Description

The DRIVE-CLiQ Hub Module Cabinet 20 (DMC20/DME20) is used for the star-shaped distribution of a DRIVE-CLiQ line. With the DMC20, an axis grouping can be expanded with 4 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 process.

Example: Distributed structure

Several direct length measuring systems are used in a machine. These are to be combined in a control cabinet and connected to the Control Unit via a DRIVE-CLiQ cable.

When using a DMC20, up to five measuring systems can be combined.

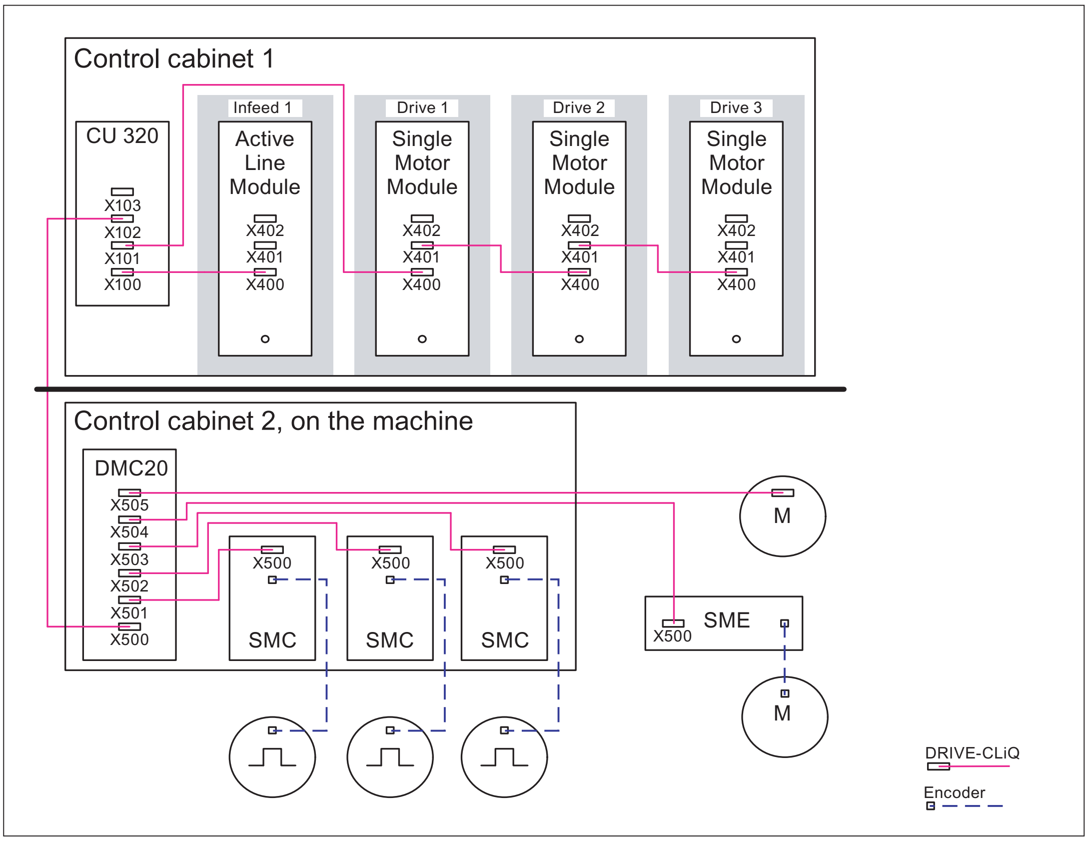


Figure 11-4 Example, distributed topology using DMC20

Example: Hot plugging

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 all of the drive objects or components involved must first be deactivated/parked using parameter p0105 or STW2.7.

The following requirements must be satisfied:

Hot plugging only functions when a drive object is connected in a star configuration to a Control Unit or to the DRIVE-CLiQ Hub DMC20/DME20.

The system does not support removing DRIVE-CLiQ connections between the other DRIVE-CLiQ components e.g. Sensor/Terminal Module to Motor Module, Motor Module to 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 in combination with pulse inhibit.

Note

Drives with enabled Safety functions must not be deactivated, see chapter "Safety Integrated" for further details.

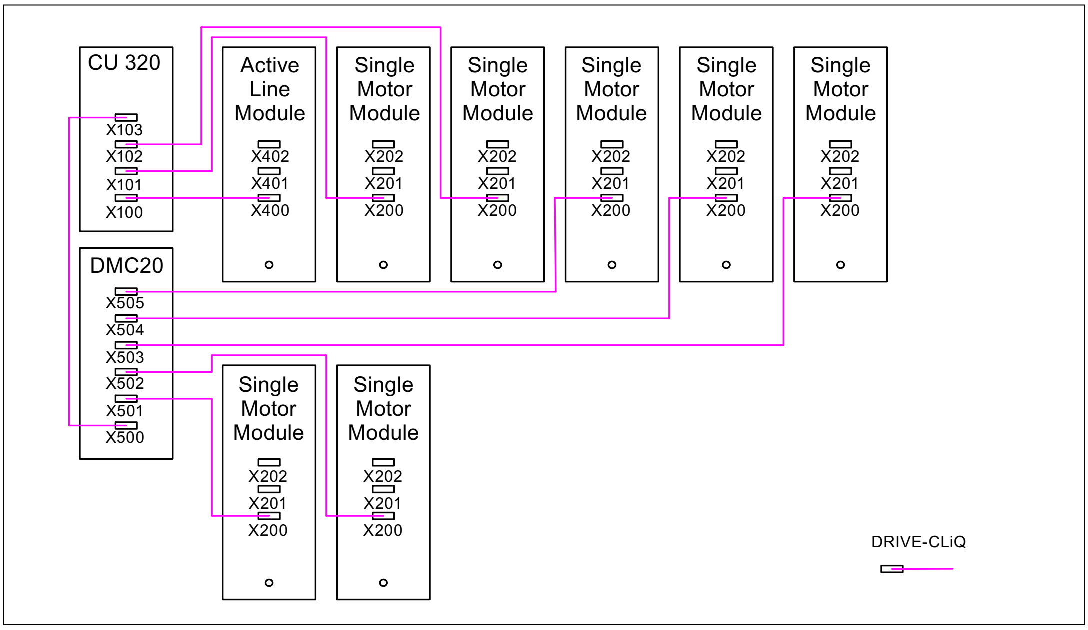


Figure 11-5 Example topology for hot plugging in vector V/f_control mode

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.

Instructions for offline commissioning with STARTER

With automatic online configuration in STARTER, the DMC20 is detected and integrated in the topology. The following steps must be taken to commission offline:

1. Configure a drive unit offline
2. Right-click on Topology -> Insert New Object -> DRIVE-CLiQ Hub
3. Configure the topology

Overview of important parameters (see SINAMICS S120/S150 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 Tolerant encoder monitoring

The tolerant encoder monitoring offers the following expanded functionality regarding the evaluation of encoder signals:

- Encoder track monitoring (Page 663)
- Zero mark tolerance (Page 664) (also for other sensor modules)
- Freeze speed raw value (Page 664)
- Adjustable hardware filter (Page 665)
- Edge evaluation of the zero mark (Page 666)
- Pole position adaptation (Page 667)
- Pulse number correction for faults (Page 668)
- Monitoring, tolerance band, pulse number (Page 669)
- Expansion of the encoder evaluation (1x, 4x) (Page 670)
- Setting the measuring time to evaluate speed "0" (Page 671)
- The number of current controller cycles can be set to generate the average value of the speed actual value (Page 671)

These supplementary functions allow you to improve the evaluation of your encoder signals. This may be necessary in special cases where the Control Unit receives incorrect encoder signals or specific properties of the signals must be compensated for.

Some of these supplementary functions can be combined with one another.

Terminology

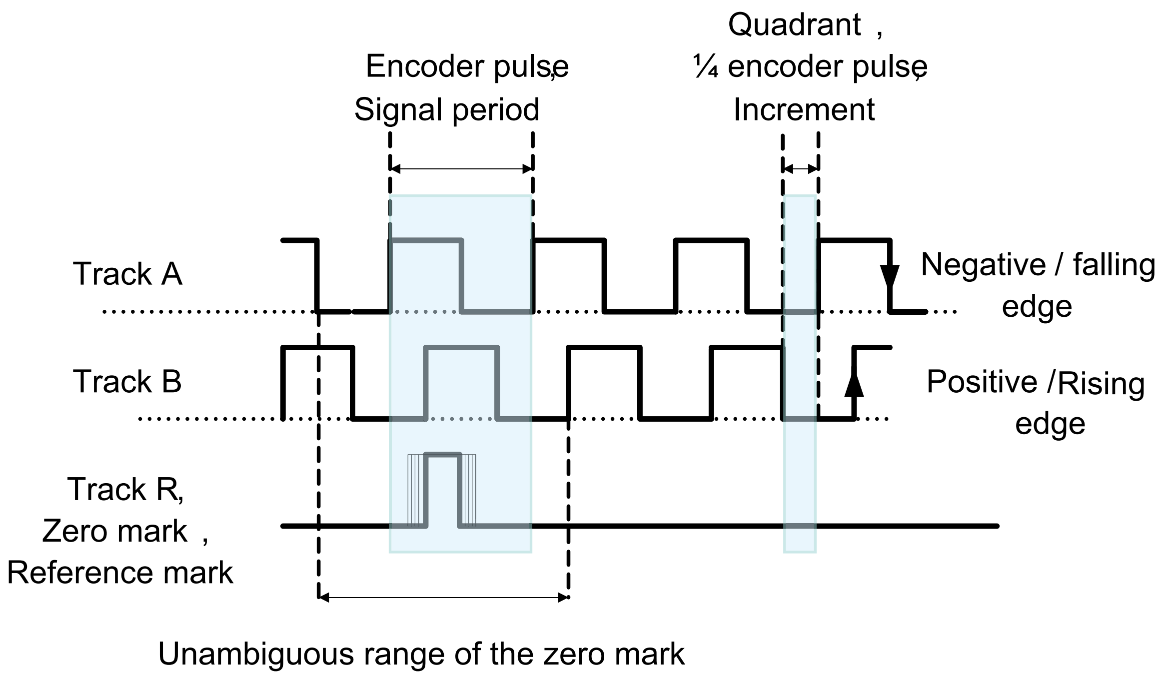


Figure 11-6 Terminology

Commissioning

The tolerant encoder monitoring is commissioned using parameters p0437 and r0459.

r0458.12 = 1 indicates whether your hardware supports the expanded encoder properties.

Note

- You can only parameterize the tolerant encoder monitoring functions when commissioning the encoder. The encoder monitoring parameters cannot be changed while the drive is running!
- The functions can only be parameterized using the expert list of STARTER.
- The functions described in the following apply to SMC30 modules and to CU modules with internal encoder evaluation.

11.5.1 Encoder track monitoring

For squarewave encoders with push-pull signals, this function monitors encoder tracks A/B ↔ -A/B, as well as R ↔ -R. The encoder track monitoring monitors the most important properties of the signals (amplitude, offset, phase position).

Commissioning

The following parameters must be set as precondition for track monitoring:

- p0404.3 = 1 switches to the squarewave encoder
- p0405.0 = 1 sets the signal to bipolar

Set p0405.2 = 1 to activate track monitoring.

If you selected your encoder from the list of parameter p0400, then the values above are pre-selected and cannot be changed (also refer to the information on p0400 in the SINAMICS S120/S150 List Manual).

Deactivating track monitoring

If encoder track monitoring is activated, you can deactivate the function by setting p0437.26 = 1.

Evaluating messages

All of the track monitoring functions can be individually evaluated. You can use both HTL as well as TTL encoders.

If a fault is detected, then fault F3x117[1)] is output. The faulted tracks are included in the fault value bit-coded.

Note

For modules CU310, CUA32, D410 and SMC30 (only order numbers 6SL3055-0AA00-5CA0 and 6SL3055-0AA00-5CA1) there is only a general signal. If you connect a squarewave encoder without R track to one of these modules, then if track monitoring is activated, fault F3x117[1)] is output.

To avoid this fault, at the encoder connection, you must connect the "ground encoder supply" (pin 7) with the "reference signal R" (pin 10), as well as the "encoder supply" (pin 4) with the "inverse reference signal R" (pin 11).

[1)] x = encoder number (x = 1, 2 or 3)

11.5.2 Zero mark tolerance

This function allows individual faults to be tolerated regarding the number of encoder pulses between two zero marks.

Commissioning

Set parameter p0430.21 = 1 to activate the "zero mark tolerance" function.

Principle of operation

The function runs as follows:

- The "zero mark tolerance" function starts to become effective after the 2nd zero mark has been detected.
- After this, if the number of track pulses between two zero marks does not match the configured number of pulses **once**, then alarms A3x400[1)] (alarm threshold, zero mark distance error) or A3x401[1)] (alarm threshold, zero mark failed) is output.
- The alarms are cleared if the next zero mark is received at the correct position.
- However, if a new zero mark position error is identified, fault F3x100[1)] (zero mark distance error) or Fx3101[1)] (zero mark failed) is output.

[1)] x = encoder number (x = 1, 2 or 3)

11.5.3 Freezing the speed raw value

If, for high speed changes, the dn/dt monitoring function responds, then the "freeze speed raw value" function gives you the opportunity of briefly specifying the speed actual value therefore equalizing the speed change.

Commissioning

Set parameter p0437.6 = 1 to activate the "freeze speed raw value" function.

Sequence

The function runs as follows:

- If the dn/dt monitor responds, the alarm A3x418 " Encoder x: Speed difference per sampling rate exceeded"[1)] is output.
- A frozen speed actual value limited for 3 current controller clock cycles is supplied.

[1)] x = encoder number (x = 1, 2 or 3)

11.5.4 Adjustable hardware filter

The adjustable hardware filter function allows an encoder signal to be filtered, therefore suppressing short interference pulses.

Commissioning

- Set parameter p0438 ≠ 0 to activate the "adjustable hardware filter" function.

Parameterization

- In parameter p0438 (squarewave encoder filter time) enter the filter time in the range from 0 to 100 μs. The hardware filter only supports values 0 (no filtering), 0.04 μs, 0.64 μs, 2.56 μs, 10.24 μs and 20.48 μs

  If a value is set that does not match one of the discrete values specified above, the firmware automatically sets the next closest discrete value. The drive does not output an alarm or fault message.
- You can see the active, effective filter time in parameter r0452.

Note

The zero mark alarms F3x100, F3x101 and F3x131[1)], that are already output for a zero mark with a width of ¼ encoder pulse at half n_max speed, are suppressed when the hardware filter is activated.

Effect

You can calculate the influence of the filter time on the maximum possible speed as follows:

n_max [rpm] = 60 / (p0408 · 2 · r0452)

Here, p0408 is the pulse number of the rotary encoder.

Example

Specifications:

- p0408 = 2048
- r0452 = 10.24 [μs]

n_max is then calculated as follows:

- n_max = 60 / (2048 · 2 · 10.24 · 10^{-6}) = 1430 [rpm]

As a consequence, with this filter time you can operate the motor up to a maximum of 1430 rpm.

1) x = encoder number (x = 1, 2 or 3)

11.5.5 Edge evaluation of the zero mark

This functionality is suitable for encoders, where the zero mark ≥ 1 pulse wide. In this particular case, errors would otherwise occur as a result of the edge detection of the zero mark.

For a positive direction of rotation, the positive edge of the zero mark is evaluated and for a negative direction of rotation, the negative edge. As a consequence, for encoders where the zero mark is wider than one pulse, it is possible to parameterize them with equidistant zero marks (p0404.12 = 1), i.e. the zero mark checks (F3x100, F3x101[1)]) are activated.

Commissioning

- Set parameter p0437.1 = 1 to activate the "edge evaluation of the zero mark" function.

  The factory setting p0437.1 = 0 keeps the operation at the known zero mark detection.

Parameterization

- Under unfavorable conditions, if the drive oscillates around the zero mark for one revolution, a zero mark error can occur with the rough order of magnitude of the zero mark width.
- This behavior can be avoided using the appropriate value of parameter "p4686 zero mark minimum length". You can assign ¾ of the zero mark width to parameter p4686 in order to achieve the most rugged behavior possible.
- In order that the drive, for small inaccuracies, does not output fault F3x100 (N, A) "Encoder x: Zero mark distance error"[1)] a small, adjustable deviation of the zero mark distances is permitted:
  "p4680 zero mark monitoring tolerance permissible"
  This parameter makes the system less sensitive to issuing F3x100[1)], if p0430.22 = 0 (no pole position adaptation) and p0437.2 = 0 (no pulse number correction for faults) are set.

[1)] x = encoder number (x = 1, 2 or 3)

11.5.6 Pole position adaptation

For example, for a dirty encoder disk, the drive adds the missing pulses to the pole position using the zero mark that is cyclically received in order to correct the pole position error. If, for example EMC interference causes too many pulses to be added, then these will be subtracted again every time the zero mark is crossed.

Commissioning

- Set parameter p0430.22 = 1 to activate the "pole position adaptation" function.

Principle of operation

When the pole position adaptation is activated, the incorrect pulses on the A/B track are corrected in the pole position for commutation. The tolerance bandwidth for the zero mark is ±30° electrical. The rate of correction is ¼ of an encoder pulse between two zero marks; this means that sporadically missing or superfluous pulses are corrected.

Note

When the function "Commutation with zero mark" (p0404.15 = 1) is activated, then the system waits until fine synchronization has been completed before making a correction (r1992.8 = 1).

11.5.7 Pulse number correction for faults

Interference currents or other EMC faults can falsify encoder evaluation. However, it is possible to correct the measured signals using the zero marks.

Commissioning

- Set p0437.2 = 1 to activate "Pulse number correction for faults".
- Define the permissible tolerance (encoder pulses) for the zero mark distance (p4680).
- Define the limits of the tolerance window, up to which the drive corrects the pulse number (p4681, p4682).
- Using p4686, define the minimum zero mark length.

Principle of operation

- This function completely corrects encoder pulse errors up to the tolerance window (p4681, p4682) between two zero marks. The rate of correction is ¼ encoder pulses per current controller clock cycle. As a consequence, it is possible to continually compensate for missing encoder pulses (for example, if the encoder disk is dirty). Using the two parameters, set the tolerance for the deviating pulse number.

  If the deviation exceeds the tolerance window size, fault F3x131[1)] is output.

  Note

  When the function "Commutation with zero mark" (p0404.15 = 1) is activated, then the system waits until fine synchronization has been completed before making a correction (r1992.8 = 1).

  The pole position for the commutation is also corrected. To do this, you do not have to activate pole position adaptation (p0430.22 = 1).

  This function does not make any corrections in the speed sensing.

- Using p4686, set the minimum zero mark length. With a factory setting of 1, it is prevented that EMC faults result in a zero mark error.

  Shorter zero marks are only suppressed when "Zero mark edge detection" is parameterized (p0437.1 = 1).
- Zero mark deviations of less than the minimum zero mark length (p4686) are not corrected.
- A permanently failed zero mark is indicated using the fault F3x101 "Encoder x: Zero mark failed"[1)] or the alarm A3x401[1)] "Alarm threshold zero mark failed".

[1)] x = encoder number (x = 1, 2 or 3)

11.5.8 "Tolerance band pulse number" monitoring

This function monitors the number of encoder pulses between two zero marks. An alarm is output if the number lies outside a tolerance band that can be selected.

Commissioning

- Set parameter p0430.2 = 1 to activate the "tolerance band pulse number monitoring" function.
- Using parameters p4683 and p4684, set the upper and the lower limits of the tolerance band. Within this tolerance band, the detected number of pulses is considered to be correct.

Principle of operation

- After each zero mark, it is again checked as to whether up to the next zero mark the number of pulses lies within the tolerance band. If this is not the case and "pulse number correction for faults" (p0437.2 = 1) is parameterized, then alarm A3x422[1)] is output for 5 seconds.
- If one of the limits has a value of 0, then alarm A3x422[1)] is deactivated.
- Display of uncorrected encoder pulses
  For p0437.7 = 1, the number of corrected pulse errors is displayed in r4688 with the correct sign. Set p0437.7 = 0 in order to indicate the corrected pulse errors per zero mark distance in r4688.

  For a drift after one revolution, if the tolerance band limit is not reached, an alarm is not output. A new measurement is performed if the zero mark is exceeded.
- Number of pulses outside the tolerance band

  If the tolerance band is violated, then in addition to alarm A3x422[1)] r4689.1 = 1 is set. This value remains for a minimum of 100 ms, so that a control can detect several violations in quick succession one after the other even for high-speed drives.

  You can send the message bits of parameter r4689 to a higher-level control via PROFIBUS / PROFINET as process data.
- You can send the accumulated correction value to a higher-level control via PROFIBUS (e.g.: p2051[x] = r4688). The control can then set the contents of the counter to a specific value.

Note

The "tolerance band pulse number monitoring" also functions for external encoders, which operate in a drive line-up as leading value encoder (monitoring the position value XIST1 from a direct measuring system).

[1)] x = encoder number (x = 1, 2 or 3)

11.5.9 Signal edge evaluation (1x, 4x)

The "signal edge evaluation" function allows squarewave encoders with higher production tolerances or older encoders to be used. Using this function, a "steadier" speed actual value is calculated for encoders with an uneven pulse duty factor of the encoder signals. As a consequence, you can keep the old motors together with the encoders - for example when modernizing plants.

Commissioning

- Sets parameters p0437 bit 4 and bit 5 as follows to activate "signal edge evaluation":

p0437.4	p0437.5	Evaluation
0	0	4 x (factory setting)
0	1	Reserved
1	0	1 x
1	1	Reserved

Principle of operation

For the 4x evaluation, both the rising and falling edges of a contiguous pulse pair on the A and B tracks are evaluated.

For the 1x evaluation, only the first or the last edge of a contiguous pulse pair on the A and B tracks are evaluated.

A 4x evaluation of the pulse encoder signals allows a minimum speed to be detected which is a factor of 4 lower than for the 1x evaluation. For incremental encoders with uneven pulse duty factor of the encoder signals or where the encoder signals are not precisely offset by 90°, a 4x evaluation can result in a speed actual value that is somewhat less steady.

The following formula defines the lowest speed where a distinction can be made to 0:

n_min = 60 / (x*p0408) [rpm]

with x = 1 or 4 (x times evaluation)

Note

You can only use the reduction to 1x evaluation in conjunction with the edge zero mark or without zero mark. Detection with an accuracy of one pulse is no longer possible for zero marks with "unambiguous range" or distance-coded zero marks.

11.5.10 Setting the measuring time to evaluate speed "0"

This function is only necessary for slow-speed drives (up to 40 rpm rated speed) in order to be able to output actual speeds correctly close to 0. For a stationary drive, this prevents that the I component of the speed controller slowly increases and the drive unnecessarily establishes a torque.

Commissioning

- Enter the required measuring time in parameter p0453: A speed actual value of 0 is output, if, within this time, no pulses are detected from the A/B track.

11.5.11 Sliding averaging of the speed actual value

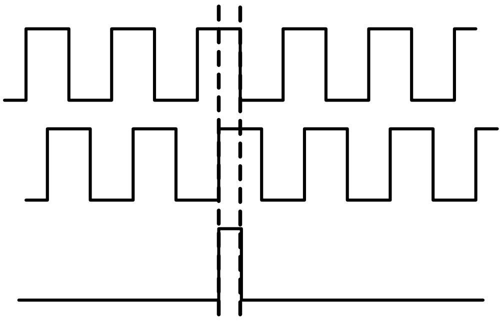
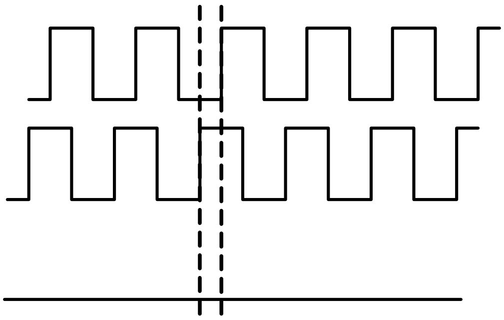
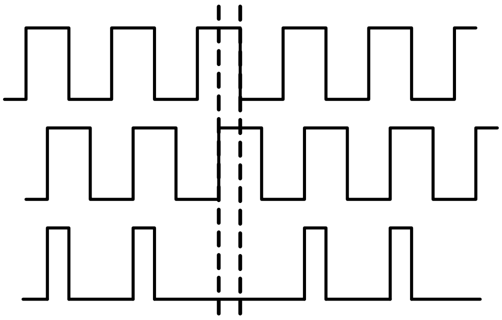
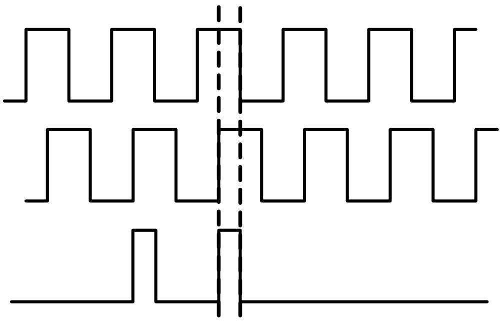
For slow-speed drives (< 40 rpm), when using standard encoders with a pulse number of 1024, a problem is encountered due to the fact that the same number of encoder pulses is not available for every current controller clock cycle (for p0430.20 = 1: Speed calculation without extrapolation, "Incremental difference"). The different number of encoder pulses means that the speed actual value display jumps, although the encoder itself is running at a constant speed.

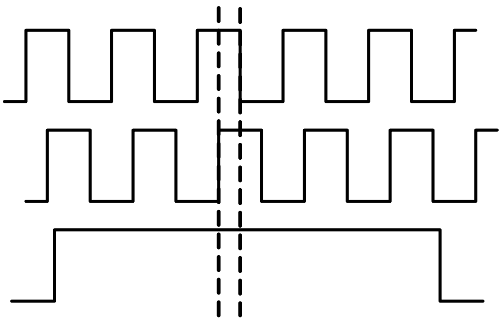
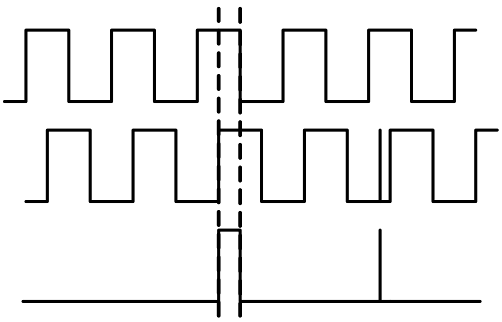
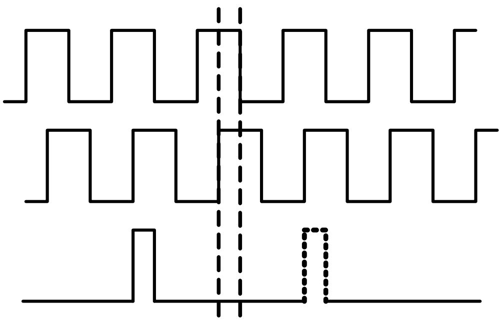
Commissioning

- For sliding averaging, set parameter p0430.20 = 0 (edge time measurement).
- In parameter p4685, enter the number of current controller clock cycles over which the average value should be formed to calculate the speed. The averaging means that individual incorrect pulses, depending on the number of specified clock cycles, are smoothed.

11.5.12 Troubleshooting

Table 11- 6 Fault profiles and their possible causes

Fault profile	Fault description	Remedy
	No fault	–
	F3x101 (zero mark failed)	Check that the connection assignment is correct (A interchanged with –A or B interchanged with –B)
	F3x100 (Zero mark distance error)	Check whether the connection assignment is correct (R interchanged with –R)
	Interjected zero mark	Use zero mark tolerance

Fault profile	Fault description	Remedy
	Zero mark too wide	Use edge evaluation of the zero mark
	EMC faults	Use an adjustable hardware filter
	Zero mark too early/late (interference pulse or pulse loss on the A/B track)	For faults, use pole position adaptation or pulse number correction

11.5.13 Tolerance window and correction

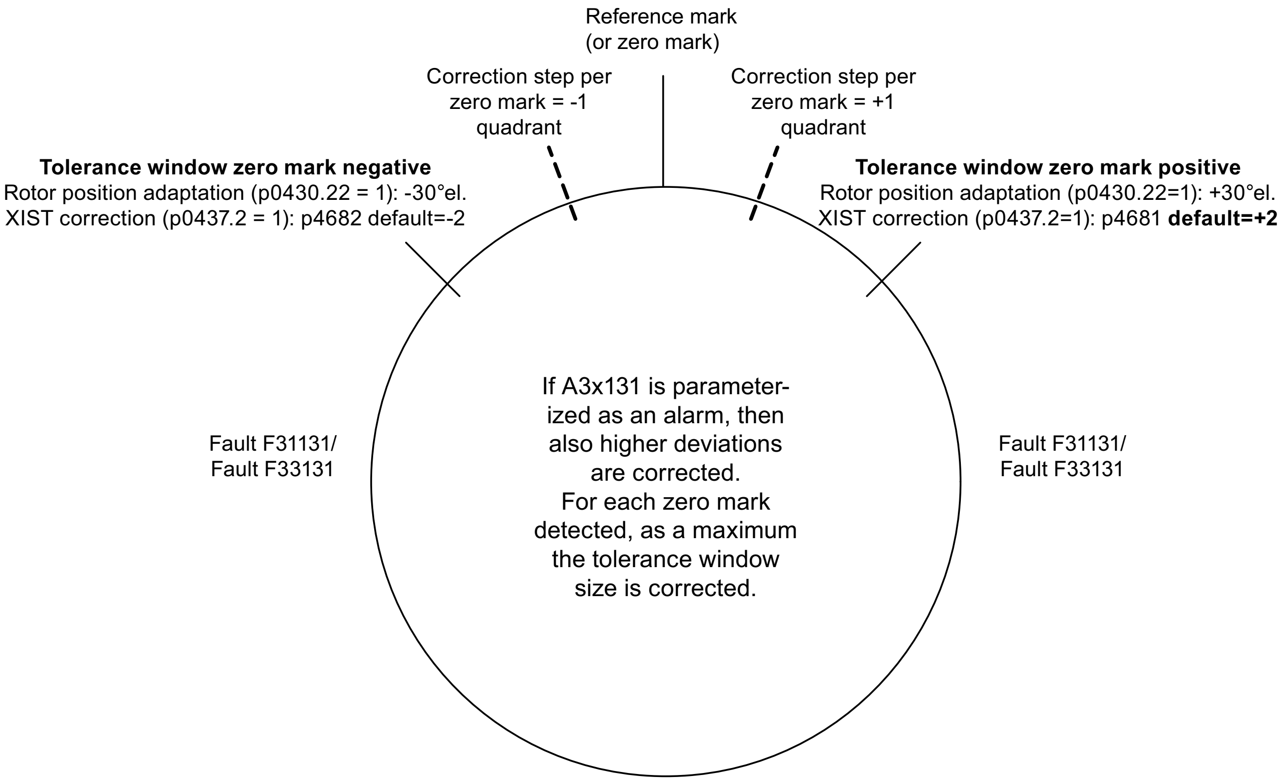


Figure 11-7 Tolerance window and correction

11.5.14 Dependencies

		Scope of functions										
		Functions can be freely combined with one another.								These functions build on one another from the left to right and can be combined with the adjacent one.		
Parameter		Encoder track monitoring	Zero mark tolerance	Freezing the speed raw value	Adjustable hardware-Filter	Sets the measuring time for the evaluation of speed "0"	Sliding averaging of the speed actual value	Edge evaluation of the zero mark	Signal edge evaluation (1-x; 4-x)	Pole position adaptation	Pulse number correction for faults (pole position for the commutation is also corrected.)	Monitoring "To lerance bandwidth, pulse number"
p0405.2	Track monitoring	x										
p0430.20	Speed calculation mode						x					
p0430.21	Zero mark tolerance		x									
p0430.22	Rotor position adaptation									x		
p0437.1	Zero mark edge detection							x				
p0437. 2	Correction position actual value XIST1										x	x
p0437.4	Edge evaluation								x			
p0437.5	Edge evaluation								x			
p0437.6	Freeze speed actual value for dn/dt -Error			x								

p0437.7	Not corrected encoder pulses accumulate										x	x
p0437.26	Deselect track monitoring	x										
p0438	Square wave encoder filter time				x							
r0452	Square wave encoder filter time Display				x							
p0453	Pulse encoder evaluation Speed zero measuring time					x						
p4680	Zero mark monitoring Tolerance Permissible							x			x	
p4681	Zero mark monitoring Tolerance window limit 1 Positive										x	
p4682	Zero mark monitoring Tolerance window limit 1 Negative										x	
p4683	Zero mark monitoring Tolerance window alarm threshold Positive											x
p4684	Zero mark monitoring Tolerance window alarm threshold Negative											x
p4685	Speed actual value Averaging						x					
p4686	Zero mark minimum length							x			x	
r4688	Zero mark monitoring Differential pulse count										x	x
r4689	Squarewave encoder diagnostics										x	x
Alarms												
F3x117	Inversion, signals A and B and R incorrect	x										
F3x118	Speed difference out of tolerance			x								
F3x131	Deviation position incremental/absolute too high										x	
A3x400	Alarm threshold Zero mark distance error		x									
A3x401	Alarm threshold zero mark failed		x									
A3x418	Speed difference each sampling rate exceeded			x								
A3x422	Pulse number squarewave encoder out of tolerance bandwidth											x

11.5.15 Overview of important parameters

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0404[0...n] Encoder configuration active
- p0405[0...n] Squarewave encoder track A/B / squarewave encoder A/B
- p0408[0...n] Rotary encoder pulse number
- p0430[0...n] Sensor Module configuration
- p0437[0...n] Sensor Module configuration extended
- p0438[0...n] Squarewave encoder filter time
- r0452[0...n] Squarewave encoder filter time display
- r0458[0...n] Sensor Module properties
- r0459[0...n] Sensor Module properties extended
- p4680[0...n] Zero mark monitoring permissible tolerance
- p4681[0...n] Zero mark monitoring tolerance window positive limit
- p4682[0...n] Zero mark monitoring tolerance window negative limit
- p4683[0...n] Zero mark monitoring tolerance window alarm threshold positive
- p4684[0...n] Zero mark monitoring tolerance window alarm threshold negative
- p4686[0...n] Zero mark minimum length
- r4688[0...n] Zero mark monitoring, differential pulse count
- r4689[0...n] Squarewave encoder, diagnostics

11.6 Encoder diagnostics

11.6.1 Datalogger

A datalogger is available to support troubleshooting; this datalogger can localize errors in the encoder evaluation.

Commissioning

Set parameter p0437.0 = 1 to activate this function.

The datalogger is automatically active as soon as the current controller time is slower than 125 µs.

Principle of operation

The datalogger reads out several internal signals of the encoder evaluation, which serve as basis for the actual value generation. A change in the fault state serves as trigger for the recording. Data is recorded a short time before the fault state as well as afterwards.

The diagnostics data is saved on the memory card in the following directories:

`/USER/SINAMICS/DATA/SMTRC00.BIN`

…

`/USER/SINAMICS/DATA/SMTRC07.BIN`

`/USER/SINAMICS/DATA/SMTRCIDX.TXT`

The following information is contained in the index file (SMTRCIDX.TXT):

- Displaying the last written BIN file
- Number of still possible write operations (from 10000 downwards).

Note

BIN files can only be evaluated by Siemens.

Alarm A3x930[1)] is output while diagnostics data is being actively recorded. Do not switch off the system during this time.

[1)] x = encoder number (x = 1, 2 or 3)

11.6.2 Encoder dirty signal

Some encoders have an additional output, which switches from "high" to "low", if the evaluation electronics in the encoder can no longer determine a reliable position.

To inform you about this condition, the drive outputs alarm A3x470[1].

[1] x = encoder number (x = 1, 2 or 3)

Commissioning

Connect the corresponding encoder signal with the CTRL input (monitoring signal) of the device. Parameterization is not required.

Note

The input is automatically set to a high level if a wire is broken: As a consequence, for a broken wire, the encoder is considered to be "good".

11.6.3 Overview of important parameters

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0437[0...n] Sensor Module configuration extended
- r7831[0...15] Telegram diagnostics signals

11.7 DCC axial winder

Description

The "DCC axial winder" functionality covers a wide variety of winder applications.

With a suitable setup, the function provides a winder or unwinder for a wide variety of applications, such as film production 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 is used to wind or unwind a continuous web with a defined tension. The wound roll diameter changes 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 characteristic
   The block is used for defining the tension setpoint as a function of the actual diameter of the roll being wound. The setpoint is adjusted according to a selectable characteristic curve.
2. DCA block: Diameter calculator
   The DCA (Diameter Calculator) is used to determine the actual diameter of a roll being wound 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 a wound roll, 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 parameer p1497 (referred to the static moment of inertia).

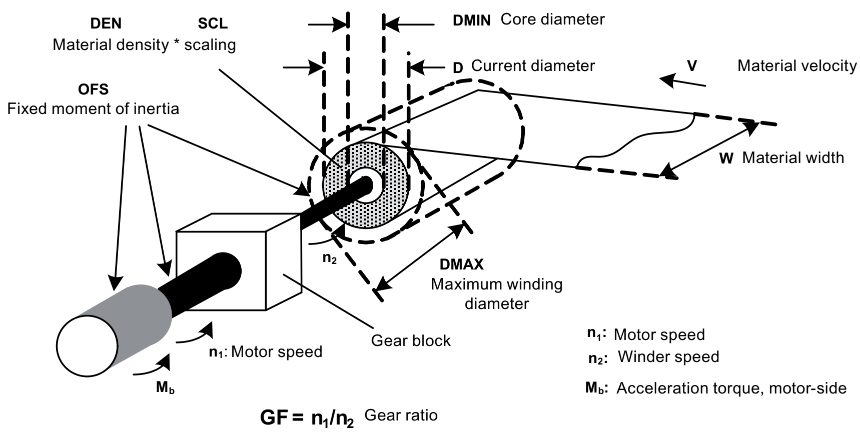


Figure 11-8 Axial winder setup

Operating principle

To maintain a constant tension of the continuous web, the drive torque is increased linearly as the wound roll diameter increases - or is decreased linearly as the diameter decreases.

To protect the material being wound, the tension is reduced according to a characteristic as the wound roll 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 [5042] / without encoder [5210]:

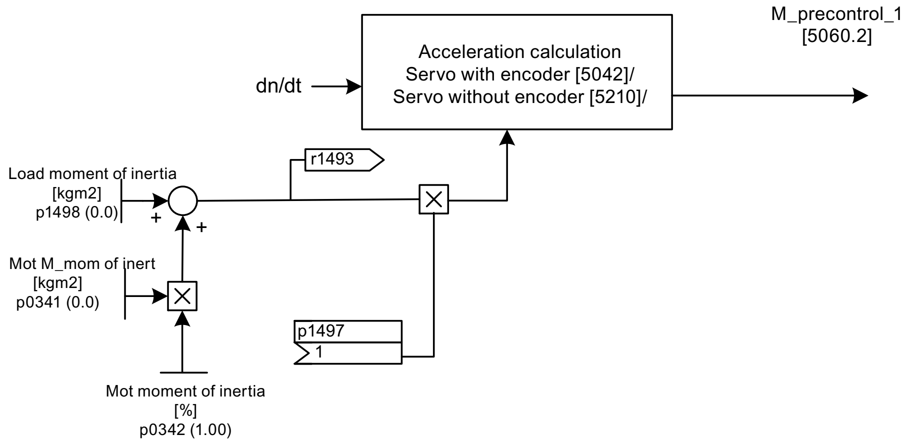


Figure 11-9 Torque pre-control for SERVO control

The function diagram below shows the calculation flow for VECTOR control [6031]:

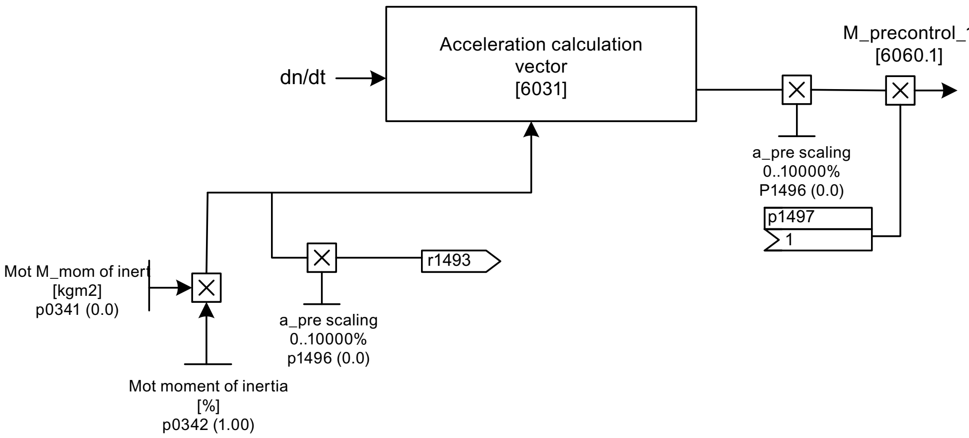


Figure 11-10 Torque pre-control for VECTOR control

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

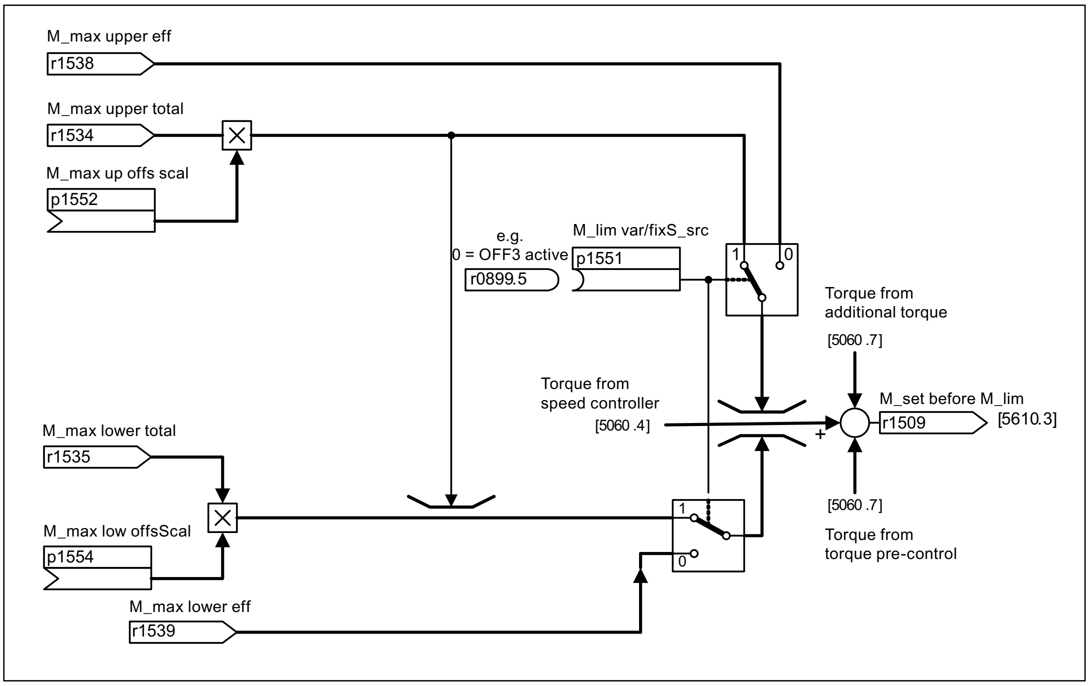


Figure 11-11 Limitation of the speed controller output with dynamic speed limits (example of SERVO) See 6060 for VECTOR application.

Parameters of the function diagram for torque limitation

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 S120/S150 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

11.8 Control Units without infeed control

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 precisely one Control Unit and which includes a drive object X_INF[1)], 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

Examples: interconnecting "Infeed ready"

Smart Line Modules without DRIVE-CLiQ (5 kW and 10 kW)

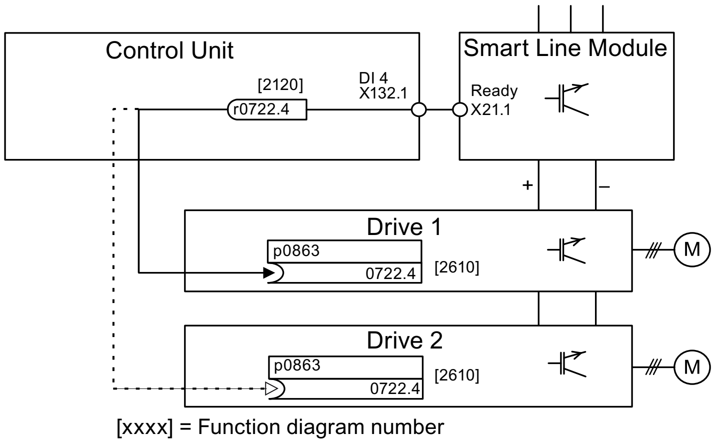


Figure 11-12 Example: interconnecting a Smart Line Module without DRIVE-CLiQ

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 is a digital input in the example.

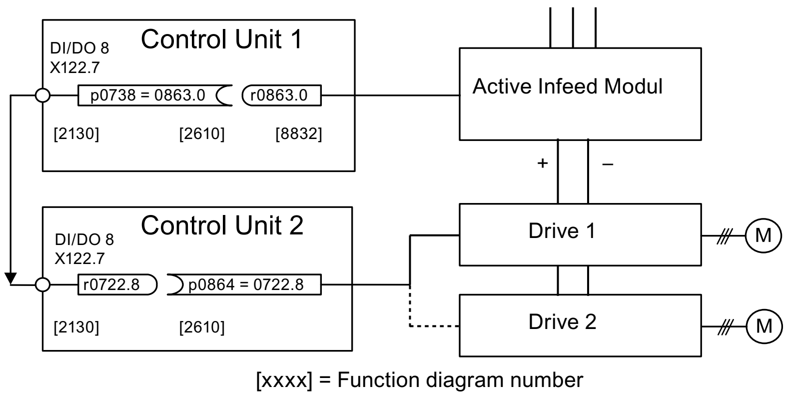


Figure 11-13 Example: interconnection with more than one Control Unit

1) X_INF stands for all drive objects "Infeed"; i.e.: A_INF, B_INF, S_INF

11.9 Derating function for chassis units

Description

An adjusted derating function greatly reduces the noise produced by chassis format power units (Motor Modules and Power Modules) and enables 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 format) and Power Modules (AC/AC units of chassis format). Units that are connected in parallel operate in the same manner als 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.

Operating 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.

11.10 Application: emergency stop with power failure and/or emergency stop (Servo)

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 provided that the DC link voltage is still available. The following section describes how all the drives carry out a quick stop (OFF3) if the power fails.

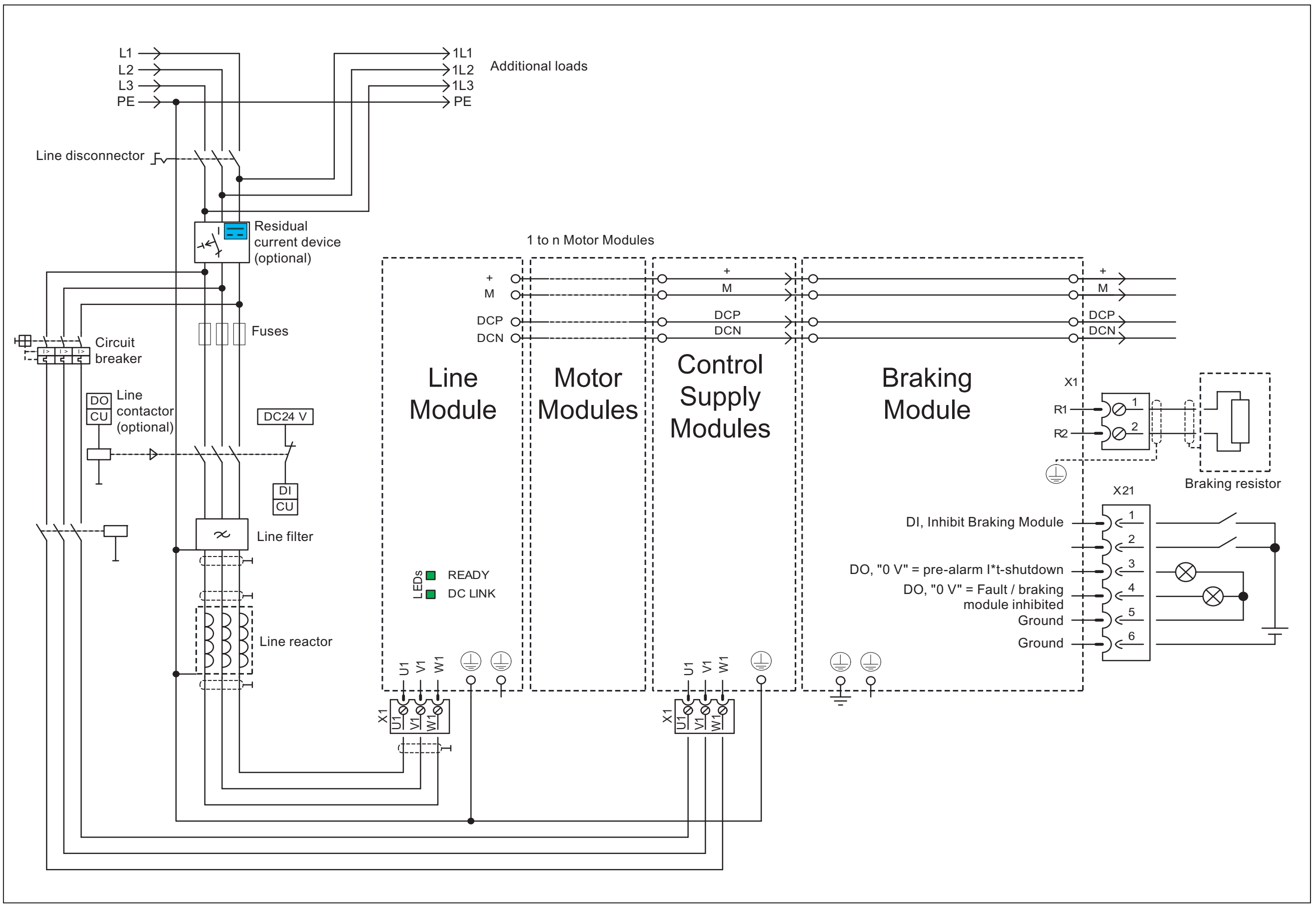


Figure 11-14 Example: interconnection of quick stop due to power failure or emergency off

In addition to the component wiring shown above, each drive object that is to carry out a quick 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 (quick 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). Fault F07403 is triggered when this threshold is reached. 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

12 Basic information about the drive system

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

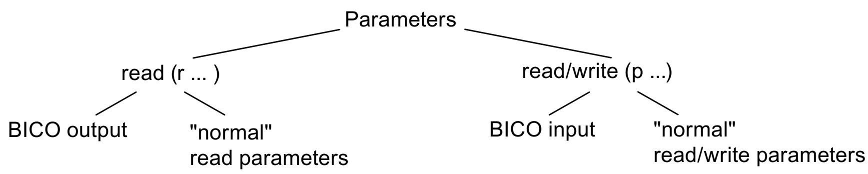


Figure 12-1 Parameter types

All these drive parameters can be read via PROFIBUS and changed by means of p parameters 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 changeover.

- EDS Encoder Data Set
- MDS Motor Data Set

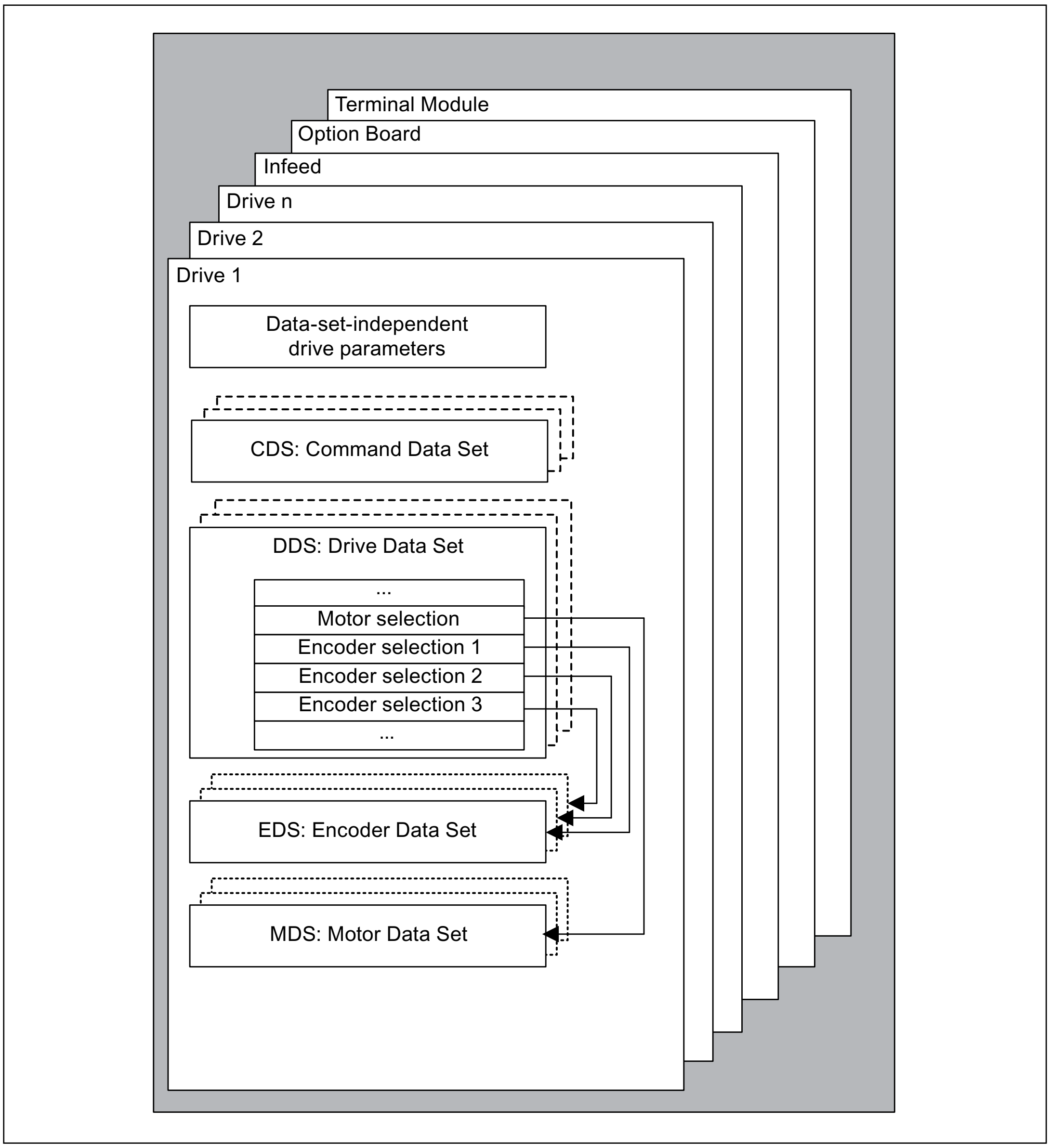


Figure 12-2 Parameter categories

Saving parameters in a non-volatile memory

The modified parameter values are stored in the volatile RAM. When the drive system is switched off, these data are lost.

The data must be saved retentively on the memory card, as described below, 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 S120/S150 List Manual specifies the access level in which 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 1 Standard	Parameters from the user-defined list (p0013) 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:

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: Changeover between command data set 0 and 1

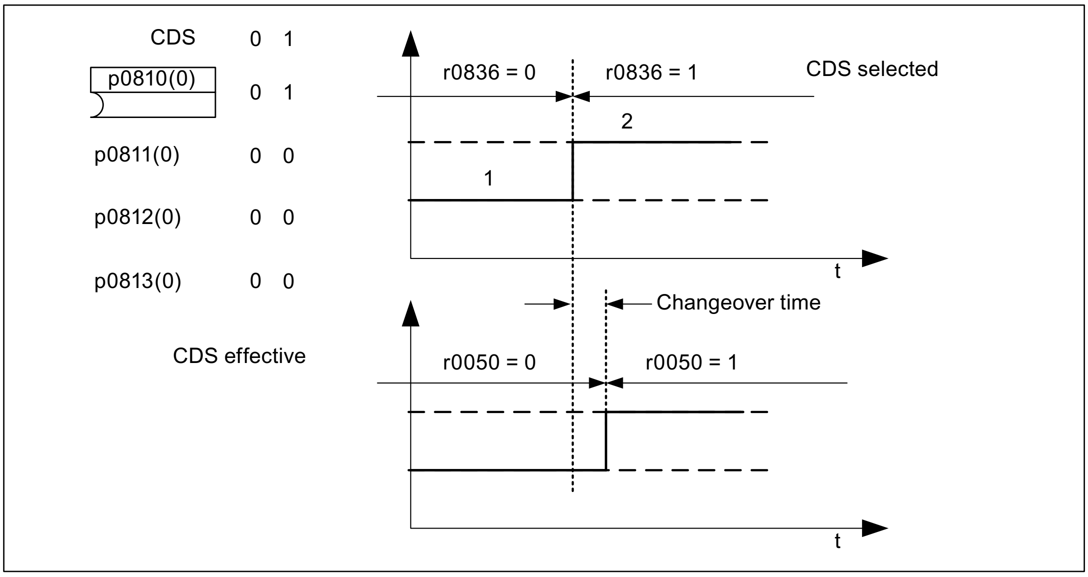


Figure 12-3 Switching the command data set (example)

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 changeover. The following must therefore apply:

  p0180 (DDS) ≥ max. (p0120 (PDS), p0130 (MDS))
- Max. 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 (pollage ID performed or commutation angle determined for absolute encoders).

Within a drive, each encoder must always be either encoder 1, encoder 2, or encoder 3 in each drive data set.

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. 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.

If a motor is to operate with motor encoder 1 and then another time with motor encoder 2, then two different MDS must be created, in which the motor data are then the same.

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.

NOTICE
EDS in Safety mode
The encoders used for the Safety function must not be changed when the data set is switched. When the data set is switched, the Safety function checks the safety-relevant encoder data to see if it has changed. If it has changed, fault F=1670 is output with fault value 10, which results in a non-acknowledgeable STOP A.

The safety-relevant encoder in the different data sets must, therefore, be identical.

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. It also contains certain display parameters with calculated data.

- Adjustable parameters, e.g.:
  - Motor component number (p0131)
  - Motor type selection (p0300)
  - Rated motor data (p0304 ff)
  - ...
- Display parameters, e.g.:
  - Calculated rated data (p0330 ff)
  - ...

The parameters that are grouped together in the motor data set are identified in the SINAMICS S120/S150 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 changeover)
- 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 changeover" 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; 9-16;...). 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	-	-

12.2.5 Integration

Function diagrams (see SINAMICS S120/S150 List Manual)

- 8560 Command Data Sets (CDS)
- 8565 Drive Data Sets (DDS)
- 8570 Encoder Data Sets (EDS)
- 8575 Motor Data Sets (MDS)

Overview of important parameters (see SINAMICS S120/S150 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 possibly 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).

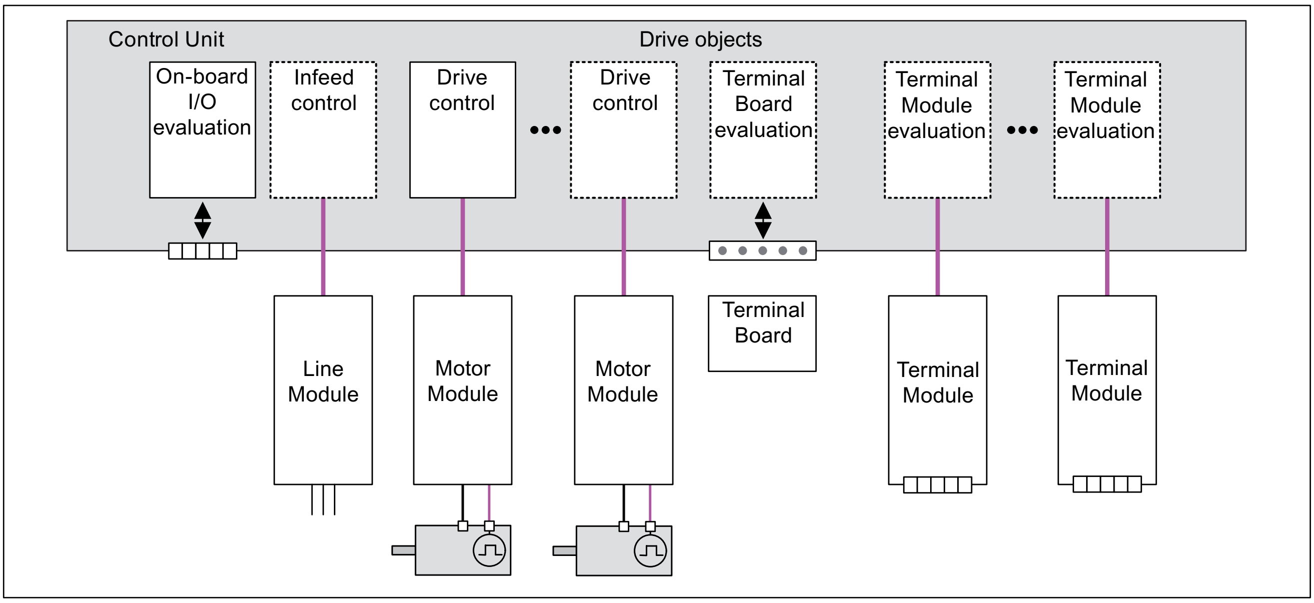


Figure 12-4 Drive objects

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 drive control modes 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 first 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 first 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 first commissioning for unique identification.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

Adjustable parameters

- p0101 Drive object numbers
- p0107 Drive object type
- p0108[0...23] Drive object configuration (only for the Control Unit drive object)

Display parameters

- r0102 Number of drive objects
- r0108 Drive object configuration (all other 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 commissioning tool is recommended when using BICO technology.

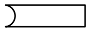
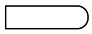
12.4.2 Binectors, connectors

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).

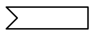
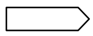
Table 12- 3 Binectors

Abbreviation	Symbol	Name	Description
BI		Binector input (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 (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 32-bit format. It can be used to emulate words (16 bits), double words (32 bits) or analog signals. Connectors are subdivided into connector inputs (signal sink) and connector outputs (signal source).

Table 12- 4 Connectors

Abbreviatio n	Symbol	Name	Description
CI		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 (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)

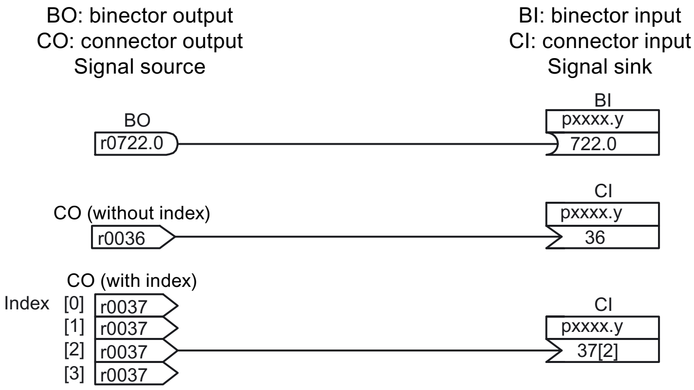


Figure 12-5 Interconnecting signals using BICO technology

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: SINAMICS S120/S150 List Manual,
section "Explanation of list of parameters" in table "Possible combinations for BICO interconnections".

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.

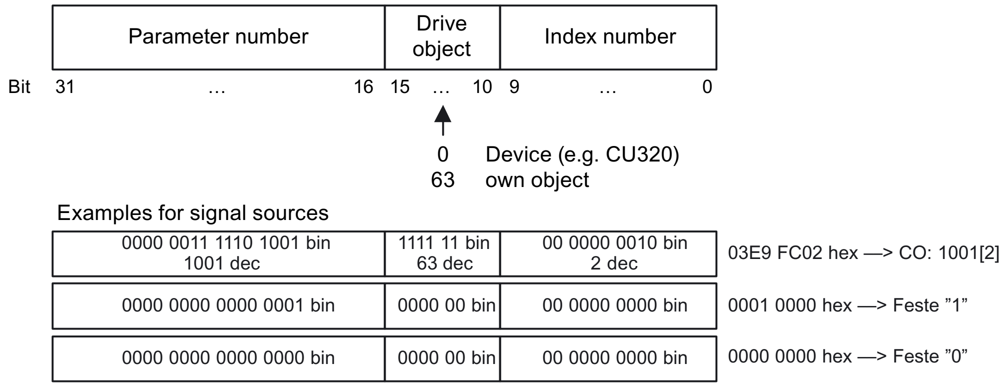


Figure 12-6 Internal encoding of the binector/connector output parameters

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.

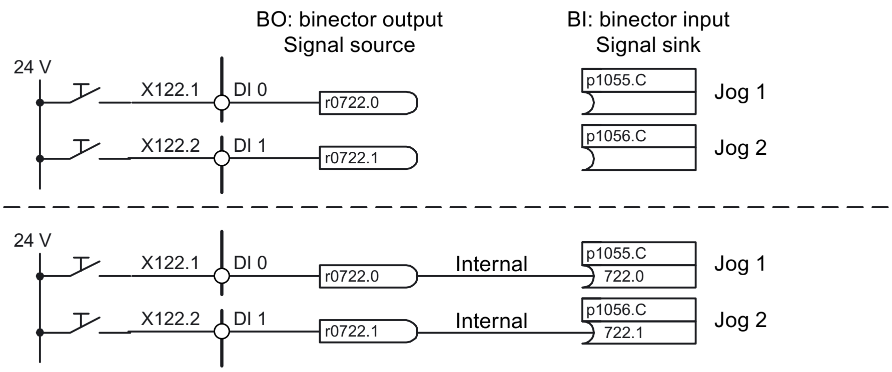


Figure 12-7 Interconnection of digital signals (example)

Example 2: connection of OC/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).

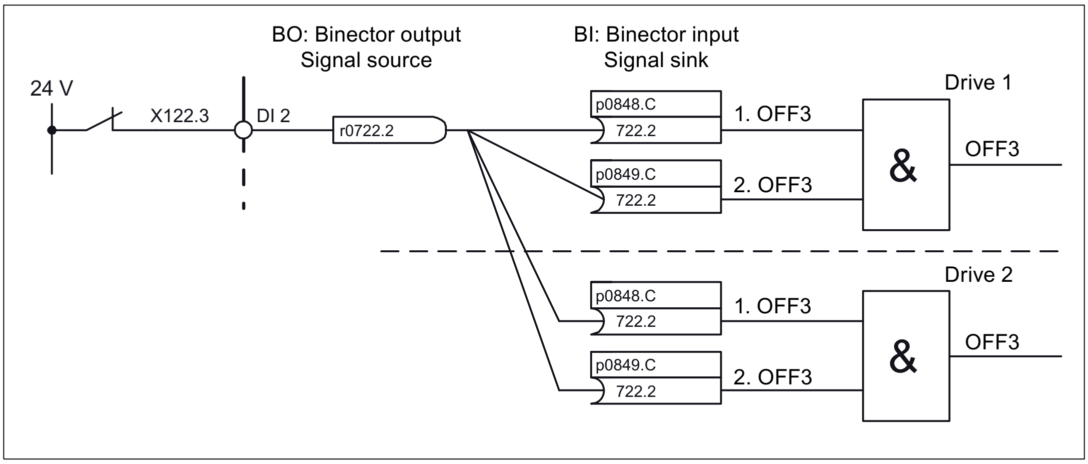


Figure 12-8 Connection of OFF3 to several drives (example)

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
Speed actual value	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 modulation depth
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 per unit representation is selected and the reference parameter is subsequently changed (e.g. p2000), the per unit values of some control parameters are automatically adapted so that the control behavior does not change.

12.4.8 Forwarding of faults

Forwarding of CU faults

When faults are triggered on the drive object of the CU, it is always assumed that central functions of the drive unit are affected. For this reason, these faults are not only signaled on the drive object of the CU, but may also be forwarded to all other drive objects (propagation). The fault reaction affects the drive object of the CU and all other drive objects. This behavior also applies to the faults set in a DCC chart on the CU with the aid of DCB STM.

A fault that is set on the drive object of the CU must be acknowledged on all drive objects to which this fault was forwarded. In this way, the fault is then automatically acknowledged on the drive object of the CU. Alternatively all faults of all drive objects can also be acknowledged on the CU.

Alarms are not forwarded to other drive objects by the CU.

Example

Drive object faults are only transferred to the drives, i.e. a fault on a TB30 stops the drive - however, a fault on the drive does not stop the TB30.

Forwarding of faults due to BICO interconnections

If two or more drive objects are connected via BICO interconnections, faults of drive objects of the type CU, TB30, DMC20, TM31, TM15, TM17, TM15DIDO, TM54F_MA, TM54F_SL and CU_LINK are forwarded to drive objects of the type AFE, AFEMV, DFEMV, SIC, BIC, SERVO, VECTOR, VECTOR_MV, VECTOR_GL, VECTOR_SL and TM41. There is no forwarding of faults within these two groups of drive object types.

This behavior also applies to the faults set in a DCC chart on the above drive object types with the aid of DCB STM.

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
CU320-2	12 1)	8 2)	-	-	-
TB30	4	-	4	2	2
TM15DI_DO	-	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)				
TM120	Temperature sensor inputs: 4				
1) Variable: Floating or non-floating 2) 6 of these are "high-speed inputs"					

Note

For detailed information about the hardware properties of I/Os, please refer to document: 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 document: SINAMICS S120/S150 List Manual.

12.5.2 Digital inputs/outputs

Digital inputs

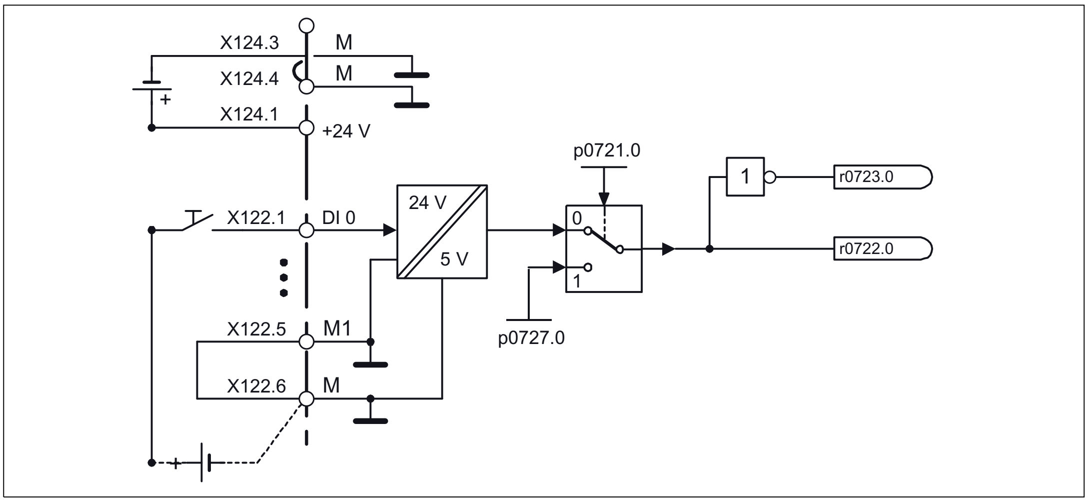


Figure 12-9 Digital inputs: Signal processing using DI 0 as an example

Properties

- The digital inputs are "high active".
- An open input is interpreted as "low".
- Fixed debounce 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.
- 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 can be adjusted (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

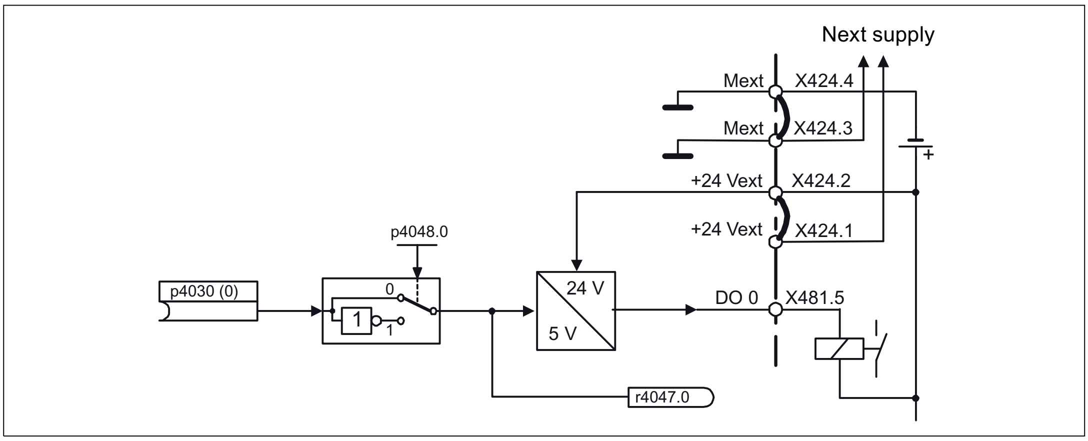


Figure 12-10 Digital outputs: Signal processing using DO 0 of the TB30 as an example

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

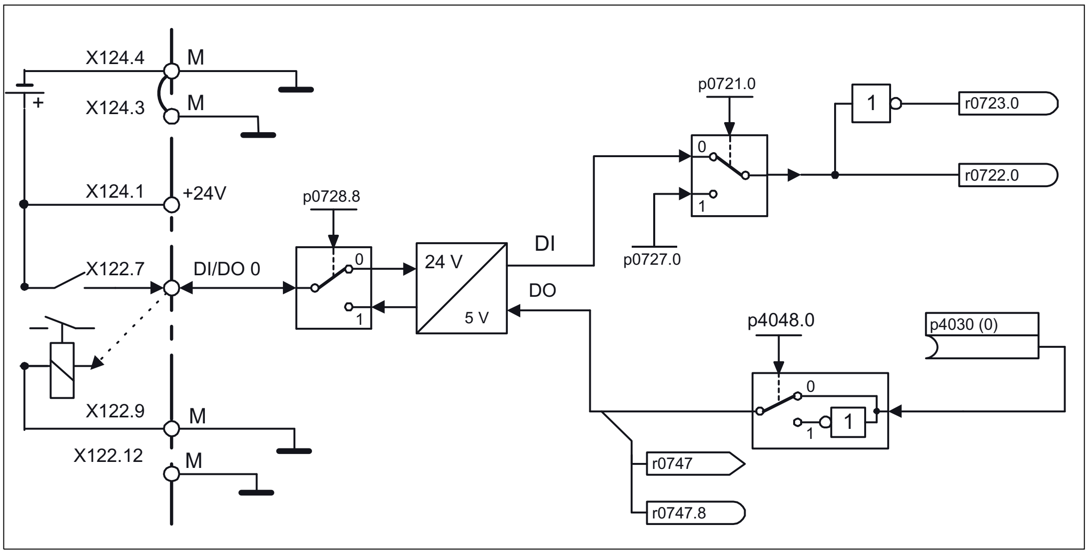


Figure 12-11 Bidirectional inputs/outputs: Signal processing using DI/DO 0 as an example

Properties

- Can be parameterized as digital input or output.
- When set as digital input:
  - Six "high-speed inputs" on Control Unit

    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.
- Sharing of bidirectional input/output resources by the CU and higher-level control (see section "Use of bidirectional inputs/outputs on the CU")

Function diagrams (see SINAMICS S120/S150 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 Use of bidirectional inputs/outputs on the CU

Description

The bidirectional inputs/outputs on terminals X122 and X132 on the CU (DO1) can be used by a drive DO as well as a higher-level control (resource sharing).
The assignment to a terminal is defined by means of BICO interconnections, which are either connected to a control by DO1 telegram p0922 = 39x and to a drive DO.

The setting of parameter p0729 indicates how a digital output has been assigned to a drive CU, i.e. whether the output of an onboard terminal X122 or X132 is assigned directly to the CU or connected via PROFIBUS to a higher-level control.

- r0729 = 0: Output is assigned to the drive CU or terminal output is not available.
- r0729 = 1: Output is assigned to the higher-level control (PROFIBUS connection).
  Assignment to the control means:
  - Terminal is parameterized as output x (p0728.x =1) and
  - Terminal is BICO-connected with p2901, i.e. the control uses the output in conjunction with the DO1 telegram (p0922 = 39x) as standard
  - Use of the terminal's output signal for integrated platform via high-speed bypass channel of the control (standard channel with DO1 telegram is always written in parallel).

Parameter r0729 is updated if

- the direction of the onboard terminals changes (p0728)
- the signal sources for the outputs (p0738ff) are changed.

Access priorities

- Reconfiguration output control --> output drive via parameter p738ff
  The drive output has higher priority than a standard control output using the DO1 telegram, but direct access by the control to the terminal (bypass) has higher priority than the drive output.
  When the output is reconfigured to the drive, the control needs to cancel a bypass to the terminals (if one has been set up) before the new configuration can take effect.
- Reconfiguration input drive --> output control
  The output of the control has higher priority. This is the specified behavior.
  The drive is notified of the change so that the affected application can issue an alarm.
- Reconfiguration output drive --> output control
  The output of the control has higher priority.
  This is the specified behavior.
  The drive is notified of the change so that the affected application can issue an alarm/fault message is necessary. Readback of the output information can cause problems in the drive, i.e. the drive application checks the interconnection condition of "its" terminals. If the terminal remains assigned to a drive I/O device as required by the drive function, but is assigned simultaneously a control terminal status, the drive function cannot be guaranteed to work correctly.

Fault reaction to control failure

The onboard I/Os assigned to the control are switched to the safe state in response to a fault.
This also applies to terminals whose signals are transferred via the bypass channel on the control. This status is signaled by failure of the DO1 telegram (sign-of-life failure).

12.5.4 Analog inputs

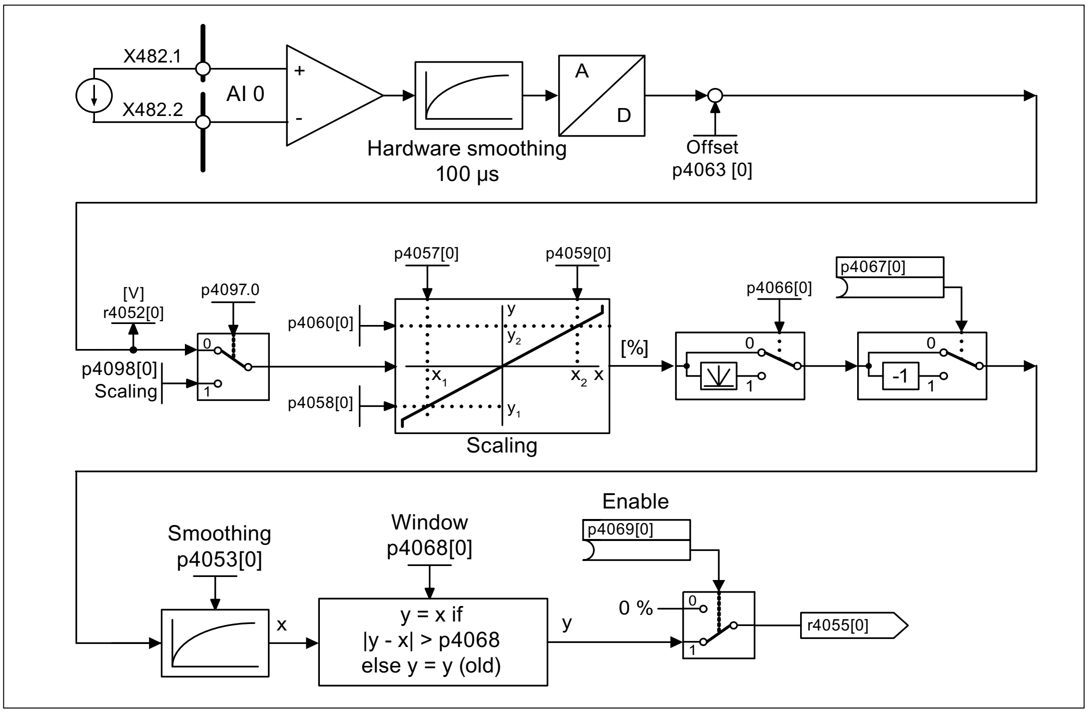


Figure 12-12 Analog inputs: Signal processing using AI0 of the TB30

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
- Skalierung
- 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)

12.5.5 Analog outputs

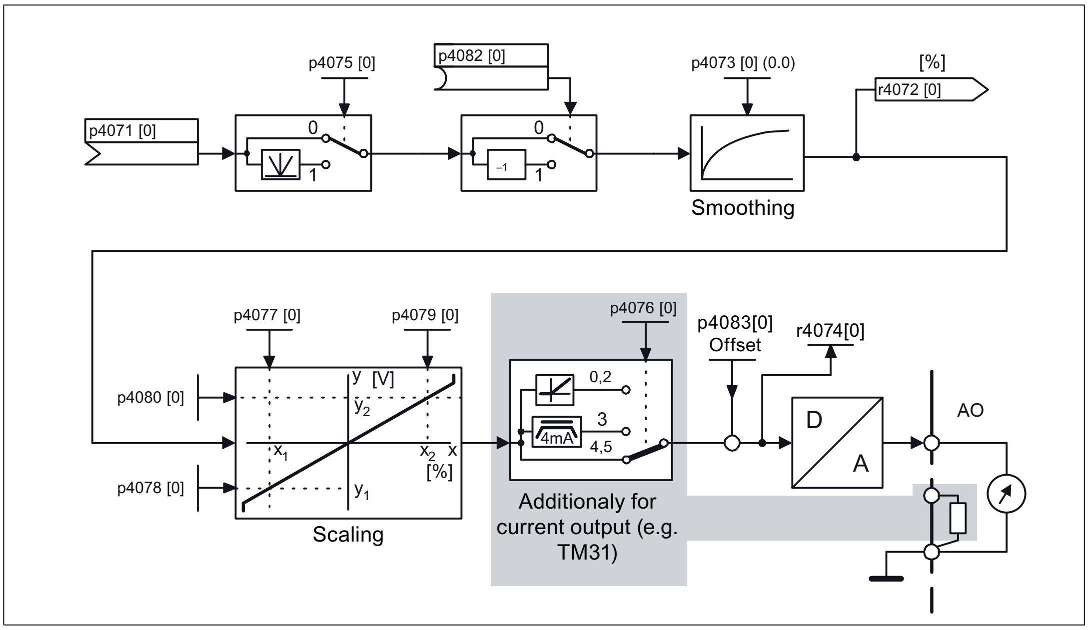


Figure 12-13 Analog outputs: Signal processing using AO 0 of TB30/TM31 as an example

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 output can be used as current output).

Function diagrams (see SINAMICS S120/S150 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

The BOP20 can be used to switch on and switch off drives during the commissioning phase as well as display and modify parameters. Faults can be diagnosed as well as acknowledged.

The BOP20 is snapped onto the Control Unit. To do this, the blanking cover must be removed (for additional notes on installation, see the Manual).

Overview of displays and keys

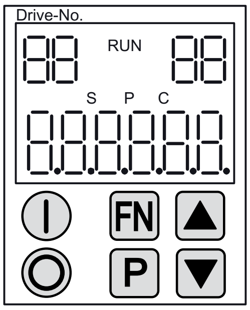


Figure 12-14 Overview of displays and keys

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
	ON	Powering up the drives for which the command "ON/OFF1" should come from the BOP. Binector output r0019.0 is set using this key.
	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).
	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.
	Parameter	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.

Overview of important parameters (see SINAMICS S120/S150 List Manual)

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

- r0002 Control Unit status 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, VECTOR, X_INF, 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.

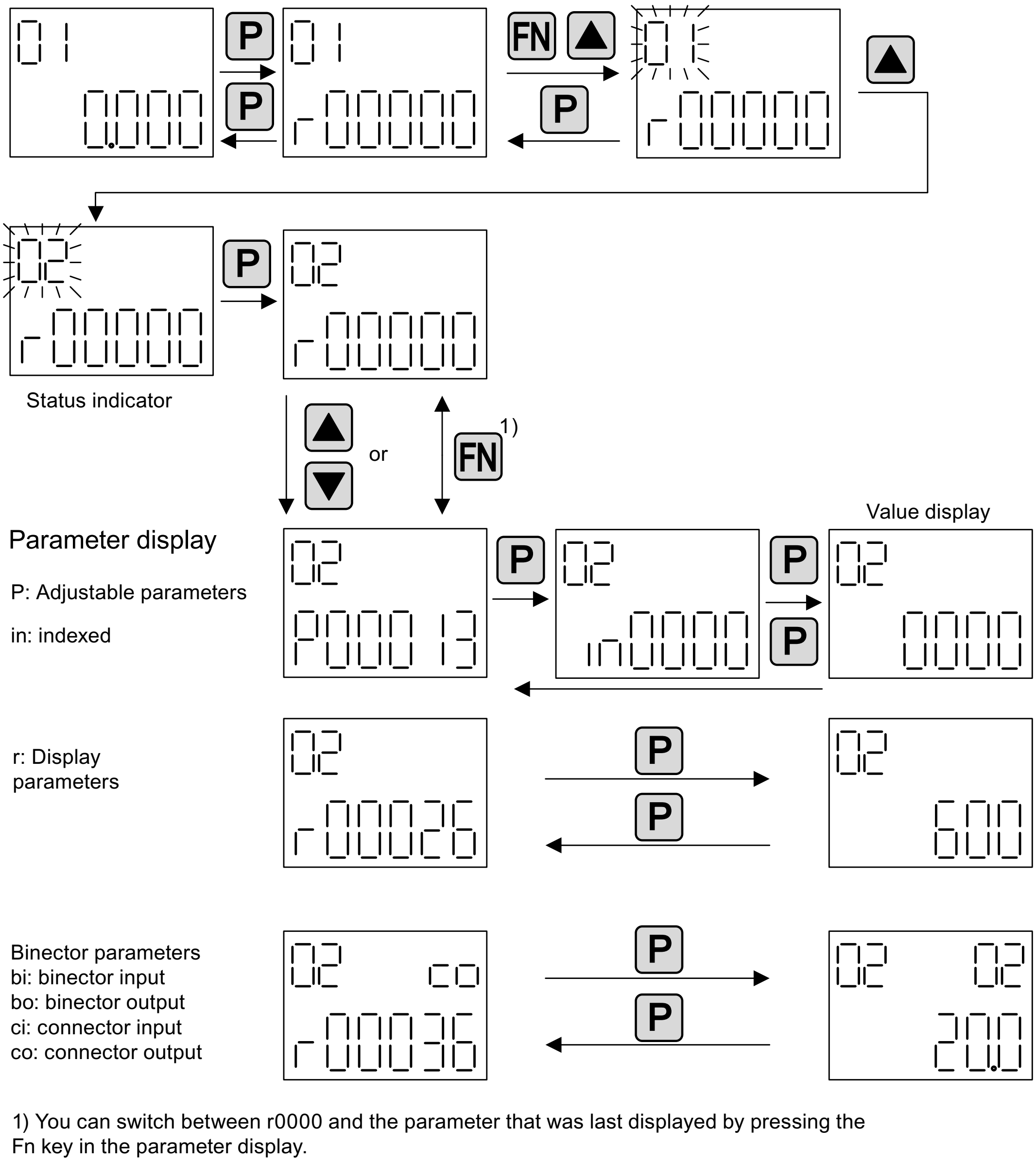


Figure 12-15 Parameter display

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.

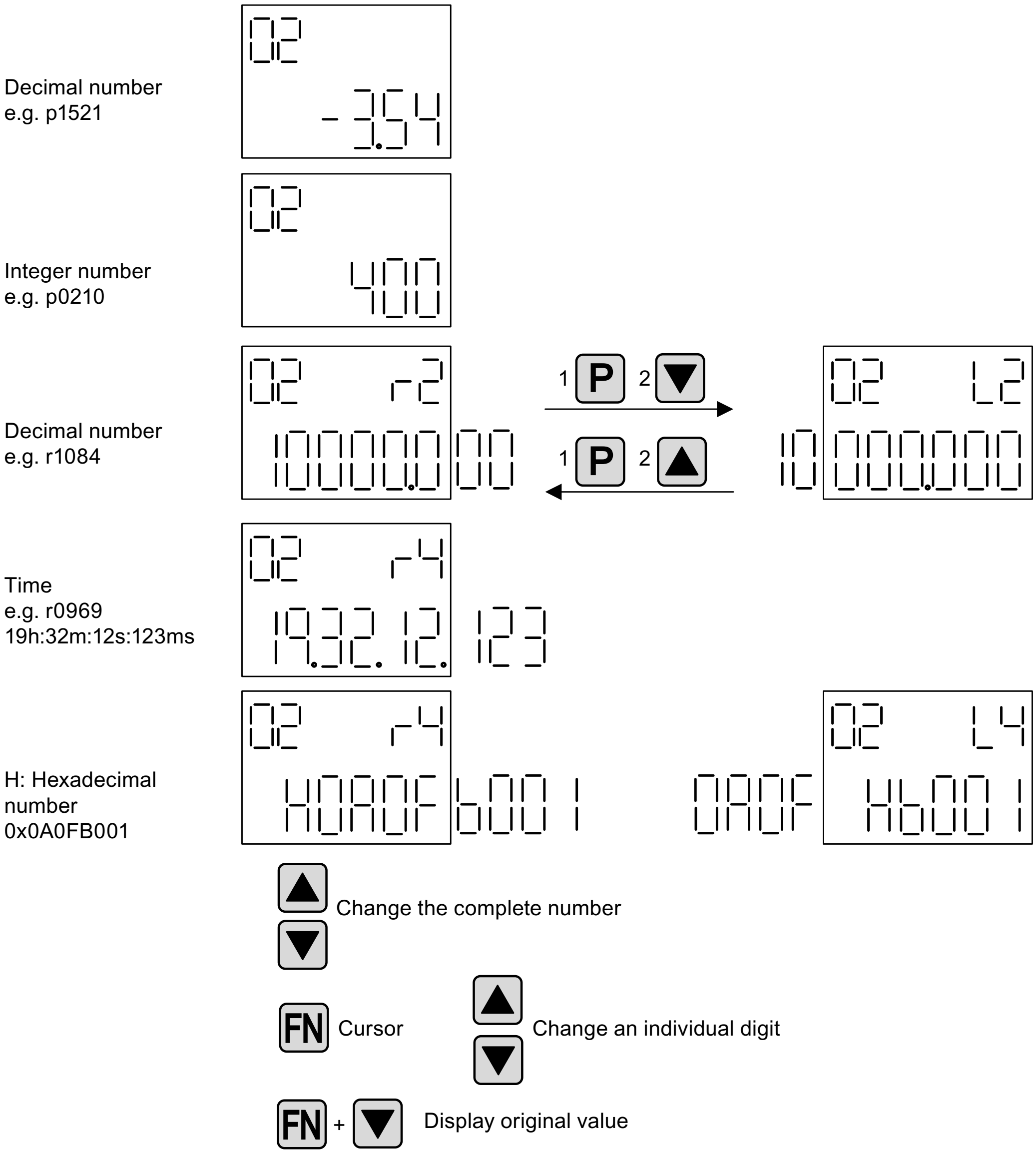


Figure 12-16 Value display

Example: Changing a parameter

Precondition: The appropriate access level is set
(for this particular example, p0003 = 3).

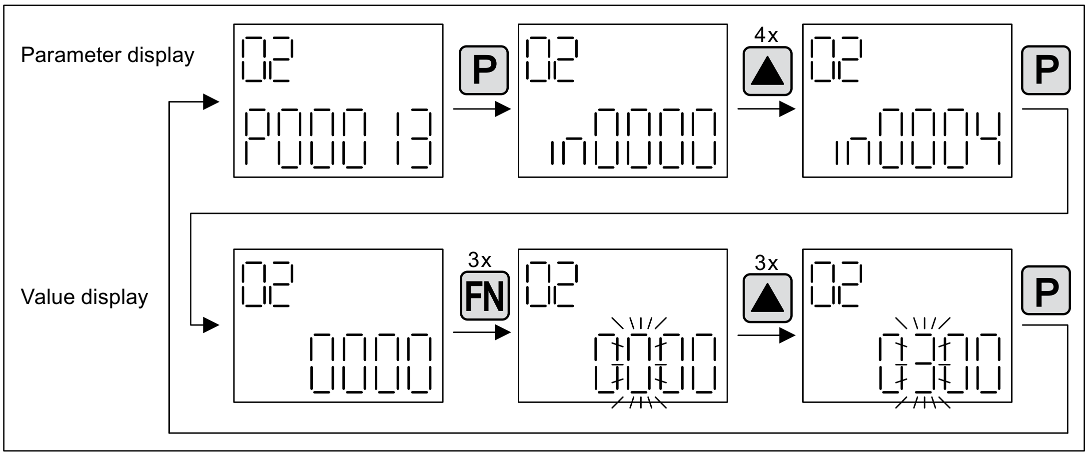


Figure 12-17 Example: Changing p0013[4] from 0 to 300

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.

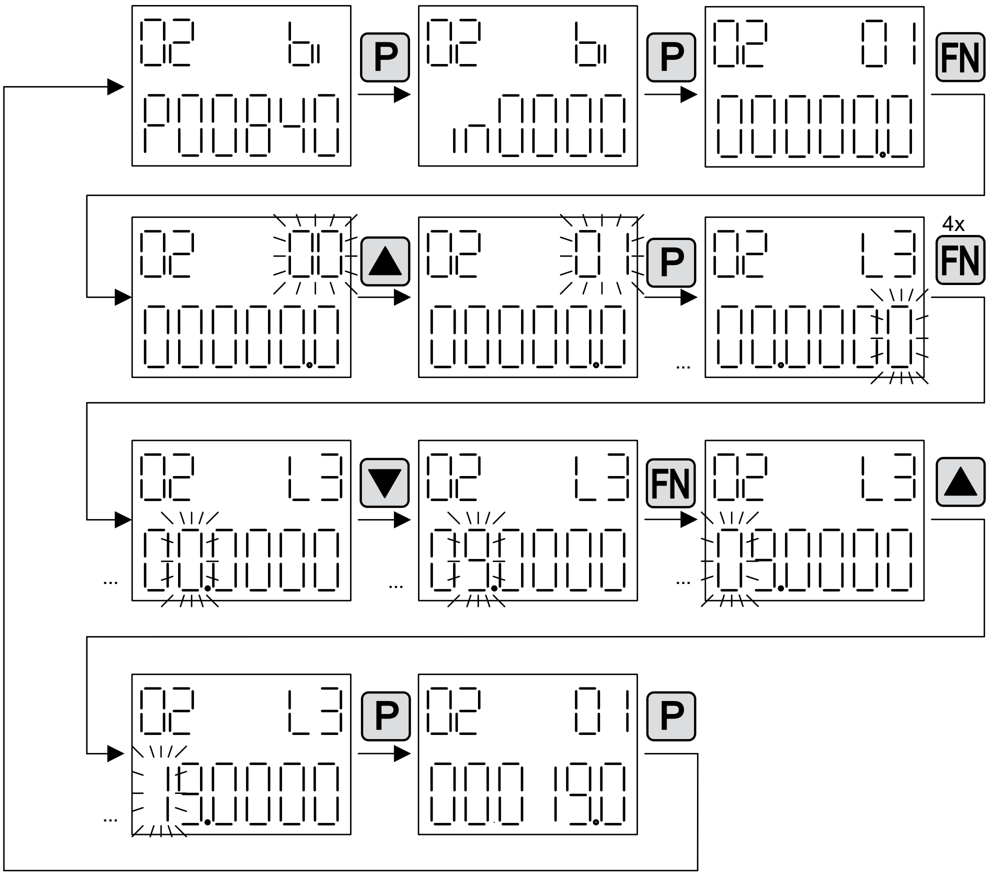


Figure 12-18 Example: Changing indexed binector parameters

12.6.3 Fault and alarm displays

Displaying faults

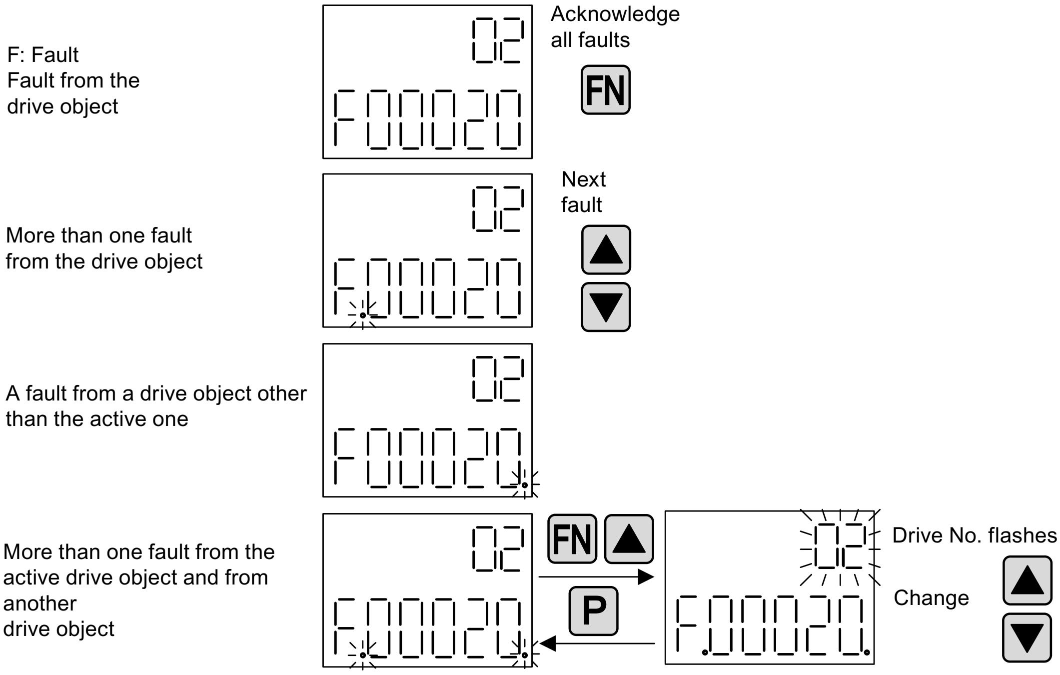


Figure 12-19 Faults

Displaying alarms

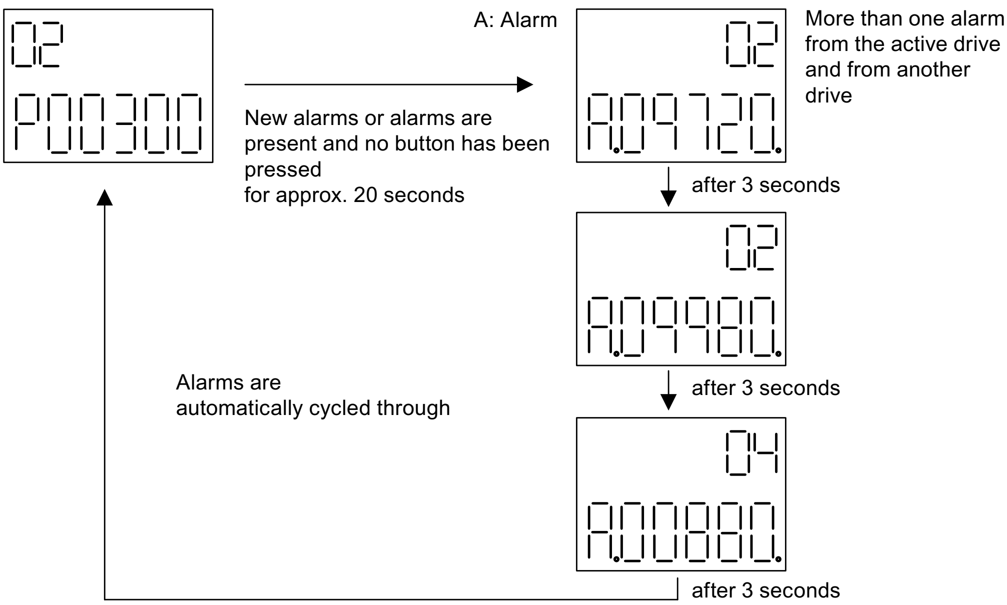


Figure 12-20 Alarms

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) for this purpose, which can be interconnected with the appropriate binector inputs of e.g. the drive.

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 rating plate match, the transfer is realized using p9904 = 1 or p9905 = 1.

For the components that have been replaced, the electronic rating plate must match as far as the following data are concerned:

- Component type (e.g. "SMC20")
- Order No. (e.g. "6SL3055–0AA00–5Bxx")

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	Remark
• Switch off the power supply • Replace the defective component and connect the new one • Switch on the power supply	• Alarm A01420	
• 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 p0977 = 1 and p0971 = 1. As an alternative, STARTER can be used to backup data with a RAM to ROM operation.
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	Remark
• Switch off the power supply • Replace the defective component and connect the new one • Switch on the power supply	• Alarm A01425	
• 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 p0977 = 1 and p0971 = 1. As an alternative, STARTER can be used to backup data with a RAM to ROM operation.
The component has been successfully replaced.		

Example: Replacing a Motor Module/Power Module with a different power rating

Preconditions:

- 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	Remark
• 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 has been significantly reduced so that if DRIVE-CLiQ lines are accidentally changed over this will not be detected.
• 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 p0977 = 1 and p0971 = 1. As an alternative, STARTER can be used to backup data with a RAM to ROM operation.
The component has been successfully replaced.		

Replacing SINAMICS Sensor Module Integrated or DRIVE-CLiQ Sensor Integrated

If a defect occurs in a SINAMICS Sensor Module Integrated (SMI) or in a DRIVE-CLiQ Sensor Integrated (DQI), contact your local Siemens office for a repair.

12.8 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 various components in SINAMICS (e.g. Control Unit, Line Module, Motor Module, motor and encoder).

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 rating 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 memory 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 memory 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 memory 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 boots, the Control Unit compares the detected actual topology and the electronic rating plates with the target topology stored on the memory card.

You can specify how the electronic rating 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 rating plate are compared by default.

The following data in the target and actual topologies is compared depending on the settings made in p9906/9908:

- p9906/p9908 = 0 component type, order number, manufacturer, serial number
- p9906/p9908 = 1 component type, order number
- p9906/p9908 = 2 component type
- p9906/p9908 = 3 component class (e.g. Sensor Module or Motor Module)

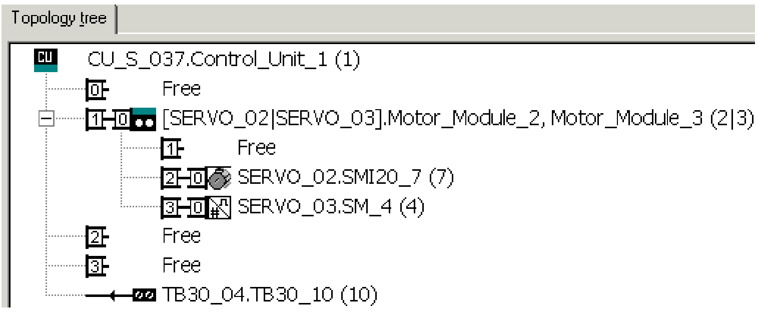


Figure 12-21 Topology view in STARTER

NOTICE
The Control Unit and the Option Board are not monitored. A replacement of components is accepted automatically and not displayed.

12.9 Rules for wiring with DRIVE-CLiQ

Rules apply for wiring components with DRIVE-CLiQ. A distinction is made between **binding DRIVE-CLiQ rules**, which **must** be unconditionally observed and **recommended rules**, which**should** then be maintained so that the topology, generated offline in STARTER, no longer has to be changed.

The maximum number of DRIVE-CLiQ components and the possible wiring type depend on the following factors:

- 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.

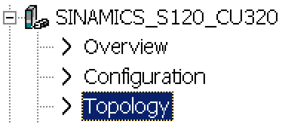
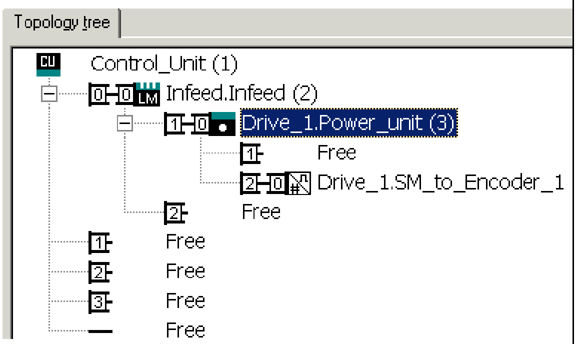
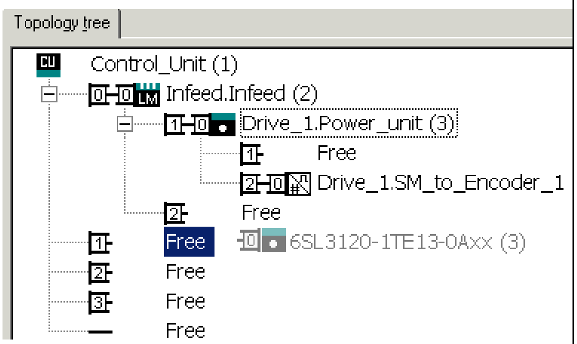
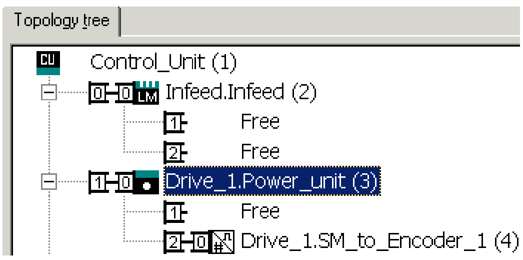
The components used in these examples can be removed, replaced with others or supplemented. If components are replaced by another type or additional components are added, the SIZER tool should be used to check the topology.

If the actual topology does not match the topology created offline by STARTER, the offline topology must be changed accordingly before it is downloaded.

12.9.1 Changing the offline topology in STARTER

The device topology can be changed in STARTER by moving the components in the topology tree.

Table 12- 14 Example: changing the DRIVE-CLiQ topology

	Topology tree view	Remark
		Select the DRIVE-CLiQ component.
		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.

12.9.2 Binding DRIVE-CLiQ rules

DRIVE-CLiQ rules

The wiring rules below apply to standard cycle times (servo 125 µs, vector 250 µs). For cycle times that are shorter than the corresponding standard cycle times, additional restrictions apply due to the computing power of the Control Unit (configured using the SIZER configuration tool).

General DRIVE-CLiQ rules

The following general binding DRIVE-CLiQ rules must be observed to ensure safe operation of the drive.

1. A maximum of 14 DRIVE-CLiQ nodes can be connected to one DRIVE-CLiQ line at a Control Unit (e. g. 12 U/f axes + Infeed Module + 1 additional module). In the example below, the DRIVE-CLiQ line includes drive objects 1 to 14.
2. It is permissible to connect a maximum total of 8 Motor Modules to the Control Unit. For multi-axis modules, each axis counts individually (1 Double Motor Module = 2 Motor Modules). Exception: For U/f control it is permissible to connect a maximum of 12 Motor Modules.
3. With vector U/f control, it is only permissible to connect more than 4 participants to one DRIVE-CLiQ line of the Control Unit.
4. Ring wiring of components is not permitted.
5. Double wiring of components is not permitted.

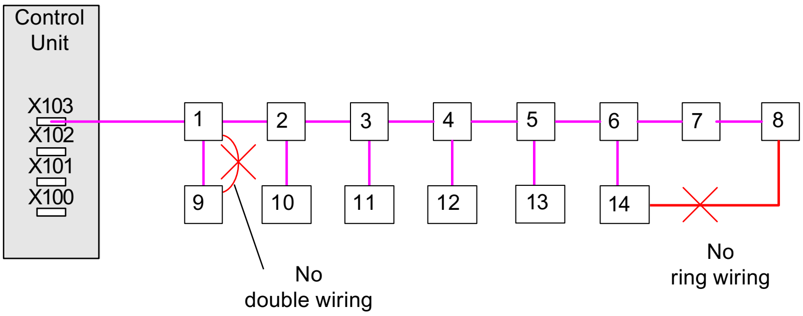


Figure 12-22 Example: DRIVE-CLiQ line connected to the X103 DRIVE-CLiQ connection of a Control Unit

6. DRIVE-CLiQ components of unknown type within a topology are functionally not supported. The DRIVE-CLiQ signals are looped through.
   The following criteria denote the unknown type:
   – Characteristics of the component are not available.
   – A deputy drive object is not defined.
   – An assignment of the component to a known drive object is not defined.
7. In a DRIVE-CLiQ topology with a CU link and DRIVE-CLiQ connections, precisely one Control Unit is permissible as a CU link master/DRIVE-CLiQ master.

8. If a CU link connection is detected, the DRIVE-CLiQ basic clock cycle 0 (r0110[0]) is set to 125 µs and assigned to this DRIVE-CLiQ socket.
9. The following applies for booksize format:
   – In the servo control and vector U/f control operating modes, only one Line Module may be connected to the Control Unit. In the vector control operating mode, a maximum of three further Line Modules may be connected in parallel (i.e. at total of 4 Line Modules).
   – One Line Module and Motor Modules can be connected to one DRIVE-CLiQ line in the servo control mode.
   – One Line Module and Motor Modules must be connected to separate DRIVE-CLiQ lines in the vector control mode.
   – For booksize format, a parallel connection of Infeed Modules or Motor Modules is not possible.
10. The following applies for chassis format:
   – Line Modules (Active Line, Basic Line, Smart Line) and Motor Modules must be connected to separate DRIVE-CLiQ lines.
   – Motor Modules with different pulse frequencies (frame sizes FX, GX, HX, JX) must be connected to separate DRIVE-CLiQ lines.
11. Parallel operation of power units in chassis format:
   – A parallel connection of power units is permissible for vector control and U/f control but not for servo control.
   – A maximum of 4 Infeed Modules are permissible within a parallel connection.
   – A maximum of 4 Motor Modules are permissible within a parallel connection.
   – Only just one parallel connection of Motor Modules is permissible. For a parallel connection, exactly one drive object ("Servo" or "Vector") is created in the topology.
12. For parallel connection of Motor Modules, only one SINAMICS Sensor Module Integrated (SMI) is permitted for each Motor Module.
13. Switchover between different motors is not permitted for a parallel connection.
14. Mixed operation of Infeed Modules or Motor Modules:
   – The operation of Infeed Modules or Motor Modules with different performance values is not permitted within a parallel connection.
   – For Line Modules in chassis format, two parallel connections are permissible for mixed operation of Smart Line Modules and Basic Line Modules.
   – The following combinations of Line Modules are not permissible:
     Active Line Module (ALM) with Basic Line Module (BLM)
     Active Line Module (ALM) with Smart Line Module (SLM)
15. Mixed operation of formats:
   – Chassis Motor Modules and booksize Motor Modules must be connected to separate DRIVE-CLiQ lines.

16. Mixed operation of control types:
    - Mixed operation of servo control and vector control is not permissible.
    - Mixed operation of servo control and U/f control is permissible.
    - Mixed operation of vector control and U/f control is permissible.
17. Mixed operation of control cycles:
    The following combinations are permissible:
    - Servo with 62.5 µs and servo with 125 µs
    - Servo with 125 µs and servo with 250 µs
    - Vector with 250 µs and vector with 500 µs
18. Operation with Voltage Sensing Module (VSM):
    - Exactly 1 Voltage Sensing Module (VSM) may be connected to one Line Module.
      Exception: If the "Transformer" function module is activated, a second VSM may be connected.
    - A maximum of 2 VSMs may be connected to one Motor Module.
    - The VSM must be connected to a free DRIVE-CLiQ socket of the associated Line Modules/Motor Modules (to support automatic assignment of the VSM).
19. At a "SERVO" or "VECTOR" drive object, the number of connected encoders must be equal to the number of parameterized encoder data sets (p0140). A maximum of three encoders are permissible per drive object.
    Exception:
    - For a maximum quantity structure of 6 axes in servo control with a controller cycle of 125 µs and one Line Module, a maximum of 9 encoders can be connected.
    - For 5 axes in servo control with a controller cycle of 125 µs, a maximum of 15 encoders can be connected.
20. A maximum of up to 24 drive objects can be connected.
21. A maximum of 16 Terminal Modules can be connected to the CU320-2.
    Note: If a TM15 Base, TM31, TM54F or a TM41 is connected, it is necessary to reduce the number of connected standard axes.
22. Cycle times with TM31
    A maximum of 3 Terminal Modules 31 (TM31) can be connected for a 2 ms time slice.

Note

A Double Motor Module, one DMC20, one DME20, one TM54F and one CUA32 each correspond to two DRIVE-CLiQ participants. This also applies to Double Motor Modules, at which just one drive is configured.

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23. The communication basic clock cycles (p0115[0] and p4099) of all components that are connected to a DRIVE-CLiQ line must be divisible by one another with an integer result.
    - The smallest communication basic clock cycle is 125 µs.
    - The exception are a maximum of 3 servo-controlled axes with 62.5 µs communication basic clock cycle or a servo-controlled axis with 31.25 µs communication basic clock cycle.

24. For current controller clock cycles T_i < 125 µs, the Motor Modules - also with the same controller clock cycle - must be symmetrically connected to two DRIVE-CLiQ ports.
25. The fastest sampling time of a drive object in servo control mode is given as:
    - T_i = 31.25 µs: Exactly 1 drive object in servo control
    - T_i = 62.5 µs: Max. 3 drive objects in servo control
    - T_i = 125 µs: Max. 6 drive objects in servo control
26. The fastest sampling time of a drive object in vector control mode is given as:
    - T_i = 250 µs: Max. 3 drive objects in vector control
    - T_i = 400 µs: Max. 5 drive objects in vector control
    - T_i = 500 µs: Max. 6 drive objects in vector control
27. The fastest sampling time of a drive object in vector U/f vector control mode is given as:
    - T_i = 500 µs: Max. 12 drive objects in U/f control mode
28. The maximum number of DRIVE-CLiQ nodes on a DRIVE-CLiQ line of the Control Unit depends on the basic clock cycle of the DRIVE-CLiQ line:
    - For a current controller cycle of 31.25 µs, a maximum of 3 DRIVE-CLiQ nodes are permissible
    - For a current controller cycle of 62.5 µs, a maximum of 5 DRIVE-CLiQ nodes are permissible
    - For a current controller cycle of 125 µs, a maximum of 14 DRIVE-CLiQ nodes are permissible
    - For a current controller cycle of 250 µs, a maximum of 20 DRIVE-CLiQ nodes are permissible
    - For a current controller cycle of 500 µs, a maximum of 30 DRIVE-CLiQ nodes are permissible
29. Examples for clock cycle level 62.5 µs:
    - Topology 1: 1 x ALM (250 µs) + 2 x servo (62.5 µs) + 2 x servo (125 µs) + 3 x TM15 + TM54F + 4 x dbSI2 with encoder SI Motion monitoring clock cycle (p9500) = 12 ms + SI Motion actual value sensing clock cycle (p9511) = 4 ms + 4 x dir. measuring systems
    - Topology 2: 1 x ALM (250 µs) + 2 x servo (62.5 µs) + 2 x U/f (500 µs) + 3 x TM15 Base 2 ms +2 x dbSI2 with encoder SI Motion monitoring clock cycle (p9500) = 12 ms + SI Motion actual value sensing clock cycle (p9511) = 4 ms + 2 x dbSI2 sensorless + 2 x dir. measuring systems
    - Topology 3: 1 x servo (62.5 µs) + 4 x U/f is not possible in connection with Safety Integrated.
30. Examples for clock cycle level 31.25 µs: 1 x servo (31.25 µs)

31. If the current controller sampling time T_i at one drive object has to be changed in a sampling time that does not match the other drive objects in the DRIVE-CLiQ line, the following solutions are available:
    - Insert the modified drive object into a separate DRIVE-CLiQ line.
    - Modify the current controller sampling times and/or the sampling times of the inputs/outputs of the other drive objects in the same way, so that they match the modified sampling time again.
32. Only components that have the same sampling time may be be connected to free DRIVE-CLiQ connections with a sampling time of T_i = 31.25 µs.
    The following components are permissible:
    - Sensor Modules
    - High-frequency damping modules (HF damping modules)
    - Active Line Modules Booksize in the line of the HF filter module.
    - Smart Line Modules Booksize in the line of the HF filter module.
    - Additional DRIVE-CLiQ lines must be used for further components:
      Further Motor Modules in servo control, in vector control, in U/f control or TMs.
33. Connection of the following components is not permissible for a sampling time of T_i = 31.25 µs:
    - Further Motor Modules in servo control.
    - Further Motor Modules in U/f control.
34. Rules for using a TM54F:
    - A TM54F must be connected directly to a Control Unit via DRIVE-CLiQ.
    - Only one TM54F Terminal Module can be assigned to each Control Unit.
    - Additional DRIVE-CLiQ nodes can be operated at the TM54F, such as Sensor Modules and Terminal Modules (excluding an additional TM54F).
    - For a CU310-2, no TM54F may be connected to the same DRIVE-CLiQ line as the Power Module.
35. A maximum of 4 Motor Modules with Safety Extended Functions may be operated on one DRIVE-CLiQ line (only for T_I = 125 µs). Additional DRIVE-CLiQ components may not be connected to this DRIVE-CLiQ line.
36. If an axis has only one encoder, and if Safety functions are activated for this axis, then this encoder may be connected to the Motor Module or to the Hub Module DMC20 only.
37. The following applies to the DRIVE-CLiQ connection of CX/NX components to a Control Unit:

    The connection to the Control Unit is obtained from the PROFIBUS address of the CX/NX (10 → X100, 11 → X101, 12 → X102, 13 → X103, 14 → X104, 15 → X105).

38. It is not permissible to combine SIMOTION Master Control Units and SINUMERIK Slave Control Units.
39. It is not permissible to combine SINUMERIK Master Control Units and SIMOTION Slave Control Units.

Note

To enable the function "Automatic configuration" to assign the encoders to the drives, the recommended rules below must also be observed.

12.9.3 Recommended DRIVE-CLiQ rules

Recommended DRIVE-CLiQ rules

1. The following applies to all DRIVE-CLiQ components with the exception of the Control Unit: The DRIVE-CLiQ sockets Xx00 are DRIVE-CliQ inputs, the other DRIVE-CLiQ sockets are outputs.
2. A single Line Module should be connected directly to the X100 DRIVE-CLiQ socket of the Control Unit.
   – Several Line Modules should be connected in a line.
   – If the X100 DRIVE-CLiQ socket is not available, the next higher DRIVE-CLiQ socket should be used.
3. For a current controller cycle of 31.25 μs, a filter module should be directly connected to a DRIVE-CLiQ socket of the Control Unit.
4. For the chassis format, Motor Modules with a current controller cycle of 250 μs should be connected to DRIVE-CLiQ socket X101 of the Control Unit. If required, they should be connected in a line.
   – If the DRIVE-CLiQ socket X101 is not available, the next higher DRIVE-CLiQ socket should be used for these Motor Modules.
5. For the chassis format, Motor Modules with a current controller cycle of 400 μs should be connected to DRIVE-CLiQ socket X102 of the Control Unit. If required, they should be connected in a line.
   – If the DRIVE-CLiQ socket X102 is not available, the next higher DRIVE-CLiQ socket should be used for these Motor Modules.
6. For the chassis format, the Line Module and the Motor Modules should be connected to separate DRIVE-CLiQ lines.
7. Peripheral components (e.g. Terminal Module, TM) should be connected to DRIVE-CLiQ socket X103 of the Control Unit in a line.
   – If the DRIVE-CLiQ socket X103 is not available, any free DRIVE-CLiQ socket should be selected for the peripheral components.

8. For the booksize format, the Motor Modules in servo control mode should be connected in line to DRIVE-CLiQ socket X100 of the Control Unit.
   - If the DRIVE-CLiQ socket X100 is not available, the next higher DRIVE-CLiQ socket should be used for these Motor Modules.
9. The motor encoders for the first drive of a Double Motor Module should be connected to the associated DRIVE-CLiQ socket X202.
10. The motor encoders for the second drive of a Double Motor Module should be connected to the associated DRIVE-CLiQ socket X203.
11. The motor encoder should be connected to the associated Motor Module:
    Connecting the motor encoder via DRIVE-CLiQ:
    - Single Motor Module Booksize to terminal X202
    - Double Motor Module Booksize motor X1 to terminal X202 and motor X2 to terminal X203
    - Single Motor Module Chassis to terminal X402
    - Power Module Blocksize with CUA31: Encoder to terminal X202
    - Power Module Blocksize with CUA31: Encoder to terminal X100 or via TM31 to X501
    - Power Module Chassis to terminal 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.

12. DRIVE-CLiQ sockets should, as far as possible, be symmetrically wired.
    Example: Do not connect 8 DRIVE-CLiQ nodes in series at one DRIVE-CLiQ socket of the CU - but instead, connect 2 nodes at each of the 4 DRIVE-CLiQ sockets.
13. The DRIVE-CLiQ cable from the Control Unit should be connected to DRIVE-CLiQ socket X200 on the first booksize power unit or X400 on the first chassis power unit.
14. The DRIVE-CLiQ connections between the power units should each be connected from the DRIVE-CLiQ sockets X201 to X200 and/or X401 to X400 on the follow-on component.
15. A Power Module with the CUA31 should be connected to the end of the DRIVE-CLiQ line.

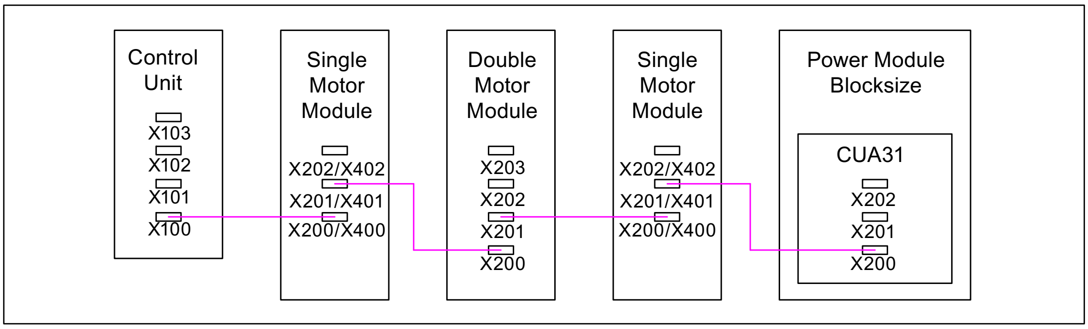


Figure 12-23 Example: DRIVE-CLiQ line

16. Only one final node should be connected to free DRIVE-CLiQ sockets of components within a DRIVE-CLiQ line (e.g. Motor Modules wired in series), for example, one Sensor Module or one Terminal Module, without routing to additional components.
17. If possible, Terminal Modules and Sensor Modules of direct measuring systems should not be connected to the DRIVE-CLiQ line of Motor Modules, but rather, to free DRIVE-CLiQ sockets of the Control Unit.
    Note: This restriction does not apply to star-type connections.
18. The TM54F should not be operated on the same DRIVE-CLiQ line as Motor Modules.
19. The Terminal Modules TM15, TM17 and TM41 have faster sample cycles than the TM31 and TM54F. For this reason, the two Terminal Module groups should be connected to separate DRIVE-CLiQ lines.
20. For mixed operation of the servo control and vector U/f control operating modes, separate DRIVE-CLiQ lines should be used for the Motor Modules.
    – Mixed operation of operating modes is not possible on a Double Motor Module.
21. The Voltage Sensing Module (VSM) should be connected to the DRIVE-CLiQ socket X202 (Booksize format) or X402 (Chassis format) of the Line Module.
    – If the X202/X402 DRIVE-CLiQ sockets are not available, a free DRIVE-CLiQ socket of the Line Module should be used.

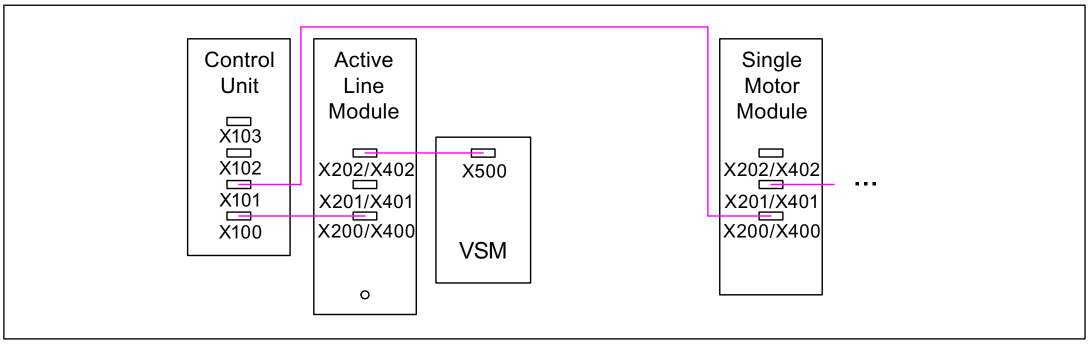


Figure 12-24 Example of a topology with VSM for booksize and chassis components

Table 12- 15 VSM connection

Component	VSM connection
Active Line Module booksize	X202
Active Line Module chassis	X402
Power Module chassis	X402
Motor Module Chassis	X402 (active with PEM encoderless and "Flying restart" function)

12.9.4 Wiring example for drives in vector control mode

Example 1

A drive line-up with three Motor Modules in chassis format with identical pulse frequencies or three Motor Modules in booksize format in vector control mode:

The Motor Modules Chassis with identical pulse frequencies or the Motor Modules Booksize in vector control mode can be connected to one DRIVE-CLiQ interface on the Control Unit.

In the following diagram, three Motor Modules are connected to the DRIVE-CLiQ socket X101.

Note

This topology does not match the topology created offline by STARTER and must be changed manually.

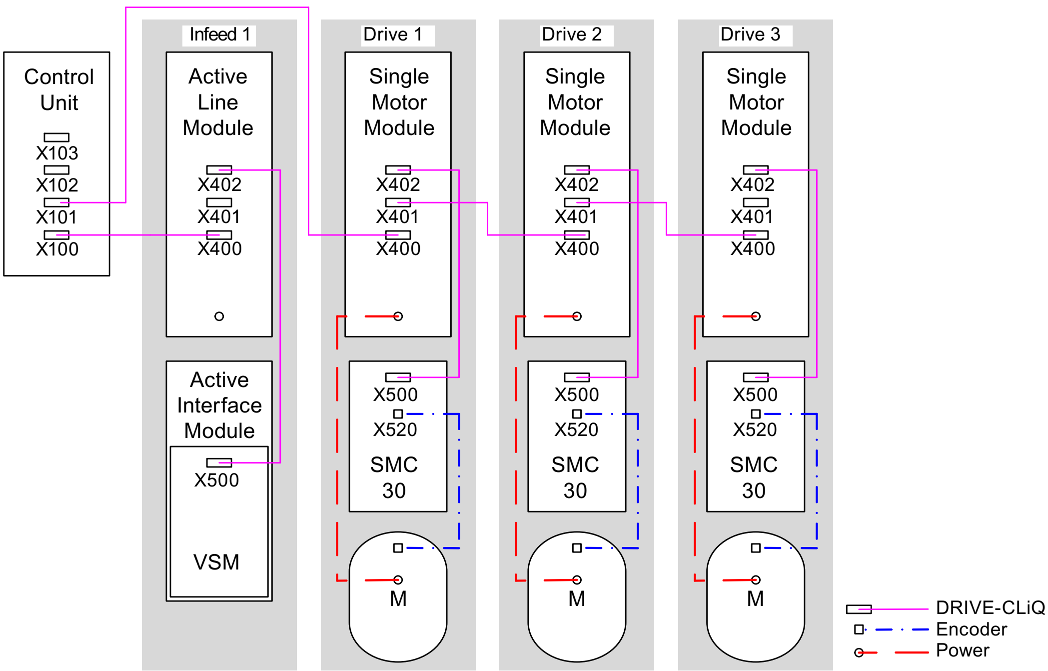


Figure 12-25 Drive line-up (chassis) with identical pulse frequencies

Drive line-up comprising four Motor Modules in chassis format with different pulse frequencies

Motor Modules with different pulse frequencies must be connected to different DRIVE-CLiQ sockets 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 manually.

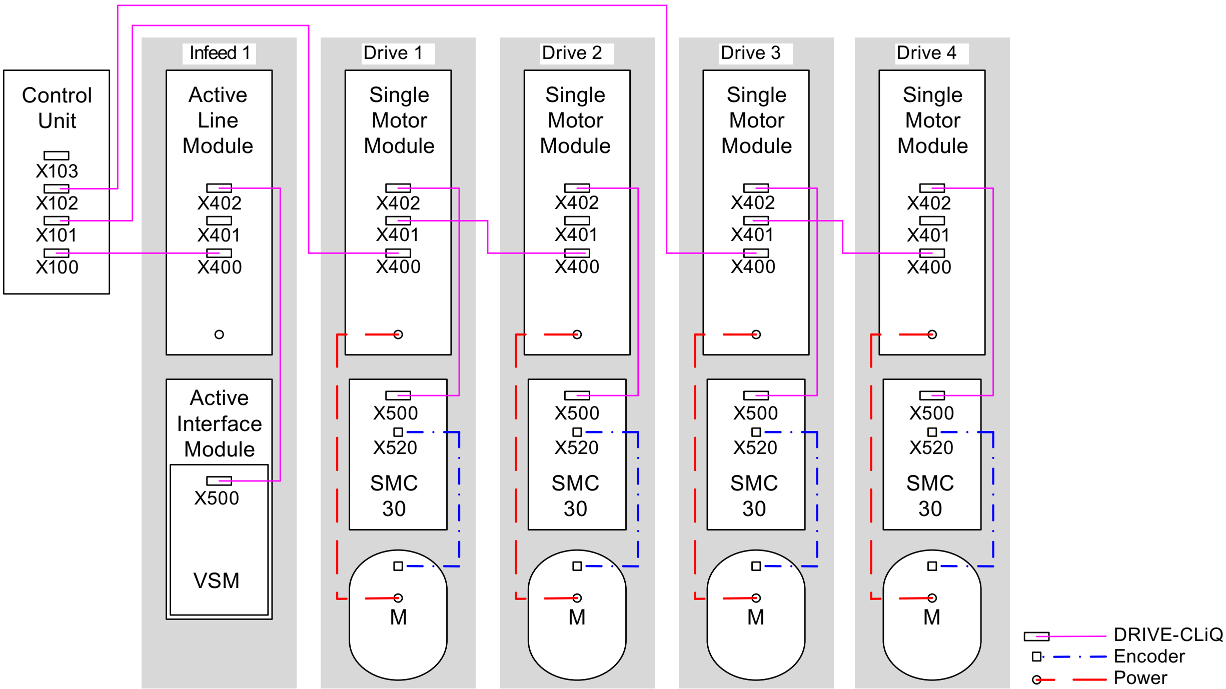


Figure 12-26 Drive line-up in chassis format with different pulse frequencies

12.9.5 Wiring example for parallel connection of Motor Modules in vector control mode

Drive line-up with two parallel-connected Line Modules and Motor Modules in chassis format of the same type

Parallel-connected Line Modules in chassis format and Motor Modules in chassis format of the same type can be connected to a DRIVE-CLiQ socket of the Control Unit.

In the following diagram, two Active Line Modules and two Motor Modules are connected to the X100 or X101 socket.

For further information on parallel connection, see the chapter "Parallel connection of power units" in the SINAMICS S120 Function Manual.

Note

This topology does not match the topology created offline by STARTER and must be changed manually.

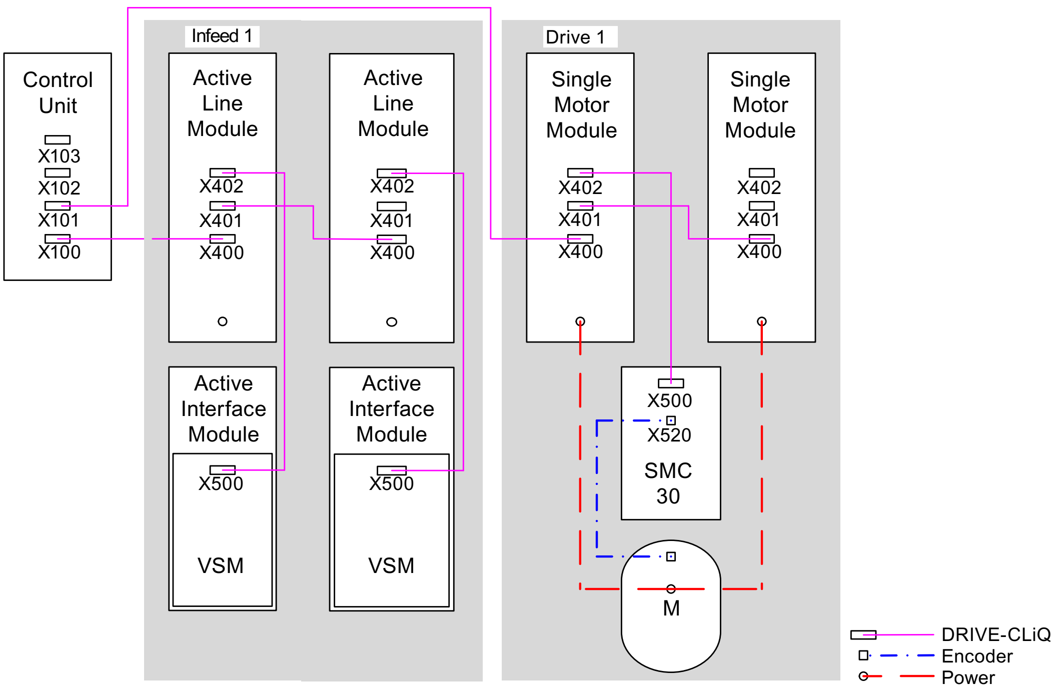


Figure 12-27 Drive line-up with parallel-connected power units in chassis format

12.9.6 Sample wiring: Power Modules

Blocksize

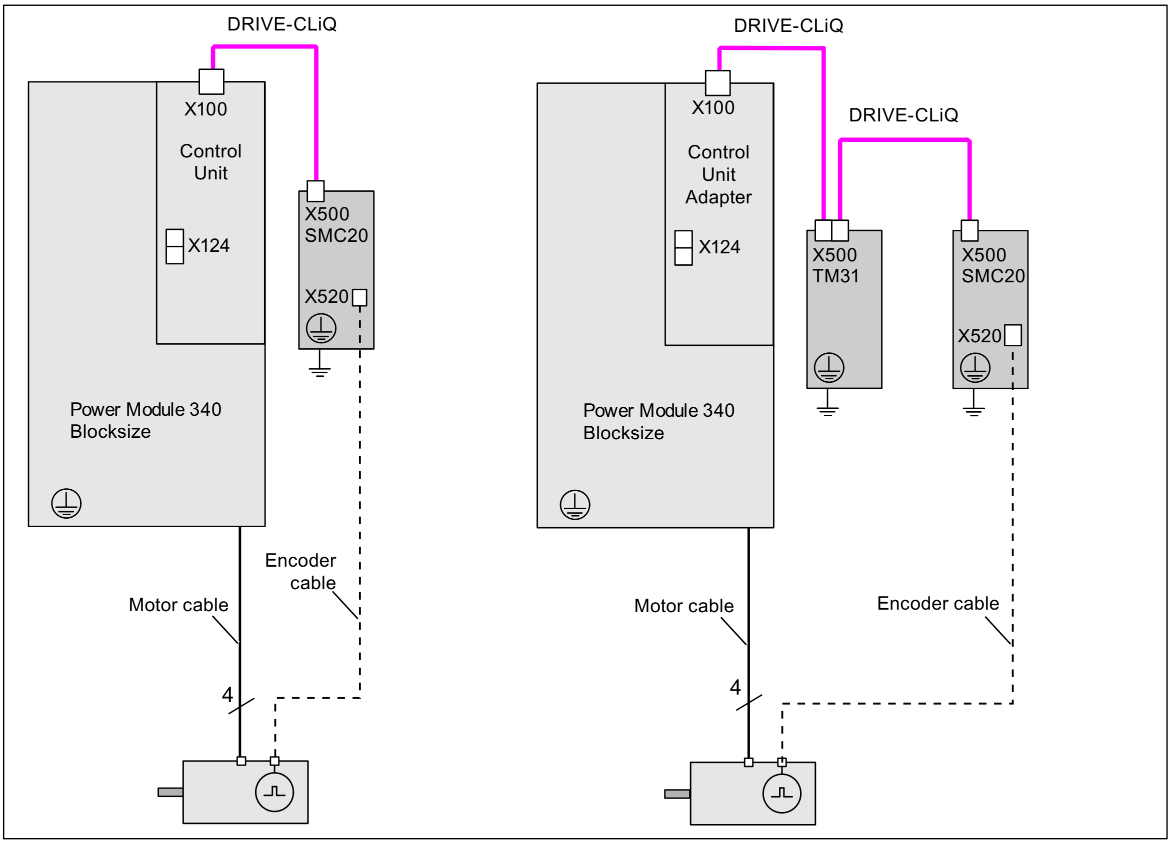


Figure 12-28 Wiring example for Power Modules Blocksize

Chassis

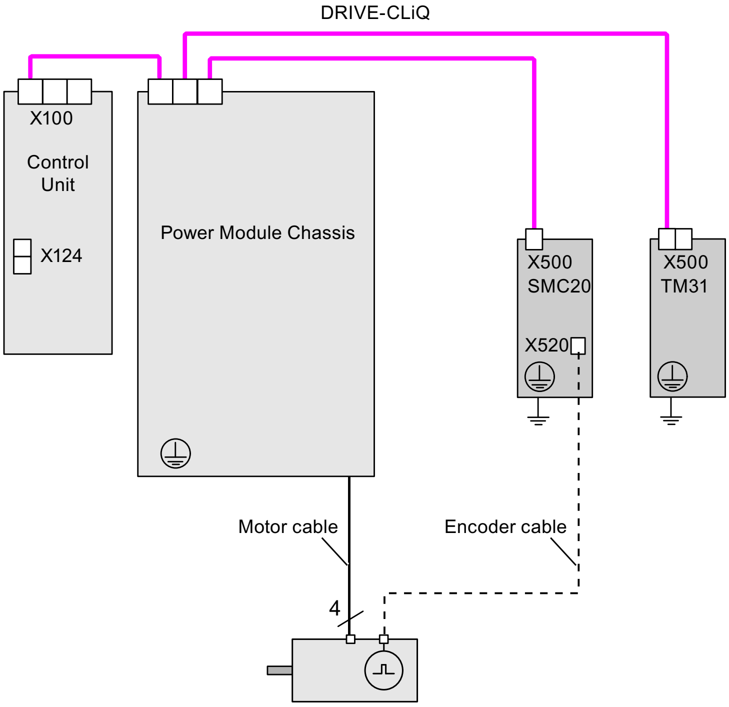


Figure 12-29 Wiring example for Power Modules Chassis

12.9.7 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

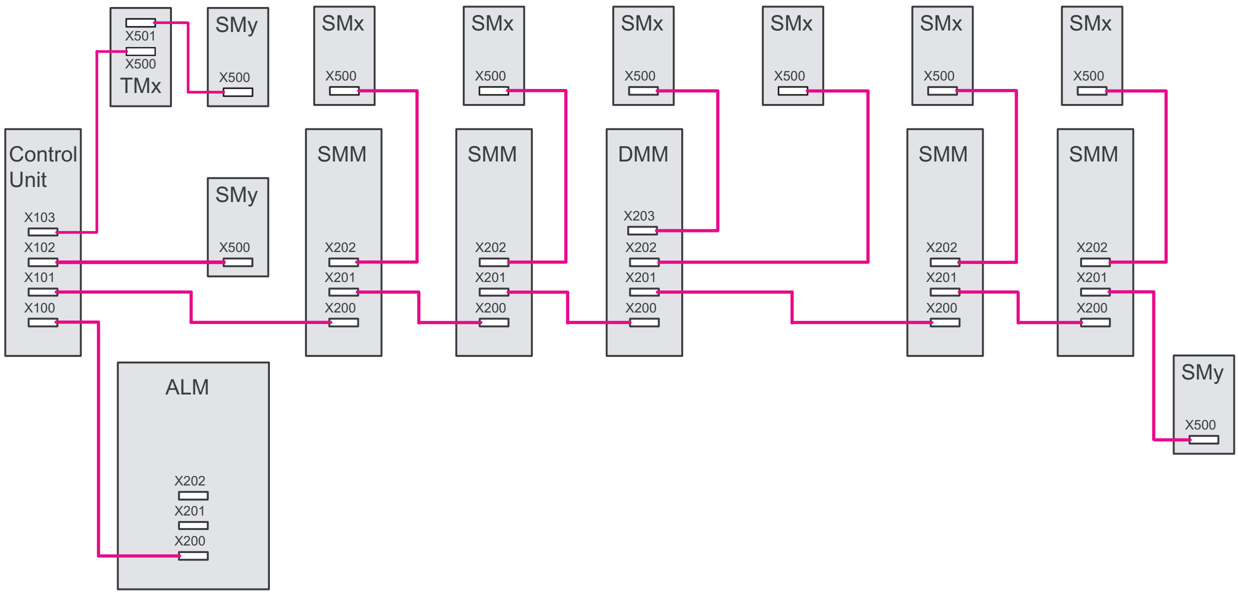


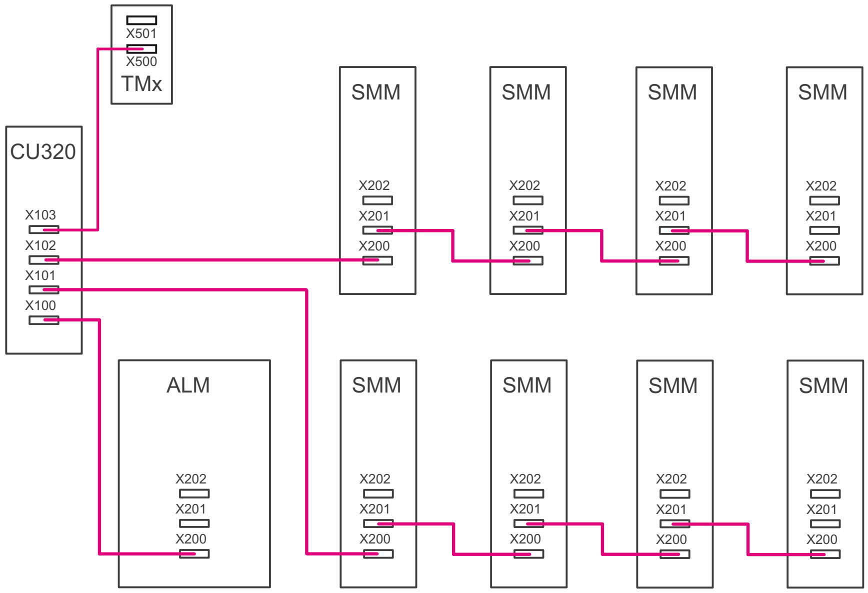
Figure 12-30 Sample servo topology

Legend for topology example:
ALM = Active Line Module
SMM = Single Motor Module
DMM = Double Motor Module
SMx = Motor encoder
SMy = Direct measuring system
TMx = TM31, TM15DI/DO, TB30

12.9.8 Sample wiring for vector V/f drives

The following diagram shows the maximum number of controllable vector V/f drives with additional 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
- Max. 12 axes can be controlled in V/f mode



ALM = Active Line Module
SMM = Single Motor Module
TMx = TM31, TM15DI/DO

Figure 12-31 Sample topology for vector V/f control

12.10 Autonomous operating mode for DRIVE-CLiQ components

Description

In order to protect the drive system against excessive voltage when the CU or DRIVE-CLiQ communication fails (e.g. while a spindle is rotating), an autonomous operating mode (emergency operation) is implemented in DRIVE-CLiQ components for the following functions:

- Chopper mode (for Basic Line Module 20 kW / 40 kW in combination with an external braking resistor).
- Integrated voltage protection for machines with a high kinetic energy (armature short circuit controlled by the Motor Modules on the basis of the DC link voltage).

Features

- Resumption and re-synchronization of DRIVE-CLiQ communication in emergency mode when necessary (only if clock cycle conditions have not changed) and without POWER ON.
- Changeover from emergency operation to normal operation without POWER ON of the component.
- Defined response with factory setting / project download.

Note

Autonomous (emergency) operation is only possible for Motor Modules and Basic Line Modules with order numbers which end with the code ..3, e.g. 6SL3130-6TE21-6AA3,.

Principle of operation

Autonomous time-slice operation is dependent on successful execution of the following two tasks:

- Detection that a critical state has developed on the component which means that the protective function must be maintained.
  In this state, the time-slice interrupts of the protective function must be sustained.
- Attainment of a state in which communication with the higher-level control can be resumed.

In order to maintain the protective function, the time-slice system must remain active. The logged-on time-slice system remains active until the protective functions signal that a safe state has been reached and the time slices can therefore be deactivated. When communication is resumed and the DRIVE-CLiQ master signals that no bus timing changes will be made as compared to the old parameter settings, the DRIVE-CLiQ components can be synchronized, the time-slice system remains active as before.

Note

All algorithms for autonomous time-slice operation are executed as a background process for the component. They thus have no influence on the computer resources utilized cyclically by the component.

A prerequisite for resumption of communication is that the topology can be scanned in emergency operation.

Note

When the component is running in emergency mode, it cannot be deactivated.

Preparation for autonomous time-slice operation

The application signals (basic system DRIVE-CLiQ slave components) preparation for autonomous time-slice operation. This occurs, for example, when the "armature short circuit" protective function is active or in chopper operation.

Changeover from normal to autonomous operation

The application activates autonomous time-slice operation. Changeover takes place instantaneously.

Changeover from autonomous to normal operation

It is always possible to change over into normal operation without a POWER ON.

Resumption of DRIVE-CLiQ communication when autonomous mode is active

A distinction must be made between the two operating states below:

- The DRIVE-CLiQ bus timing, e.g. clock cycle settings, has not changed since the component last booted:
  The DRIVE-CLiQ component boots in cyclic mode.
- The DRIVE-CLiQ timing has changed:
  Autonomous operation must continue at all costs. The DRIVE-CLiQ component refuses to boot until the application signals that autonomous operation is no longer required. The component can then restart with the modified clock cycle settings.

The component may already be running when the second download takes place. To permit a second download (reparameterization, factory setting, ...), the DRIVE-CLiQ master must "deactivate" the protective function (if one is selected) and thus also autonomous time-slice operation. All timing changes can be accepted in this state.

The DRIVE-CLiQ master performs a relevance check on the download (relevant here means only those settings which affect the time-slice behavior of the component).

Reconfigurations which must be linked to the DRIVE-CLiQ slave with message "Timing change" are

- Changes to the DRIVE-CLiQ clock cycle for the component
- Changes to oversampling settings which require internal reconfiguration of the time-slice system.

Please also note the following:

- Changes to component connections and longer cables between components require adjustments to signal propagation delays and therefore also change the timing.

12.11 System sampling times and number of controllable drives

The software functions installed in the system are executed cyclically with different sampling times (p0115, p0799, p4099).

The sampling times of the functions are automatically pre-assigned when configuring the drive unit.

These 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.

12.11.1 Notes on the number of controllable drives

12.11.1.1 Introduction

The number and type of controlled axes and the extra activated functions of the project can be scaled by configuring the firmware. Especially for demanding configurations, drives with high dynamics or a large number of axes with additional utilization of special functions for example, a check using the SIZER configuration tool is recommended. The SIZER calculates the feasibility of the project.

The maximum possible functionality depends on the performance of the Control Unit used and the components configured.

12.11.1.2 System sampling times and number of controllable drives

This chapter contains a list of the axes that can be operated with SINAMICS S120 depending on the cycle times in the various control modes. The other available remaining computation times are available for options (e.g. DCC).

Cycle times for the "servo" control mode

The following table shows the number of axes that can be operated depending on the selected cycle times in the "servo" control mode:

Table 12- 16 Sampling time setting for servo

Cycle times [µs]		Number		Motor / dir. measuring systems	TM[1] / TB
Current controller	Speed controller	Axes	Infeed		
125	125	6	1 [250 µs]	6 / 6	3 [2000 µs]
62.5	62.5	3	1 [250 µs]	3 / 3	3 [2000 µs]
31.25[2]	31.25[2]	1	1 [250 µs]	1 / 1	3 [2000 µs]
1) Valid for TM31 or TM15IO; for TM54F, TM41, TM15, TM17, TM120 - restrictions are possible dependent on the set sampling time.					
2) In the clock cycle level 31.25 µs you can additionally set-up the following objects: - 1 servo axis with a sampling time of 125 µs - 2 U/f axes with a sampling time of 500 µs					

The following combinations are permissible for current controller cycle mixed operation:

- Servo with 125 µs and servo with 250 µs (only 2 clock cycle levels may be mixed)
- Servo with 62.5 µs and servo with 125 µs (only 2 clock cycle levels may be mixed)

Note the following: 1 axis with 31.25 µs corresponds to

- 2 servo axes with 62.5 µs
- 4 servo axes with 125 µs
- 8 U/f axes with 500 µs

Cycle times in the "vector" control mode

The following table shows the number of axes that can be operated depending on the selected cycle times in the "vector" control mode:

Table 12- 17 Sampling time setting for vector

Cycle times [µs]		Number		Motor / dir. measuring systems	TM[1] / TB
Current controller	Speed controller	Axes	Infeed[2]		
500	2000	6	1 [250 µs]	6 / 6	3 [2000 µs]
400[3]	1600	5	1 [250 µs]	5 / 5	3 [2000 µs]
250	1000	3	1 [250 µs]	3 / 3	3 [2000 µs]
1) Valid for TM31 or TM15IO; for TM54F, TM41, TM15, TM17, TM120 - restrictions are possible dependent on the set sampling time.					
2) For power units in chassis format, the infeed cycle depends on the power rating of the module and can assume values of 400 µs, 375 µs or 250 µs.					
3) This setting results in lower remaining computation times.					

The following combination is permissible in current controller cycle mixed operation:

- Vector with 250 μs and vector with 500 μs

NOTICE
Restriction for chassis format in the case of special functions
If edge modulation and wobbling are activated simultaneously with p1802 ≥ 7 and p1810.2 = 1 respectively, the quantity structure for vector control is halved. Then, for example, a maximum of 3 axes at a current control cycle of 500 μs, 2 axes at 400 μs or 1 axis at 250 μs are possible.

Cycle times in the "Vector U/f" control mode

The following table shows the number of axes that can be operated depending on the selected cycle times in the "Vector U/f" control mode:

Table 12- 18 Sampling time setting for vector U/f

Cycle times [μs]		Number		Motor / dir. measuring systems	TM/TB
Current controller	Speed controller	Drives /	Infeed		
500	2000	12	1 [250 μs]	- / -	3 [2000 μs]

Mixed operation of the "Servo" and "Vector U/f" control modes

In mixed "Servo" with "Vector U/f control" operation, one axis with servo control is considered to be two axes in U/f control mode.

Table 12- 19 Number of axes for mixed operation of servo controller and U/f control

Number of axes in servo control				Number of axes in U/f control	
6	125 μs	3	62.5 μs	0	
5	125 μs			2	500 μs
4	125 μs	2	62.5 μs	4	500 μs
3	125 μs			6	500 μs
2	125 μs	1	62.5 μs	8	500 μs
1	125 μs			10	500 μs
0		0		12	500 μs

Mixed operation of the "Vector" and "Vector U/f" operating modes

In mixed "Vector" with "Vector U/f control" operation, one axis in vector control is considered to be two axes in U/f control mode. A maximum of 6 axes are permitted in conjunction with vector control.

Table 12- 20 Number of axes for mixed operation of vector controller and U/f control

Number of axes in vector control		Number of axes in U/f control	
6	250 µs	0	
5	250 µs	1	500 µs
4	250 µs	2	500 µs
3	250 µs	3	500 µs
2	250 µs	4	500 µs
1	250 µs	5	500 µs
0		12	500 µs

Using DCC

The available remaining computation time can be used for DCC. In this case, the following supplementary conditions apply:

- For a 2 ms time slice, a max. of 75 DCC blocks can be configured for each servo axis with 125 µs that can be omitted/eliminated (≙ 2 U/f axes with 500 µs).
- 75 DCC blocks for 2 ms time slice correspond to 2 U/f axes with 500 µs.
- 50 DCC blocks for 2 ms time slice correspond to 1.5 U/f axes with 500 µs.

Using EPOS

The following table shows the number of axes that can be operated depending on the selected cycle times

Table 12- 21 Sampling times when using EPOS

Cycle times [µs]		Number	
Current controller	Speed controller	Axes	Infeed
250	250	6	1 [250 µs]
250	250	5	1 [250 µs]
125	125	4	1 [250 µs]

The use of an EPOS function module (with 1 ms position controller/4 ms positioner) corresponds to 0.5 U/f axes with 500 µs.

Using CUA31/CUA32

Information on using the Control Unit Adapter CUA31 or CUA32:

- CUA31/32 is the first component in the CUA31/32 topology: 5 axes
- CUA31/32 is **not** the first component in the CUA31/32 topology: 6 axes
- For a current controller cycle of 62.5 μs, only 1 axis is possible with one CUA31/32.

12.11.2 Setting the sampling times

Introduction

Setting the sampling times in μs 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 in μs and are copied to p0115[0...6] depending on the performance levels required. The performance levels range from xLow to xHigh.

Details of how to set the sampling times are given in the SINAMICS S120/S150 List Manual.

Setting the pulse frequency via p0113 when STARTER is in online mode

Enter the minimum pulse frequency in p0113. For isochronous operation (p0092 = 1), you can only set the parameter so that a resulting current controller cycle with an integer multiple of 125 μs is obtained. The required pulse frequency can be set after commissioning (p0009 = p0010 = 0) in p1800.

Table 12- 22 Pulse frequency for isochronous operation

Control type	p0115[0] Current controller cycle / μs	p0113 Pulse frequency / kHz
Servo	250	2
	125	4
Vector	500	1
	250	2

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 you can directly set the sampling times 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.

12.11.3 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 125 µs. The DRIVE-CLiQ lines with servo-controlled axes with 31.25 µs or 62.5 µs controller sampling time are an exception.
2. The sampling times of the inputs/outputs (p4099[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
3. When Safety Integrated Extended Functions are used (see Safety Integrated Function Manual), the sampling time of the current controller (p0115[0]) must be 62.5 µs, 125 µs, 250 µs, 375 µs, 400 µs or 500 µs.
4. 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.
5. For Active Line Modules (ALM) 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.
6. For Basic Line Modules (BLM), only a current controller sampling time of 2000 µs can be set.
7. For Motor Modules in chassis format, a current controller sampling time of minimum 125 µs can be set (125 µs ≤ p0115[0] ≤ 500 µs). This applies to the Servo and Vector control types.
8. For Motor Modules in blocksize format, 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).
9. When a chassis unit is connected to a DRIVE-CLiQ line, the smallest current controller sampling time must be at least 125 µs. This applies only to the Servo control type.

   Example:
   Mixture of chassis and booksize units on a DRIVE-CLiQ line.
10. A current controller sampling time between 31,25 µs and 250.0 µs can be set for servo drives (31,25 µs ≤ p0115[0] ≤ 250.0 µs).
11. A current controller sampling time between 125,0 µs and 500,0 µs can be set for servo drives (125,0 µs ≤ p0115[0] ≤ 500,0 µs).

12. 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 a different DRIVE-CLiQ line)

    – Blocksize: 1 servo with p0115[0] = 62.5 µs

    – Booksize servo drives can be combined on one DRIVE-CLiQ line with a servo with p0115[0] = 125.0 µs (but with same quantity framework).

    – A DRIVE-CLiQ hub DMC20 or DME20 cannot be operated with servo drives with p0115[0] = 62.5 µs on a DRIVE-CLiQ line but must instead be connected to a separate DRIVE-CLiQ line.

13. Synchronous PROFIBUS operation (set p0092 = 1):

    – The current controller sampling time must be a a multiple of 125.0 µs or equal to 62.5 µs.

14. For control drive type VECTOR and VECTOR U/f control, and when using a sine-wave 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.

15. For chassis:

    – For 3 drives in vector control (speed control: r0108.2 = 1), a minimum current controller sampling time of 250.0 µs can be set
    (250.0 µs ≤ p0115[0] ≤ 500 µs).
    This rule also applies to parallel connection of up to 4 Motor Modules.

    – For 4 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).

    Note

    Restriction of the number of axes for chassis in vector control

    For active edge modulation and active wobbling, only half the number of axes is permissible.

    ---

16. When vector control is operated together with vector U/f control, a maximum of 6 axes is possible (ALM, TB and TM additionally possible):

17. At the Control Unit, a maximum of two DRIVE-CLiQ lines are possible where the lowest sampling times are not integer multiples of one another.

    Example 1:

    At Control Unit X100: Active Line Module with 250 µs
    At Control Unit X101: 1 VECTOR drive object with 455 µs (p0113 = 1.098 kHz)
    This setting is permissible.
    Other DRIVE-CLiQ lines must have a minimum sampling time of 250 µs or 455 µs.

12.11.4 Default settings for the sampling times

When commissioning for the first time, the current controller sampling times (p0115[0]) are automatically pre-set with factory setting values:

Table 12- 23 Factory 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	4 (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				
Booksize	1 to 3 only n_ctrl 1 to 6 only U/f	3 (Standard)	250 µs	4 kHz
Chassis 400 V / ≤ 250 kW				2 kHz
Booksize	4 to 6 only n_ctrl 7 to 12 only U/f	0 (Expert)	500 µs	4 kHz
Chassis 400 V / ≤ 250 kW				2 kHz
Chassis > 250 kW 690 V	1 to 4 only n_ctrl 1 to 5 only U/f 1 to 6 only n_ctrl	0 (Expert) 1 (xLow) 0 (Expert)	375 µs (p0092 = 1) 400 µs (p0092 = 0) 500 µs (p0092 = 1)	1.333 kHz 1.25 kHz 2 kHz
Booksize	> 6 only U/f	0 (Expert)	500 µs	4 kHz
Chassis				2 kHz
Blocksize	1 to 3 only n_ctrl 1 to 6 only U/f	3 (Standard)	250 µs	4 kHz
	> 3 n_ctrl (min. 1) > 6 only U/f	0 (Expert)	500 µs	4 kHz
Caution If a Power Module in blocksize format is connected to a Control Unit, the sampling times of all vector drives are set according to the rules for Power Modules in blocksize format (only 250 µs or 500 µs possible).				

12.11.5 Examples when changing sampling times / pulse frequencies

Example: Changing the current controller sampling time from 62.5 µs with p0112

Note

Carry out the parameter settings subsequently listed in the expert list of the particular drive object.

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 recalculated (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 contradicts rule 1 for setting the sampling times, an alarm is output and a suitable pulse frequency is recommended in p0114. The current controller sampling times of the drive objects (DOs) and the sampling time of the inputs/outputs of the Control Unit, TM and TB modules must be a multiple integer of 125 µs. 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. Switch to 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 recalculated (p0340 = 4).

12.11.6 Overview of important parameters (see SINAMICS S120/S150 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 basic sampling times
- 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)

12.12 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.

System response if there is a not a sufficient license for an option

An insufficient license for an option is indicated via the following alarm and LED on the Control Unit:

- A13000 License not sufficient
- LED RDY flashes green/red at 0.5 Hz

NOTICE
The drive can only be operated with an insufficient license for an option during commissioning and servicing. The drive requires a sufficient license in order for it to operate.

System response for an insufficient license for a function module

An insufficient license for a function module is indicated using the following fault and LED on the Control Unit:

- F13010 licensing, function module not licensed
- The drive is stopped with an OFF1 response.
- LED RDY continuous light, red

NOTICE
It is not possible to operate a drive system with an insufficient license for a function module. The drive requires a sufficient license in order for it to operate.

Option performance 1

The Performance 1 option (order number: 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.

System response for an insufficient license for an OA application

An insufficient license for an OA application is indicated using the following fault and LED on the Control Unit:

- F13009 licensing, OA application not licensed
- The drive is stopped with an OFF1 response.
- LED READY continuous light, red

NOTICE
It is not possible to operate a drive system with an insufficient license for an OA application. The drive requires a sufficient license in order for it to operate.

Properties of the license key

- Is assigned to a specific memory card.
- Is stored retentively on the memory card.
- Is not transferrable.
- 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:

- Memory card serial number (printed on the memory card)
- License number and delivery note number of 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 memory card serial number.
5. Select a product e.g. "SINAMICS S CU320-2 DP".

   --> 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.

Enter license key in STARTER

With the STARTER commissioning software, the ASCII characters are not entered in code, but the letters and numbers of the license key can be entered directly as they appear on the license certificate. Always enter upper case letters in parameter p9920.
In this case, STARTER handles the ASCII coding in the background.

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):

p9920[0] = E 1st character

...

p9920[8] = A 9th 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

Enter license key with BOP20

If you enter the license key via BOP20, use the ASCII code for the key (example: see above). In the table below, you can enter the characters of the license key and the associated decimal numbers.

Table 12- 24 License key table

Letter/number											
decimal											

ASCII code

Table 12- 25 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 important parameters (see SINAMICS S120/S150 List Manual)

- p9920 Licensing, enter license key
- p9921 Licensing, activate license key
- p9976[0...2] system utilization

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 (CU320, 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	TM54F	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 Suitable for Safety Extended Functions PROFIsafe (dbSI1) and TM54 (dbSI2)	6SL3040-0PA00-0AA1		new
6	CUA32	6SL3040-0PA01-0AAx		new
7	SMC30 (30 mm wide)	6SL3055-0AA00-5CA2		new

Table A- 3 Hardware components available as of 10.2008

No.	HW component	Order number	Version	Revisions
1	TM31	6SL3055-0AA00-3AA1		new
2	TM41	6SL3055-0AA00-3PA1		new
3	DME20	6SL3055-0AA00-6ABx		new
4	SMC20 (30 mm wide)	6SL3055-0AA00-5BA2		new
5	Active Interface Module booksize 16 kW	6SL3100-0BE21-6ABx		new

No.	HW component	Order number	Version	Revisions
6	Active Interface Module booksize 36 kW	6SL3100-0BE23-6ABx		new
7	Smart Line Modules booksize compact	6SL3430-6TE21-6AAx		new
8	Motor Modules booksize compact	6SL3420-1TE13-0AAx 6SL3420-1TE15-0AAx 6SL3420-1TE21-0AAx 6SL3420-1TE21-8AAx 6SL3420-2TE11-0AAx 6SL3420-2TE13-0AAx 6SL3420-2TE15-0AAx		new
9	Power Modules blocksize liquid cooled	6SL3215-1SE23-0AAx 6SL3215-1SE26-0AAx 6SL3215-1SE27-5UAx 6SL3215-1SE31-0UAx 6SL3215-1SE31-1UAx 6SL3215-1SE31-8UAx		new
10	Reinforced DC link busbars for 50 mm components	6SL3162-2DB00-0AAx		new
11	Reinforced DC link busbars for 100 mm components	6SL3162-2DD00-0AAx		new

Table A- 4 Hardware components available as of 11.2009

No.	HW component	Order number	Version	Revisions
1	CU320-2 DP	6SL3040-1MA00-0AA1	4.3	new
2	TM120	6SL3055-0AA00-3KA0	4.3	new
3	SMC10 (30 mm wide)	6SL3055-0AA00-5AA3	4.3	new

Table A- 5 Hardware components available as of 01.2011

No.	HW component	Order number	Version	Revisions
1	CU320-2 PN	6SL3040-1MA01-0AA0	4.4	–
2	CU310-2 PN	6SL3040-1LA01-0AA0	4.4	new
3	CU310-2 DP	6SL3040-1LA00-0AA0	4.4	new
4	Braking Module Booksize Compact	6SL3100-1AE23-5AA0	4.4	new
5	SLM 55kW Booksize	6TE25-5AAx	4.4	new
6	TM120 evaluation of up to four motor temperature sensors	6SL3055-0AA00-3KAx	4.4	new

A.2 Availability of SW functions

Table A- 6 New functions, firmware 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 control modes on one CU	x	x	
6	Regulated V_{dc} 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- 7 New functions, firmware 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 connection	-	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	-	

No.	SW function	Servo	Vector	HW component
20	1FS6 explosion-protected motors	x	-	
21	SME20/25 external Sensor Modules for incremental and absolute encoder evaluation	x	x	

Table A- 8 New functions, firmware 2.4 or 2.4 SP1

No.	SW function	Servo	Vector	HW component
1	SINAMICS S120 functionality for AC DRIVE (CU310DP/PN)	x	x	
2	Basic positioning	x	x	
3	Encoder data set changeover (3 EDS encoder data sets per drive data set)	x	x	
4	2 command data sets (CDS)	x	x	
5	Units changeover SI / US / %	x	x	
6	Motor data identification servo	x	since FW2.1	
7	Increased torque accuracy for synchronous motors (kt estimator)	x	-	
8	Hub functionality (hot plugging, distributed encoder, star structure via DMC20)	x	x	
9	Basic Operator Panel BOP20	x	x	
10	Evaluation of SSI encoder (SMC30)	x	x	6SL3055–0AA00–5CA1
11	Pulse encoder emulation TM41	x	x	
12	Automatic restart with Active Line Module	x	x	
13	PROFIBUS extensions: – slave-to-slave communication – Y link – telegram 1 also for servo – telegram 2,3,4 also for vector	 x x x since FW2.1	 x x since FW2.1 x	
14	Safety Integrated Stop category 1 (SS1) with safety-related time	x	x	
15	Measuring gear	x	x	
16	Setting the pulse frequency grid in fine steps	x	x	
17	Controller clock cycles that can be set	x	x	
18	Possibility of mixing clock cycles on a DRIVE-CLiQ line	x	x	
19	Clockwise/counter clockwise bit (the same as changing the rotating field	x	x	
20	Sensor Module for 1FN, 1FW6 with protective separation (SME120/125)	x	-	
21	Real time stamps for alarms	x	x	CU320, 6SL3040-....- 0AA1 and Version C or higher
22	Encoderless closed-loop speed control for torque motors	-	x	
23	Separately-excited synchronous motors with encoder	-	x	

No.	SW function	Servo	Vector	HW component
24	Drive converter/drive converter, drive converter/line supply (bypass) synchronizing	x	x	For chassis drive units
25	Voltage Sensing Module (VSM) for Active Line Module			also for booksize drive units
26	Armature short-circuit braking, synchronous motors	x	-	
27	CANopen extensions (vector, free process data access, profile DS301)	x	x	
28	PROFINET IO communication with Option Module CBE20	x	x	
29	New hardware components are supported (AC DRIVE, SME120/125, BOP20, DMC20, TM41)	x	x	
30	Position tracking for torque motors (not for EPOS)	x	x	CU320, 6SL3040-....- 0AA1 and Version C or higher
31	1FW3 torque motors	x	-	

Table A- 9 New functions, firmware 2.5 or 2.5 SP1

No.	SW function	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)	x	x	
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).	x	x	Safety Integrated Extended Functions only for: • Motor Modules (6SL3xxx-xxxxx-0AA3) • CUA31 (6SL3040-0PA00-0AA1)

No.	SW function	Servo	Vector	HW component
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	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)	x	1PL6 only	
5	Support of new components • Basic Line Module (BLM) in booksize format	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)	x	x	
7	Save data (motor and encoder data) from the Sensor Module on motor with DRIVE-CLiQ to memory card and load to "empty" Sensor Module	x	x	
8	Evaluation of SSI encoders on AC Drive Controller CU310 (onboard interface)	x	x	only for CU310 (6SL3040-0LA00-0AA1)
9	Edge modulation (higher output voltages) in the vector control mode, also with booksize devices	-	x	only for Motor Modules (6SL3xxx-xxxxx-0AA3)
10	DC braking	x	x	
11	Armature short-circuit: Internal	x	x	
12	Armature short-circuit: Intermittent voltage protection	x	-	only for Motor Modules (6SL3xxx-xxxxx-0AA3)
13	Automatic firmware update for DRIVE-CLiQ components	x	x	
14	Save STARTER project directly to memory card	x	x	
15	The terminal area for booksize infeeds (BLM, SLM, ALM) can be parameterized to 230 V 3 AC	x	x	only for infeeds in booksize format (6SL3xxx-xxxxx-0AA3)

No.	SW function	Servo	Vector	HW component
16	Automatic speed controller setting	x	since FW2.1	
17	Technological pump functions	-	x	
18	Simultaneous cyclical operation of PROFIBUS and PROFINET on CU320	x	x	
19	Automatic restart also with servo	x	since FW2.2	
20	Operates at 500 µs PROFINET I/O	x	-	
21	Absolute position information (X_IST2) with resolver	x	x	
22	DC link voltage monitoring depending on the line voltage	x	x	
23	Automatic line frequency detection	x	x	
24	Acceleration signal at the ramp-function generator output	x	x	
25	Reset the drive device via parameter (p0972)	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)	-	x	
27	Dynamic energy management, extension of the Vdc_min, Vdc_max control	x	x	
28	Endless trace	x	x	
29	Extended PROFIBUS monitoring with timer and binector	x	x	
30	Indexed actual value acquisition Simultaneous evaluation of multiple encoders	x	x	

Table A- 10 New functions, firmware 2.6

No.	SW function	Servo	Vector	HW component
1	Offset pulsing in the synchronous drive line-up	x	x	
2	Safety Integrated Extended Functions: Internal armature short circuit and integrated voltage protection	x	x	Safety Integrated Extended Functions only for: • Motor Modules (6SL3xxx-xxxxx-xxx3) • CUA31 (6SL3040-0PA00-0AA1)
3	PROFIsafe via PROFINET	x	x	
4	Pulse frequency wobbling	-	x	Motor Modules in chassis format: (6SL3xxx-xxxxx-xxx3)
5	Position control load gear with multiple drive data sets (DDS)	x	x	
6	Sensorless vector control (SLVC), New closed-loop control for passive loads	-	x	
7	Variable signaling function	x	-	

No.	SW function	Servo	Vector	HW component
8	Quick magnetization for induction motors		x	
9	Flux reduction for induction motors	x	-	
10	Component status display	x	x	
11	Downgrade disable	x	x	
12	Parallel connection of motors	x	x	
13	Parallel connection of Motor Modules	-	x	
14	Parallel connection of power units	x	x	
15	Master/slave function for infeeds	x	x	
16	Thermal motor monitoring I2t model for synchronous motors	x	-	
17	New PROFIdrive telegrams 116, 118, 220, 371	x	x	
18	New RT classes for PROFINET IO	x	x	
19	Use of bidirectional inputs/outputs on the CU	x	x	
20	Autonomous operating mode for DRIVE-CLiQ components	x	x	
21	Central signal for "ready for switching on" state on drive object	x	x	
22	New motor series/types supported: 1FN6 continuous load (linear motor for continuous load operation)	x	-	

Table A- 11 New functions, firmware 4.3

No.	SW function	Servo	Vector	HW component
1	The 1FN6 motor series is supported	x	-	
2	DRIVE-CLIQ motors with star-delta changeover are supported	x	-	
3	Referencing with several zero marks per revolution via the encoder interface	x	-	
4	Permanent-magnet synchronous motors can be controlled down to zero speed without having to use an encoder	-	x	
5	"SINAMICS Link" : Direct communication between several SINAMICS S120	x	x	
6	Safety Integrated: • Control of the Basic Functions via PROFIsafe • SLS without encoder for induction motors • SBR without encoder for induction motors • Own threshold value parameters for SBR: Up until now, SSM used parameter p9546	x	x	
7	Drive object encoder: An encoder can now be directly read in via the encoder drive object and can then be evaluated by SIMOTION using the TO external encoder.	-	x	
8	Support of new components • CU320-2 • TM120	x	x	
9	GSDML file expanded for Profisafe	x	x	

No.	SW function	Servo	Vector	HW component
10	Improved usability of the SMI spare parts: • Automatic backup of motor and encoder data • Operation with an empty SMI - also possible without reducing the comparison level • An SMI where data has already been written to can be cleared and then used as replacement SMI. • Fault message if incorrect data is written to an SMI	x	x	
11	USS protocol at interface X140	x	x	
12	U/f diagnostics (p1317) permitted as regular operating mode	x	-	
13	Setpoint-based utilization display, instead of the previous actual value-based utilization display	x	x	
14	A performance license is now required from the 4th axis (for servo/vector) or from the 7th U/f axis, instead of from a utilization of 50 % and higher - which was the case up until now.	x	x	
15	Tolerant encoder monitoring, 2nd part: • Monitoring, tolerance band, pulse number • Switchable edge evaluation for squarewave encoders • Setting the zero speed measuring time for pulse encoder signal evaluation • Changeover measuring technique, actual value sensing for squarewave encoder • "LED check" encoder monitoring	x	x	

Table A- 12 New functions, firmware 4.4

No.	SW function	Servo	Vector	HW component
1	Safety Integrated functions • SLS without encoder for synchronous motors • SSM without encoder for synchronous motors • SDI (Safe Direction) for synchronous and induction motors (with and without encoder) • Supplementary conditions for Safety without encoder (synchronous and induction motors): Only possible with devices in booksize and blocksize format. Not for devices in chassis format	x	x	
2	Communication • PROFINET address can be written via parameter (e.g. when completely generating the project offline) • Shared device for SINAMICS S PROFINET modules: CU320-2 PN, CU310-2 PN	x	x	
3	Emergency retraction (ESR = Extended Stop and Retract)	x	x	
4	TM41: Rounding for pulse encoder emulation (gear ratio; also resolver as encoder)	x	x	
5	Further pulse frequencies for servo control and isochronous operation (3.2 / 5.33 / 6.4 kHz)	x	-	
6	Chassis format: Current controller in 125 µs for servo control for higher speeds (up to approx. 700 Hz output frequency)	x	x	

A.3 Functions of SINAMICS S120 Combi

Functional scope, SINAMICS S120 Combi

SINAMICS S120 Combi supports the following functions, which are described in this Function Manual. Any function not shown in this list is not available for SINAMICS S120 Combi

Table A- 13 Functional scope, SINAMICS S120 Combi

	SW function
Infeed	
	Smart Infeed
	Line contactor control
Servo control	
	Speed controller
	Speed setpoint filter
	Speed controller adaptation
	Torque controlled mode
	Torque setpoint limitation
	Current controller
	Current setpoint filter
	Note about the electronic motor model
	V/f control for diagnostics
	Optimization of current and speed controller
	Encoderless operation
	Pole position identification
	Vdc control
	Dynamic Servo Control (DSC)
	Travel to fixed stop
	Vertical axis
Basic functions	
	Reference parameters/scaling
	OFF3 torque limits
	Simple brake control
	Runtime (operating hours counter)
	Component status display
	Parking axis and parking encoder
	Update of the firmware: Upgrade of firmware and project in STARTER, retrograde lock
Safety Integrated Basic Functions	
	Safe Torque Off (STO)
	Safe Stop 1 (SS1, time controlled)
	Safe Brake Control (SBC)

	SW function
Safety Integrated Extended Functions	
	Safe Stop 1 (SS1, time and acceleration controlled)
	Safe Stop 2 (SS2)
	Safe Operating Stop (SOS)
	Safely Limited Speed (SLS)
	Safe Speed Monitor (SSM)
	Safe Acceleration Monitor (SAM)
Communication PROFIBUS DP/PROFINET IO	

Topology

Fixed DRIVE-CLiQ topology rules for SINAMICS S120 Combi. The device must always be connected according to the same principle.

System clocks

The sampling times for:

- Current controller
- Speed controller and
- Flux controller

are permanently set to 125 µs. The pulse frequency is permanently set to 4 kHz. This means that a maximum spindle speed of 24000 rpm can be reached.

Available motors

- Synchronous motors: 1FT6, 1FT7, 1FK7, 1FW3
- Induction motors: 1PH7, 1PH4, 1PL6, 1PH8

A.4 List of abbreviations

Note:

The following list of abbreviations includes all abbreviations and their meanings used in the entire SINAMICS user documentation.

Abbreviation	Source of abbreviation	Meaning
A		
A...	Alarm	Alarm
AC	Alternating Current	Alternating current
ADC	Analog Digital Converter	Analog digital converter
AI	Analog Input	Analog input
AIM	Active Interface Module	Active Interface Module
ALM	Active Line Module	Active Line Module
AO	Analog Output	Analog output
AOP	Advanced Operator Panel	Advanced Operator Panel
APC	Advanced Positioning Control	Advanced Positioning Control
AR	Automatic Restart	Automatic restart
ASC	Armature Short Circuit	Armature short circuit
ASCII	American Standard Code for Information Interchange	American standard code for information interchange
ASM	Asynchronmotor	Induction motor
B		
BERO	-	Contactless proximity switch
BI	Binector Input	Binector input
BIA	Berufsgenossenschaftliches Institut für Arbeitssicherheit	Germany's Institute for Occupational Safety and Health
BICO	Binector Connector Technology	Binector connector technology
BLM	Basic Line Module	Basic Line Module
BO	Binector Output	Binector output
BOP	Basic Operator Panel	Basic Operator Panel

Abbreviation	Source of abbreviation	Meaning
C		
C	Capacitance	Capacitance
C...	-	Safety message
CAN	Controller Area Network	Serial bus system
CBC	Communication Board CAN	Communication board CAN
CD	Compact Disc	Compact Disc
CDC	Crosswise data comparison	Crosswise data comparison
CDS	Command Data Set	Command data set
CF Card	CompactFlash Card	CompactFlash Card
CI	Connector Input	Connector input
CLC	Clearance Control	Clearance control
CNC	Computer Numerical Control	Computer numerical control
CO	Connector Output	Connector output
CO/BO	Connector Output/Binector Output	Connector/binector output
COB ID	CAN Object Identification	CAN Object identification
COM	Common contact of a changeover relay	Center contact of a changeover contact
COMM	Commissioning	Commissioning
CP	Communication Processor	Communication processor
CPU	Central Processing Unit	Central processing unit
CRC	Cyclic Redundancy Check	Cyclic redundancy check
CSM	Control Supply Module	Control Supply Module
CU	Control Unit	Control Unit
CUA	Control Unit Adapter	Control Unit Adapter
CUD	Control Unit DC MASTER	Control Unit DC MASTER
D		
DAC	Digital Analog Converter	Digital analog converter
DC	Direct Current	DC current
DC link	DC link	DC link
DCB	Drive Control Block	Drive Control Block
DCC	Drive Control Chart	Drive Control Chart
DCC	Data Cross Check	Crosswise data comparison
DCN	Direct Current Negative	DC current negative
DCP	Direct Current Positive	DC current positive
DDS	Drive Data Set	Drive data set
DI	Digital Input	Digital input
DI/DO	Digital Input/Digital Output	Digital input/output bidirectional
DMC	DRIVE-CLiQ Hub Module Cabinet	DRIVE-CLiQ Hub Module Cabinet
DME	DRIVE-CLiQ Hub Module External	DRIVE-CLiQ Hub Module External
DO	Digital Output	Digital output
DO	Drive Object	Drive object

Abbreviation	Source of abbreviation	Meaning
DP	Decentralized Peripherals	Distributed IOs
DPRAM	Dual Ported Random Access Memory	Memory with dual access ports
DRAM	Dynamic Random Access Memory	Dynamic memory
DRIVE-CLiQ	Drive Component Link with IQ	Drive Component Link with IQ
DSC	Dynamic Servo Control	Dynamic Servo Control
E		
EASC	External Armature Short Circuit	External armature short circuit
EDS	Encoder Data Set	Encoder data set
ESD	Electrostatic Sensitive Devices	Electrostatic sensitive devices
ELCB	Earth Leakage Circuit Breaker	Earth leakage circuit breaker
ELP	Earth Leakage Protection	Earth leakage protection
EMC	Electromagnetic Compatibility	Electromagnetic compatibility
EMF	Electromagnetic Force	Electromagnetic force
EMC	Electromagnetic compatibility	Electromagnetic compatibility
EN	European standard	European standard
EnDat	Encoder Data Interface	Encoder interface
EP	Enable Pulses	Pulse enable
EPOS	Einfachpositionierer	Basic positioner
ES	Engineering System	Engineering System
ESB	Equivalent circuit diagram	Equivalent circuit diagram
ESD	Electrostatic Sensitive Devices	Electrostatic sensitive devices
ESR	Extended Stop and Retract	Extended stop and retract
F		
F...	Fault	Fault
FAQs	Frequently Asked Questions	Frequently asked questions
FBL	Free Blocks	Free function blocks
FCC	Function Control Chart	Function Control Chart
FCC	Flux Current Control	Flux current control
FD	Function Diagram	Function diagram
F-DI	Failsafe Digital Input	Fail-safe digital input
F-DO	Failsafe Digital Output	Fail-safe digital output
FEM	Fremderregter Synchronmotor	Separately excited synchronous motor
FEPROM	Flash EPROM	Non volatile read and write memory
FG	Function Generator	Function generator
FI	-	Fault current
FOC	Fiber-Optic Cable	Fiber-optic cable
FP	Function diagram	Function diagram
FPGA	Field Programmable Gate Array	Field Programmable Gate Array

Abbreviation	Source of abbreviation	Meaning
FW	Firmware	Firmware
G		
GB	Gigabyte	Gigabyte
GC	Global Control	Global Control Telegram (Broadcast Telegramm)
GND	Ground	Reference potential for all signal and operating voltages, usually defined as 0 V (also referred to as G)
GSD	Generic Station Description	Generic station description: Describes the characteristics of a PROFIBUS slave
GSV	Gate Supply Voltage	Gate Supply Voltage
GUID	Globally Unique Identifier	Globally unique identifier
H		
HF	High Frequency	High frequency
HFD	Hochfrequenzdrossel	High-frequency reactor
HMI	Human Machine Interface	Human machine interface
HTL	High-Threshold Logic	Logic with a high fault threshold
HW	Hardware	Hardware
I		
I/O	Input/Output	Input/output
I2C	Inter-Integrated Circuit	Internal serial data bus
IASC	Internal Armature Short Circuit	Internal armature short circuit
IBN	Inbetriebnahme	Commissioning
ID	Identifier	Identification
IE	Industrial Ethernet	Industrial Ethernet
IEC	International Electrotechnical Commission	International Electrotechnical Commission
IF	Interface	Interface
IGBT	Insulated Gate Bipolar Transistor	Insulated gate bipolar transistor
IGCT	Integrated Gate-Controlled Thyristor	Semiconductor power switch with integrated control electrode
IL	Impulslöschung	Pulse cancelation
IP	Internet Protocol	Internet Protocol
IPO	Interpolator	Interpolator
IT	Isolé Terré	Non-grounded three-phase power supply
IVP	Internal Voltage Protection	Internal voltage protection
J		
JOG	Jogging	Jogging

Abbreviation	Source of abbreviation	Meaning
K		
KIP	Kinetische Pufferung	Kinetic buffering
Kp	-	Proportional gain
KTY	-	Special temperature sensor
L		
L	-	Formula symbol for inductance
LED	Light Emitting Diode	Light Emitting Diode
LIN	Linear motor	Linear motor
LSB	Least Significant Bit	Least significant bit
LSC	Line-Side Converter	Line-side converter
LSS	Line Side Switch	Line side switch
LU	Length Unit	Length unit
M		
M	-	Formula symbol for torque
M	Masse	Reference potential for all signal and operating voltages, usually defined as 0 V (also referred to as GND)
MB	Megabyte	Megabyte
MCC	Motion Control Chart	Motion Control Chart
MDS	Motor Data Set	Motor data set
MLFB	Maschinenlesbare Fabrikatebezeichnung	Machine-Readable Product Code
MMC	Man-Machine Communication	Man-machine communication
MMC	Micro Memory Card	Micro memory card
MSB	Most Significant Bit	Most significant bit
MSC	Motor-Side Converter	Motor-side converter
MSCY_C1	Master Slave Cycle Class 1	Cyclic communication between master (Class 1) and slave
MSR	Motorstromrichter	Motor-side converter
MT	Machine Tool	Machine tool
N		
N. C.	Not Connected	Not connected
N...	No Report	No message or internal message
NAMUR	Normenarbeitsgemeinschaft für Mess- und Regeltechnik in der chemischen Industrie	Standardization association for measurement and control in the chemical industry
NC	Normally Closed (contact)	NC contact
NC	Numerical Control	Numerical control
NEMA	National Electrical Manufacturers Association	Standardization body in the US
NM	Nullmarke	Zero mark
NO	Normally Open (contact)	NO contact

Abbreviation	Source of abbreviation	Meaning
NSR	Netzstromrichter	Line-side converter
NVRAM	Non-Volatile Random Access Memory	Non-volatile read/write memory
O		
OA	Open Architecture	Open Architecture
OC	Operating Condition	Operating condition
OEM	Original Equipment Manufacturer	Original Equipment Manufacturer
OLP	Optical Link Plug	Fiber-optic bus connector
OMI	Option Module Interface	Option module interface
P		
p...	-	Adjustable parameters
PB	PROFIBUS	PROFIBUS
PC	Position Controller	Position Controller
PcCtrl	PC Control	Control for master
PD	PROFIdrive	PROFIdrive
PDS	Power unit Data Set	Power unit data set
PE	Protective Earth	Protective earth
PELV	Protective Extra Low Voltage	Protective extra low voltage
PEM	Permanenterregter Synchronmotor	Permanent-magnet synchronous motor
PG	Programmiergerät	Programming device
PI	Proportional Integral	Proportional integral
PID	Proportional Integral Differential	Proportional integral differential
PLC	Programmable Logic Controller	Programmable logic controller
PLL	Phase-Locked Loop	Phase-locked loop
PN	PROFINET	PROFINET
PNO	PROFIBUS Nutzerorganisation	PROFIBUS user organization
PPI	Point-to-Point Interface	Point-to-point interface
PRBS	Pseudo Random Binary Signal	White noise
PROFIBUS	Process Field Bus	Serial data bus
PS	Power Supply	Power supply
PSA	Power Stack Adapter	Power Stack Adapter
PTC	Positive Temperature Coefficient	Positive temperature coefficient
PTP	Point-To-Point	Point-to-Point
PWM	Pulse Width Modulation	Pulse width modulation
PZD	Prozessdaten	Process data
R		
r...	-	Display parameters (read-only)
RAM	Random Access Memory	Read/write memory
RCCB	Residual Current Circuit Breaker	Residual current operated circuit breaker
RCD	Residual Current Device	Residual current operated circuit breaker
RCM	Residual Current Monitor	Residual current monitor

Abbreviation	Source of abbreviation	Meaning
RFG	Ramp-Function Generator	Ramp-function generator
RJ45	Registered Jack 45	Term for an 8-pin socket system for data transmission with shielded or non-shielded multi-wire copper cables
RKA	Rückkühlanlage	Cooling unit
RO	Read Only	Read only
RPDO	Receive Process Data Object	Receive process data object
RS232	Recommended Standard 232	Interface standard for cable-connected serial data transmission between a sender and receiver (also known under EIA232)
RS485	Recommended Standard 485	Interface standard for a cable-connected differential, parallel, and/or serial bus system (data transmission between a number of senders and receivers, also known under EIA485)
RTC	Real Time Clock	Real time clock
RZA	Raumzeigerapproximation	Space vector approximation
S		
S1	-	Uninterrupted duty
S3	-	Intermittent duty
SBC	Safe Brake Control	Safe brake control
SBH	Sicherer Betriebshalt	Safe operating stop
SBR	-	Safe acceleration monitoring
SCA	Safe Cam	Safe cam
SD Card	SecureDigital Card	Secure digital memory card
SE	Sicherer Software-Endschalter	Safe software limit switch
SG	Sicher reduzierte Geschwindigkeit	Safely reduced speed
SGA	Sicherheitsgerichteter Ausgang	Safety-related output
SGE	Sicherheitsgerichteter Eingang	Safety-related input
SH	Sicherer Halt	Safe standstill
SI	Safety Integrated	Safety Integrated
SIL	Safety Integrity Level	Safety Integrity Level
SLM	Smart Line Module	Smart Line Module
SLP	Safely-Limited Position	Safely-limited position
SLS	Safely Limited Speed	Safely limited speed
SLVC	Sensorless Vector Control	Vector control without encoder
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	Safe Operating Stop	Safe operating stop

Abbreviation	Source of abbreviation	Meaning
SP	Service Pack	Service pack
SPC	Setpoint Channel	Setpoint channel
SPI	Serial Peripheral Interface	Serial interface for connecting peripherals
SS1	Safe Stop 1	Safe stop 1 (monitored for time and ramping up)
SS2	Safe Stop 2	Safe stop 2
SSI	Synchronous Serial Interface	Synchronous serial interface
SSM	Safe Speed Monitor	Safe feedback for speed monitoring (n < nx)
SSP	SINAMICS Support Package	SINAMICS support package
STO	Safe Torque Off	Safe torque off
STW	Steuerwort	Control word
T		
TB	Terminal Board	Terminal Board
TIA	Totally Integrated Automation	Totally Integrated Automation
TM	Terminal Module	Terminal module
TN	Terre Neutre	Grounded three-phase supply network
Tn	-	Integral time
TPDO	Transmit Process Data Object	Transmit process data object
TT	Terre Terre	Grounded three-phase supply network
TTL	Transistor-Transistor Logic	Transistor-transistor logic
Tv	-	Rate time
U		
u.d.	under development	Under development: This feature is not cur- rently available
UL	Underwriters Laboratories Inc.	Underwriters Laboratories Inc.
UPS	Uninterruptible Power Supply	Uninterruptible power supply
UTC	Universal Time Coordinated	Universal time coordinated
V		
VC	Vector Control	Vector control
Vdc	-	DC link voltage
VdcN	-	Partial DC link voltage negative
VdcP	-	Partial DC link voltage positive
VDE	Verband Deutscher Elektrotechniker	Association of German electrical engineers
VDI	Verein Deutscher Ingenieure	Association of German Engineers
VPM	Voltage Protection Module	Voltage Protection Module
Vpp	Volt peak-to-peak	Volt peak-to-peak
VSM	Voltage Sensing Module	Voltage Sensing Module

Abbreviation	Source of abbreviation	Meaning
X		
XML	Extensible Markup Language	Standard language for Web publishing and document management
Z		
ZM	Zero Mark	Zero mark
ZSW	Zustandswort	Status word

SINAMICS documentation overview

General documentation/catalogs

SINAMICS G110
D11.1
Inverter Chassis Units
0.12 kW to 3 kW

SINAMICS G130, G150
D11
Drive Converter Chassis Units
Drive Converter Cabinet Units

SIMOTION SINAMICS S120
PM21
SIMOTION, SINAMICS S120 and
Motors for Production Machines

SINAMICS S120, S150
D21.3
SINAMICS S120 Chassis Units
Chassis Format Units and Cabinet Modules
SINAMICS S150
Converter Cabinet Units

Manufacturer/service documentation

SINAMICS G110
Getting Started
Operating Instructions
List Manual

SINAMICS G120
Getting Started
Operating Instructions
Hardware Installation Manual
Function Manual Safety Integrated
List Manual

SINAMICS G130
Operating Instructions
List Manual

SINAMICS G150
Operating Instructions
List Manual

SINAMICS GM150, SM150, GL150, SL150
Operating Instructions
List Manual

Manufacturer/service documentation

SINAMICS S110
Equipment Manual
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SINAMICS S120
Getting Started
Commissioning Manual
Commissioning Manual for CANopen
Function Manual Drive Functions
Function Manual Safety Integrated
Function Manual DCC
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SINAMICS S120
Equipment Manual for Control Units and
Additional Components
Equipment Manual for Booksize Power Units
Equipment Manual for Chassis Power Units
Equipment Manual for Chassis Liquid
Cooled Power Units
Equipment Manual Cabinet Modules
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