Function Manual 06/2005 Edition

sinamics

SINAMICS S120

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SINAMICS S120

Drive Functions

Manufacturer/Service Documentation

Valid for

Drive	*Firmware release*
SINAMICS S120	2.3

06/2005 Edition

SINAMICS® Documentation

Printing history

Brief details of this edition and previous editions are listed below.

The status of each edition is shown by the code in the ”Remarks” column.

Status code in the ”Remarks” column:

A New documentation
B Unrevised reprint with new Order No.
C Revised edition with new status

Edition	Order No.	Comments
12.04	6SL3 097-2AB00-0AP0	**A**
06.05	6SL3 097-2AB00-0BP1	**C**

Additional information is available on the Internet at:
http://www.siemens.de/motioncontrol
Information about SINAMICS S120 is available at:
http://www.siemens.com/sinamics

This publication was produced with Interleaf V 7

Other functions not described in this documentation might be executable in the control. The customer is not, however, entitled to these functions in the event of the system being replaced or serviced.

We have checked that the contents of this document correspond to the hardware and software described. Nevertheless, differences might exist and therefore we cannot guarantee that they are completely identical. However, the data in this manual is reviewed regularly and any necessary corrections included in subsequent editions. We are thankful for any recommendations or suggestions.

We reserve the right to make technical changes.

Order No.6SL3 097-2AB00-0BP1
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Siemens Aktiengesellschaft

Preface

Information on the SINAMICS S120 documentation

The SINAMICS S120 documentation is divided into the following areas:

- General documentation/catalogs
- Manufacturer/service documentation
- Electronic documentation

Table 1-1 Useful phases and available documentation/tools

Useful phase	Document/tool
Exploratory	Sales documents for SINAMICS S120
Planning/configuration	SIZER configuration tool
Decision/ordering	SINAMICS S120 catalog
Installation/assembly	SINAMICS S120 Equipment Manuals • Control Units and additional system components • Booksize power sections • Chassis power sections
Commissioning	• STARTER parameterization and commissioning tool • Getting Started: SINAMICS S120 • SINAMICS S120 Installation and Start-Up Manual • SINAMICS S120 Function Manual • SINAMICS S List Manual
Usage/operation	• SINAMICS S120 Installation and Start-Up Manual • SINAMICS S120 Function Manual • SINAMICS S List Manual
Maintenance/servicing	• SINAMICS S120 Installation and Start-Up Manual • SINAMICS S120 Function Manual • SINAMICS S List Manual • Booksize power sections • Chassis power sections

This documentation is part of the technical customer documentation for SINAMICS. All documents can be obtained separately.

You can obtain detailed information about the documents named in the documentation overview and other documents available for SINAMICS from your local Siemens office.

In the interests of clarity, this documentation does not contain all the detailed information for all product types and cannot take into account every possible aspect of installation, operation, or maintenance.

The contents of this documentation are not part of an earlier or existing agreement, a promise, or a legal agreement, nor do they change this. All obligations entered into by Siemens result from the respective contract of sale that contains the complete and sole valid warranty arrangements. These contractual warranty provisions are neither extended nor curbed as a result of the statements made in this documentation.

Audience

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

Objective

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

The Function Manual is structured as follows:

Chapter 1	Infeed
Chapter 2	Setpoint Channel
Chapter 3	Operating Modes
Chapter 4	Extended Functions
Chapter 5	Basic Information About the Drive System

Beginners are advised to read Chapter 5 first.

Finding Your Way Around

To help you find information more easily, the following sections have been included in the appendix in addition to the table of contents:

1. List of Abbreviations
2. References
3. Index

Danger and warning symbols – explanations

The following danger and warning notices are used in this document:

Danger

This symbol indicates that death, severe personal injury, or substantial property damage **will** result if proper precautions are not taken.

Warning

This symbol indicates that death, severe personal injury, or substantial property damage **may** result if proper precautions are not taken.

Caution

This symbol indicates that minor personal injury or property damage **may** result if proper precautions are not taken.

Caution

(Without a warning triangle) indicates that material damage **can** result if proper precautions are not taken.

Notice

Indicates that an unwanted result or situation **may** result if the appropriate advice is not taken into account.

Note

This symbol always appears in this documentation where further, explanatory information is provided.

Definition: Qualified personnel

For the purpose of this documentation and the product warning labels, a “qualified person” is someone who is familiar with the installation, mounting, start-up, operation, and maintenance of the product. He or she must have the following qualifications:

- Training and instruction, i.e. authority to switch on and off, to earth and to label circuits and equipment according to safety regulations.
- Trained in the proper care and use of protective equipment in accordance with established safety procedures.
- First aid training.

Technical notes

Technical Support

If you have any further questions, please call our hotline:

A&D Technical Supports	Tel.:	+49 (0) 180 5050 – 222
	Fax:	+49 (0) 180 5050 – 223
	http://www.siemens.com/automation/support-request	

Please send any questions about the documentation (suggestions for improvement, corrections, and so on) to the following fax number or e-mail address:

	+49 (0) 9131 98 – 2176
Fax form:	see feedback page at the end of this documentation
e-mail:	motioncontrol.docu@erlf.siemens.de

Internet Address

Up-to-date information about our products can be found on the Internet at the following address:

http://www.siemens.com/drives

Notation

The following notation and abbreviations are used in this documentation:

Notation for parameters (examples):

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

Notation for faults and alarms (examples):

- F1234 Fault 1234
- A5678 Alarm 5678

General notation:

- The sign "≐" means "is equal to"

ESD notices

Caution

An **e**lectrostatic-**s**ensitive **d**evice (ESD) is an individual component, integrated circuit, or module that can be damaged by electrostatic fields or discharges.

Regulations for handling ESD components:

- When handling components, make sure that personnel, workplaces, and packaging are well earthed.
- Personnel in ESD areas with conductive flooring may only handle electronic components if:
  - They are grounded with an ESD wrist band
  - They are wearing ESD shoes or ESD shoe grounding straps
- Electronic boards should only be touched if absolutely necessary. They must only be handled on the front panel or, in the case of printed circuit boards, at the edge.
- Electronic boards must not come into contact with plastics or items of clothing containing synthetic fibers.
- Boards must only be placed on conductive surfaces (work surfaces with ESD surface, conductive ESD foam, ESD packing bag, ESD transport container).
- Electronic modules must be kept at a distance from data display equipment, monitors, and televisions (minimum distance from screen: >10 cm).
- Measurements must only be taken on boards when:
  - The measuring device is grounded (with a protective conductor, for example).
  - The measuring head has been temporarily discharged before measurements are taken on a floating measuring device (e.g. touching a bare metal controller housing).

Safety Information

Danger

- Commissioning shall not start until you have ensured that the machine in which the components described here are to be installed complies with Directive 98/37/EC.
- SINAMICS devices and AC motors must only be commissioned by suitably qualified personnel.
- The personnel must take into account the information provided in the technical customer documentation for the product, and be familiar with and observe the specified danger and warning notices.
- When electrical equipment and motors are operated, the electrical circuits automatically conduct a dangerous voltage.
- Dangerous mechanical movements may occur in the system during operation.
- All work on the electrical system must be carried out when the system has been disconnected from the power supply.
- SINAMICS devices with AC motors must only be connected to the power supply via an AC-DC residual-current-operated device with selective switching once verification has been provided that the SINAMICS device is compatible with the residual-current-operated device in accordance with EN 50178, Chapter 5.2.11.2.

Warning

- The successful and safe operation of these devices and motors depends on correct transport, proper storage and installation, as well as careful operation and maintenance.
- The specifications in the catalogs and offers also apply to special variants of the devices and motors.
- In addition to the danger and warning information provided in the technical customer documentation, the applicable national, local, and system-specific regulations and requirements must be taken into account.
- Only protective extra-low voltages (PELVs) that comply with EN60204-1 must be connected to all connections and terminals between 0 and 48 V.

Caution

- The surface temperature of the motors can reach over +80°C.
- For this reason, temperature-sensitive parts (lines or electronic components, for example) must not be placed on or 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 rotating parts

Caution

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

Note

- When operated in dry operating areas, SINAMICS equipment with three-phase motors conforms to low-voltage Directive 73/23/EEC.

■

Contents

Notes

Supply

1

Contents of Chapter "Supply"

- Active infeed
- Smart infeed
- Basic infeed
- Line contactor control
- Pre-charging and bypass contactor (chassis)

1.1 Active infeed

1.1.1 Active Infeed closed-loop control

Features

- Controlled DC link voltage whose level can be adjusted
- Regenerative feedback capability
- Specific reactive current setting
- Low line harmonics, sinusoidal line current

Description

Active Infeed closed-loop control works together with the line reactor and the Active Line Module as a step-up converter. The DC voltage level can be defined via parameters.

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

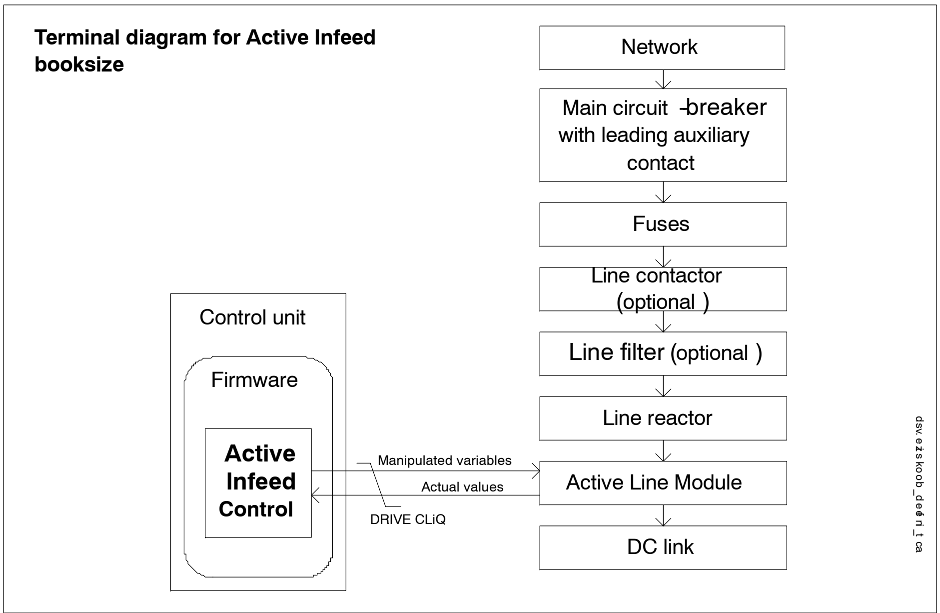


Fig. 1-1 Schematic structure of Active Infeed (booksize)

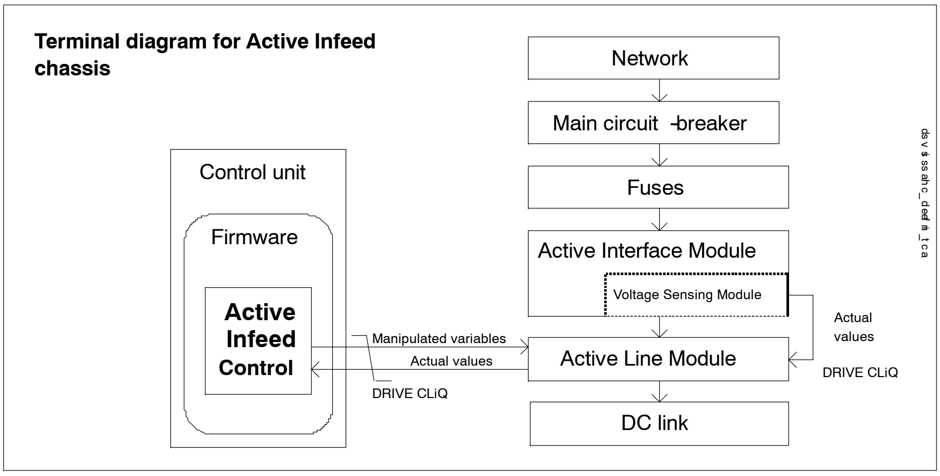


Fig. 1-2 Schematic structure of Active Infeed (chassis)

Operating modes of Active Infeed closed-loop control for Active Line Modules (booksize)

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

- Active mode

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

- Smart mode

  In smart mode, the DC link voltage is not regulated but is, instead, derived from the rectified line supply voltage. The current waveform in the direction of incoming supply is the same as that of a B6 diode converter. A square-line current occurs in the direction of regenerative feedback.

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 smart mode are derived from the rectified line supply voltage. The DC link voltage setpoint (p3510) has no effect in this control mode.

Operating modes of Active Infeed closed-loop control for Active Line Modules (chassis)

Active Line Modules (chassis) only function in active mode.

The DC link voltage setpoint (p3510) is preset in line with the supply voltage (p0210) according to the following formula: p3510 = 1.5 * p0210.

Commissioning

During commissioning, the device supply voltage (p0210) and the rated line frequency (p0211) must be parameterized. In addition, an optional line filter (p0220) must be selected.

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:

- Booksize
  - Upper limit: Maximum DC link voltage (p0280)
  - Lower limit: Supply voltage (p0210) multiplied by 1.42
- Chassis
  - Upper limit: Supply voltage (p0210) multiplied by 2
  - Lower limit: Supply voltage (p0210) multiplied by 1.42

Note

If automatic commissioning was carried out with STARTER, the line filter (if used) must be included in the configuration.

Function diagram for Active Infeed (see List Manual)

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

Key parameters for Active Infeed (see List Manual)

- r0002 Infeed/operating display
- r0046 CO/BO: Infeed missing enable signals
- p0210 Device supply voltage
- p0211 Rated line frequency
- p0220 Infeed line filter type
- p0280 DC link voltage maximum steady-state
- p0840 BI: ON/OFF1
- p0844 BI: 1. OFF2
- p0852 BI: Enable operation
- p0898 CO/BO: Control word sequential control infeed
- p0899 CO/BO: Status word central probe
- p2138 CO/BO: Control word faults/alarms
- p2139 CO/BO: Status word faults/alarms 1
- p3400 Infeed configuration word
- r3405 CO/BO: Status word infeed
- 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

1.1.2 Line and DC link identification

Automatic parameter identification is used to determine all the line and DC link parameters, thereby enabling the controller setting for the line module to be optimized.

Note

If the line environment or DC link components are changed, automatic identification should be repeated with p3410 = 5 (e.g. once the system has been installed or the drive line-up extended).

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

Identification methods

For additional identification methods, see the List Manual.

- When p3410 = 4, an identification run for the total inductance and DC link capacitance is initiated when the pulses are next enabled. The data determined during identification (r3411 and r3412) are transferred into p3421 and p3422 and the controller parameters recalculated. The identification is then repeated at an increased current level (p3415[1]). If the inductance measured the second time is lower, the parameters are written to the current controller adaptation (p3620, p3622). All of the parameters for the infeed module are then automatically stored in a non-volatile memory. The infeed continues to operate without any interruption with the new controller parameters.
- When p3410 = 5, the same measurements and write operations are carried out as when p3410 = 4. During the first identification run, however, the controller setting is initially reset by setting p3421 = p0223 and p3422 = p0227. Before the measurements are taken, a short identification run is also carried to establish the initial controller settings. p3410 is automatically set to 0 after an identification run has been successfully completed.

  Note:
  The identification method with p3410 = 5 is the preferred method.
  Closed-loop control may have to be reset to the factory setting if the identification process is unsuccessful.

Parameter overview (see List Manual)

- p3410 Infeed identification method
- p3421 Infeed inductance
- p3422 Infeed DC link capacity
- p3620 Infeed current controller adaptation lower application threshold
- p3622 Infeed current controller adaptation reduction factor

1.1.3 Active infeed open-loop control

Description

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

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0 –> 1 edge at the "Acknowledge error" (p2103.5) signal.

Switching on the Active Line Module:

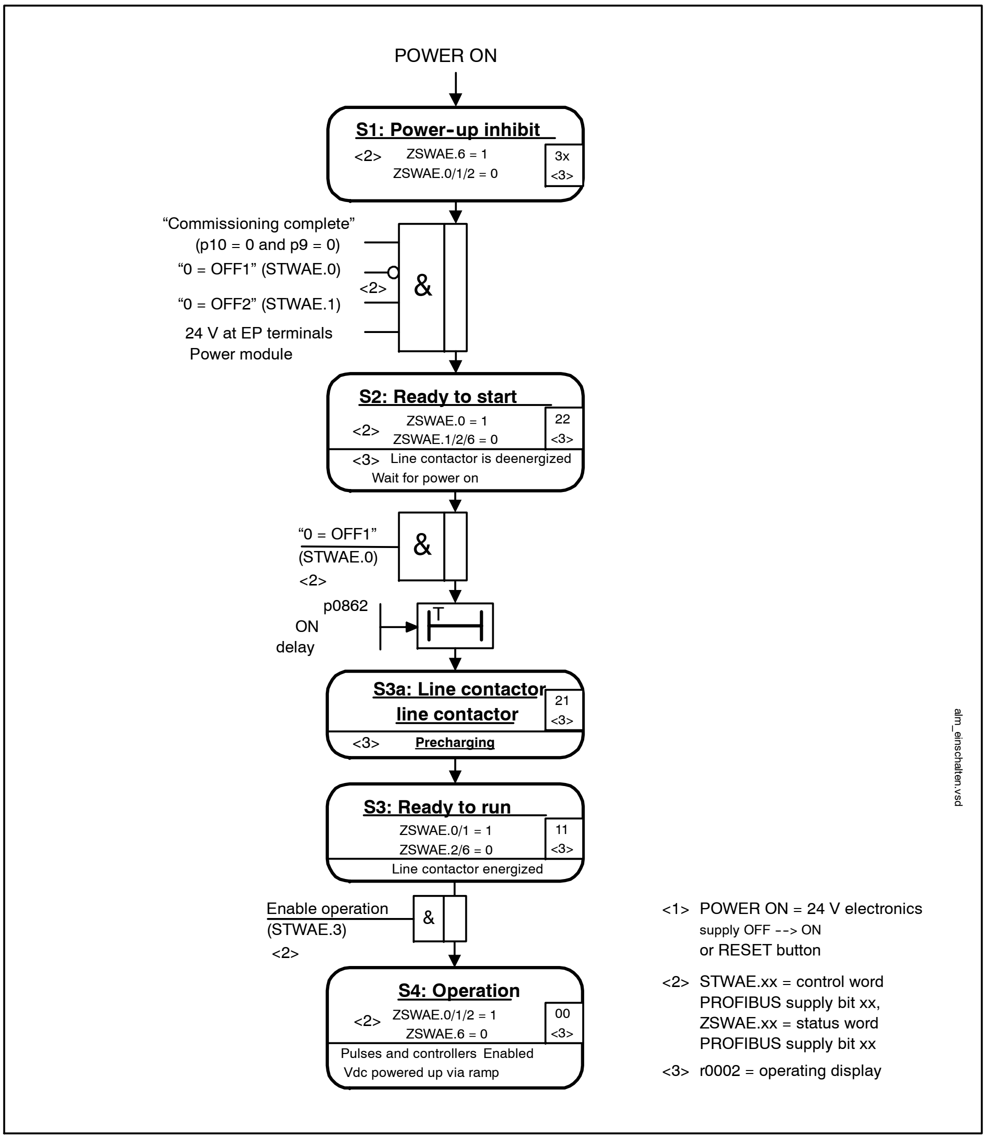


Fig. 1-3 Active Infeed ramp-up

Switching off the Active Line Module

To switch off the active line module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490, thereby allowing the connected drives to be decelerated in a controlled manner.

Control and status messages

Table 1-2 Active infeed open-loop control

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

Table 1-3 Active infeed status message

Signal name	Internal status word	Parameter	PROFIBUS telegram 370
Ready to start	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
Fault active	ZSWAE.3	r2139.3	A_ZSW1.3
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-up inhibit	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm present	ZSWAE.7	r2139.7	A_ZSW1.7
Controlled by PLC	ZSWAE.9	r0899.9	A_ZSW1.9
Pre-charging compl	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.1.4 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 binector 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 0075 no longer corresponds with the parameterized total reactive current setpoint.

Note

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

1.1.5 Harmonics controller

Description

Harmonics in the line voltage cause harmonics in the line currents. By activating the harmonics controller, you can reduce current harmonics.

Example: setting the harmonics controller

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

Table 1-4 Example parameters for the harmonics controller

Index	p3624 harmonics controller order	p3625 scaling
[0]	5	100 %
[1]	7	100 %

The phase currents in parameter p0069[0..2] (U, V, W) can be checked using the STARTER trace function.

Overview: key parameters

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

1.2 Smart infeed

1.2.1 Smart Infeed closed-loop control

Features

- For Smart Line Modules with an output of 16 kW and 36 kW
- Unregulated DC link voltage
- Regenerative feedback capability

Description

The firmware for the 16 kW and 36 kW Smart Line Modules runs on the Control Unit assigned to it. The Smart Line Module and Control Unit communicate via DRIVE-CLiQ.

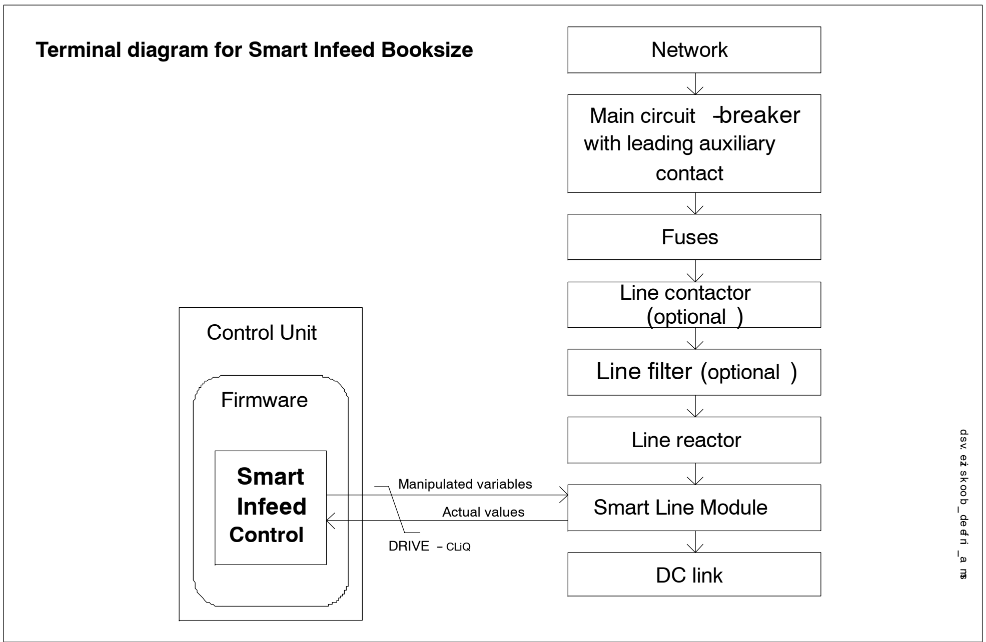


Fig. 1-4 Schematic structure of Smart Infeed (booksize)

Commissioning

The device supply voltage (p0210) and the rated line frequency (p0211) must be parameterized during commissioning.

Note

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

Function diagram for Smart Infeed (see List Manual)

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

Key parameters for Smart Infeed (see List Manual)

Adjustable parameter

- r0002 Infeed/operating display
- r0046 CO/BO: Infeed missing enable signals
- p0210 Device supply voltage
- p0211 Rated line frequency
- p0840 BI: ON/OFF1
- p0844 BI: 1. OFF2
- p0852 BI: Enable operation
- r0898 CO/BO: Control word sequential control infeed
- r0899 CO/BO: Status word sequential control infeed
- r2138 CO/BO: Control word faults/alarms
- r2139 CO/BO: Status word faults/alarms 1
- r3405 CO/BO: Status word infeed
- p3533 BI: Infeed, inhibit regenerative operation

1.2.2 Line and DC link identification

With automatic line and DC link identification, the parameters required for operating the Line Module as efficiently as possible are determined.

Note

If the line environment or DC link components are changed, automatic identification should be repeated with p3410 = 5 (e.g. once the system has been installed or the drive line-up extended).

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

Identification methods

For additional identification methods, see the List Manual.

- When p3410 = 4, an identification run for the total inductance and DC link capacitance is initiated when the pulses are next enabled. The data determined during identification (r3411 and r3412) are transferred into p3421 and p3422 and the controller parameters recalculated. The identification is then repeated at an increased current level (p3415[1]). If the inductance measured the second time is lower, the parameters are written to the current controller adaptation (p3620, p3622). All of the parameters for the infeed module are then automatically stored in a non-volatile memory. The infeed continues to operate without any interruption with the new controller parameters.
- When p3410 = 5, the same measurements and write operations are carried out as when p3410 = 4. During the first identification run, however, the controller setting is initially reset by setting p3421 = p0223 and p3422 = p0227. Before the measurements are taken, a short identification run is also carried to establish the initial controller settings. p3410 is automatically set to 0 after an identification run has been successfully completed.

  Note:
  The identification method with p3410 = 5 is the preferred method.
  Closed-loop control may have to be reset to the factory setting if the identification process is unsuccessful.

Key parameters for line and DC link identification (see List Manual)

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

1.2.3 Smart Infeed open-loop control

Description

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

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0 –> 1 edge at the "Acknowledge error" (p2103.5) signal.

Switching on the Smart Line Module:

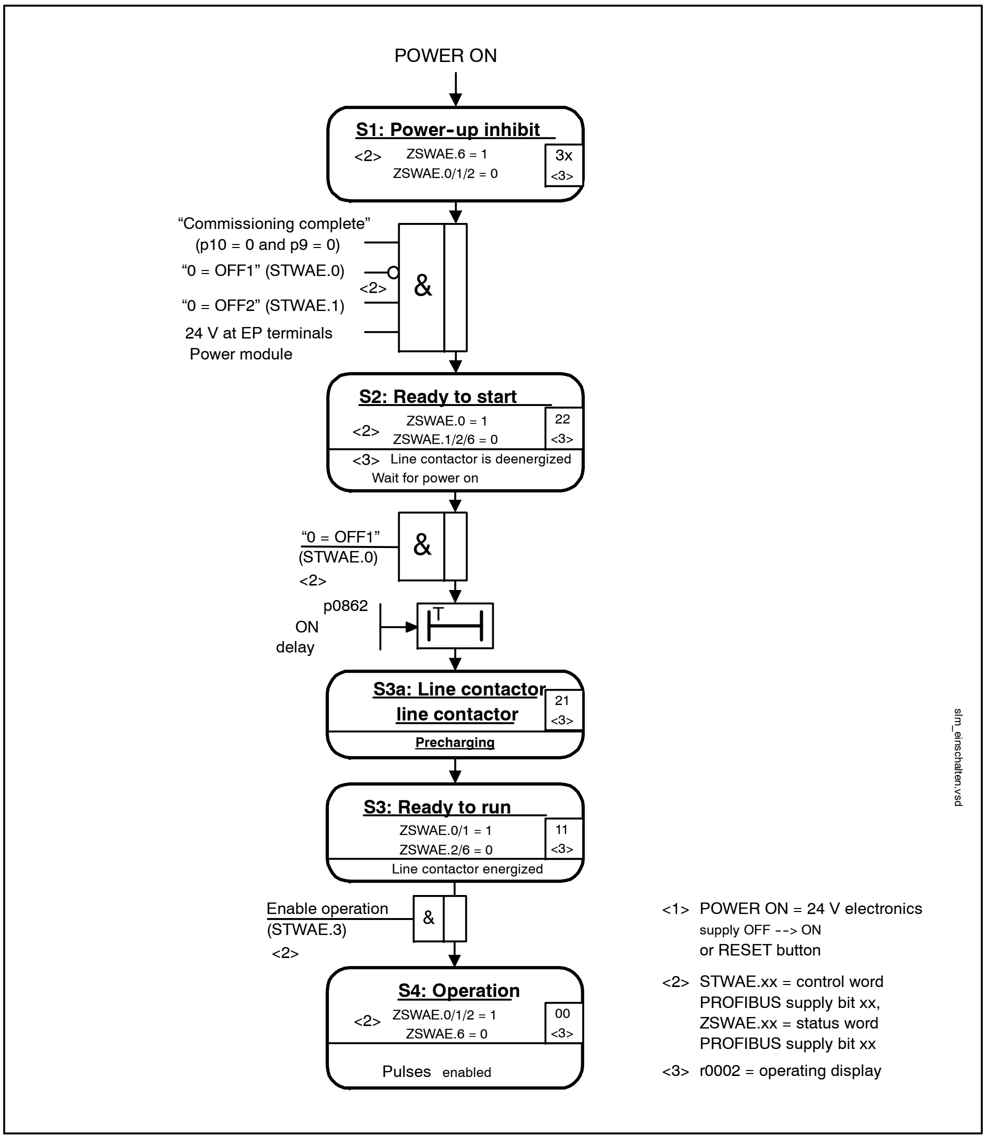


Fig. 1-5 Smart Infeed ramp-up

Switching off the Smart Line Module:

To switch off the active line module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490, thereby allowing the connected drives to be decelerated 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	PROFIBUS Telegram 370
ON/OFF1	STWAE.0	p0840 ON/OFF2	r0898.0	A_STW1.0
OFF2	STWAE.1	p0844 1 OFF2 and p0845 2 OFF2	r0898.1	A_STW1.1
Enable operation	STWAE.3	p0852 Enable operation	r0898.3	A_STW1.3
Inhibit regenerating	STWAE.6	p3533 Inhibit regenerating	r0898.6	A_STW1.6
Acknowledge error	STWAE.7	p2103 1 Acknowledge or p2104 2 Acknowledge or p2105 3 Acknowledge	r2138.7	A_STW1.7
Master ctrl by PLC	STWAE.10	p0854 Master ctrl by PLC	r0898.10	A_STW1.10

Table 1-6 Smart infeed status message

Signal name	Internal status word	Parameter	PROFIBUS telegram 370
Ready to start	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
Fault active	ZSWAE.3	r2139.3	A_ZSW1.3
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-up inhibit	ZSWAE.6	r0899.6	A_ZSW1.6
Alarm present	ZSWAE.7	r2139.7	A_ZSW1.7
Controlled by PLC	ZSWAE.9	r0899.9	A_ZSW1.9
Pre-charging compl	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.3 Basic Infeed

1.3.1 Basic Infeed open-loop control

Features

- For Basic Line Modules (chassis)
- Unregulated DC link voltage

Description

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

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

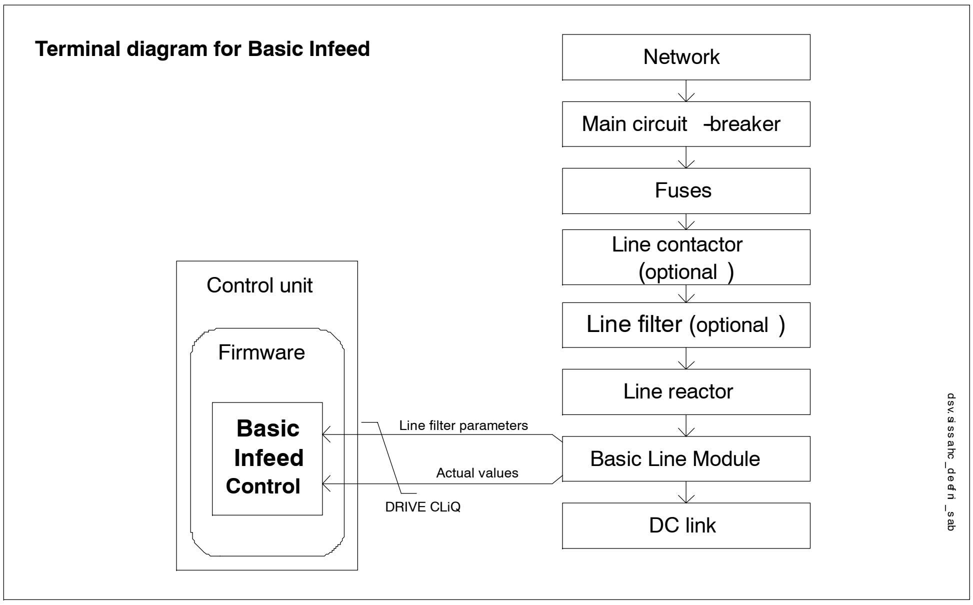


Fig. 1-6 Schematic structure of Basic Infeed (chassis)

Commissioning

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

Overview of key parameters for Basic Infeed (see List Manual)

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

Function diagram overview (see List Manual)

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

1.3.2 Basic Infeed open-loop control

Description

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

Acknowledge error

Errors that are still present but the causes of which have been rectified can be acknowledged by means of a 0 –> 1 edge at the “Acknowledge error” (p2103.5) signal.

Switching on the Basic Line Module:

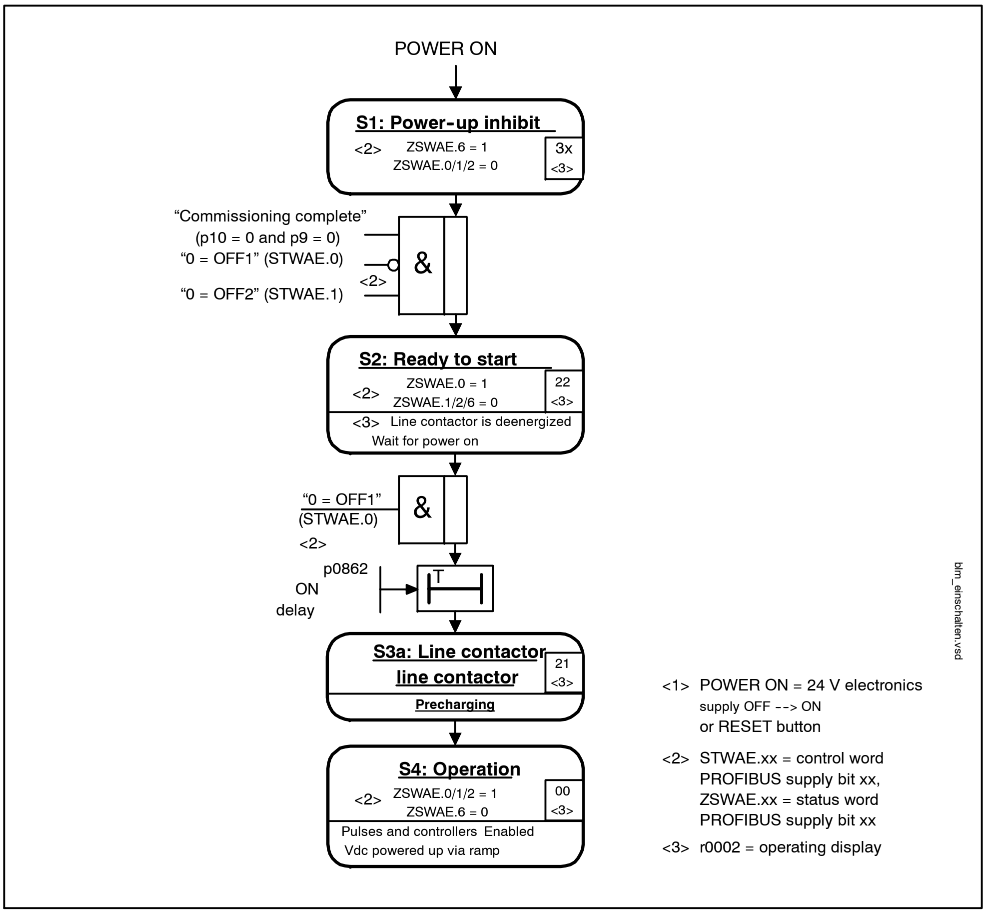


Fig. 1-7 Basic Infeed ramp-up

Switching off the Basic Line Module

To switch off the active line module, carry out the steps for switching it on in reverse order.

Switching off the controller with the OFF1 signal is delayed by the time entered in p3490, thereby allowing the connected drives to be decelerated in a controlled manner.

Control and status messages

Table 1-7 Basic Infeed open-loop control

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

Table 1-8 Basic Infeed status message

Signal name	Internal status word	Parameter	PROFIBUS telegram 370
Ready to start	ZSWAE.0	r0899.0	A_ZSW1.0
Ready to run	ZSWAE.1	r0899.1	A_ZSW1.1
Operation enabled	ZSWAE.2	r0899.2	A_ZSW1.2
No OFF2 active	ZSWAE.4	r0899.4	A_ZSW1.4
Power-up inhibit	ZSWAE.6	r0899.6	A_ZSW1.6
Controlled by PLC	ZSWAE.9	r0899.9	A_ZSW1.9
Pre-charging compl	ZSWAE.11	r0899.11	A_ZSW1.11
Line contactor energized feedback	ZSWAE.12	r0899.12	A_ZSW1.12

1.4 Line contactor control

Description

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

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

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

Note

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

Example of commissioning line contactor control

Assumption:

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

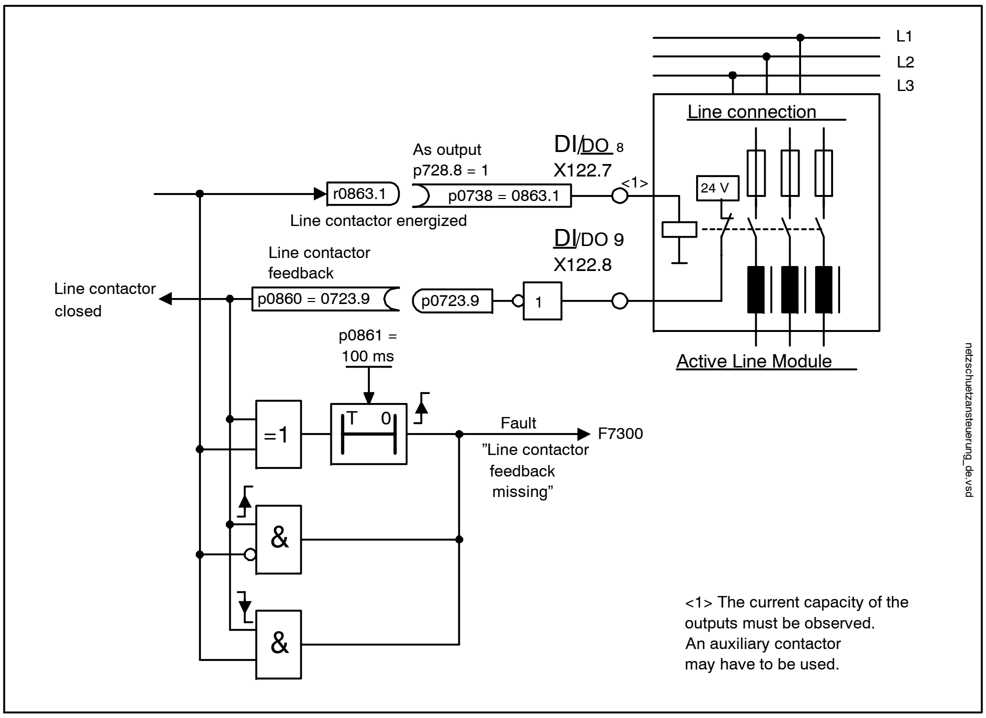


Fig. 1-8 Line contactor control

Commissioning steps:

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

Note

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

- Parameterize DI/DO 8 as an output (p728.8 = 1).
- Assign p0738 the control signal for the line contactor r0863.1.
- Connect the line contactor feedback contact to DI/DO 9.
- Assign p0860 an inverted input signal p0723.9.
- Enter the monitoring time for the line contactor (100 ms) in p0861.

Function diagram overview (see List Manual)

- 8934 Missing enable signals, line contactor control

Parameter overview (see List Manual)

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

1.5 Pre-charging and bypass contactor (chassis)

Description

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

The pre-charging input circuit for the Active Infeed (chassis) 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. This contactor must be provided separately for types HI and JI.
For more information, see the Equipment Manual.

Procedure during power ON/OFF

Power ON:

- The pre-charging contactor is closed and the DC link is charged via the pre-charging resistors.
- Once pre-charging is complete, the bypass contactor is closed and the pre-charging contactor opened. The DC link is pre-charged and ready 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.

■

Notes

Extended Setpoint Channel

2

Contents of "Extended Setpoint Channel"

2.1 Extended setpoint channel servo (booksize)

Description

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

Properties of servo mode without the “extended setpoint channel” function module

- The setpoint value is connected directly to p1155[D]
- Deceleration ramp for OFF 1 and OFF 3
- A higher number of motors can be controlled with one Control Unit at one setpoint source by moving the ramp-function generator to the higher-level controller.
- Dynamic Servo Control (DSC) only
- Deceleration ramp OFF1 via p1121[D]
- Deceleration ramp OFF3 via p1135[D]
- For PROFIBUS telegrams 2 to 106 and 999 only (free assignment)
- STW 1 bit 5 (freeze ramp-function generator), no function

2.1.1 Dynamic Servo Control (DSC)

Description

Dynamic Servo Control (DSC) enables the actual position value to be evaluated in a fast speed controller cycle directly in the drive. The position setpoint is predefined in the position control cycle by the higher-level controller (e.g. SIMOTION via the isochronous PROFIBUS with PROFIdrive telegrams (not telegram type 1 or 999).

DSC enables high position controller gain and, as a result, minimizes following errors and provides a high level of noise immunity.

Function diagram overview (see List Manual)

- 3090 Dynamic Servo Control (DSC)

Parameter overview (see List Manual)

- p1190 CI: DSC position deviation XERR
- p1191 CI: DSC position controller gain KPC
- p1192[D] DSC encoder selection
- p1193[D] DSC encoder adaption factor

2.1.2 Activating the “extended setpoint channel” function module in servo mode

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

You can check the current configuration in parameter r0108.8.

Once you have set the configuration, you have to download it to the Control Unit where it is stored in a non-volatile memory (see Section 5.1).

Note

When the “extended setpoint channel” function module for servo is activated, the number of drives that can be controlled with one Control Unit is reduced.

2.2 Extended setpoint channel

2.2.1 Description

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

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

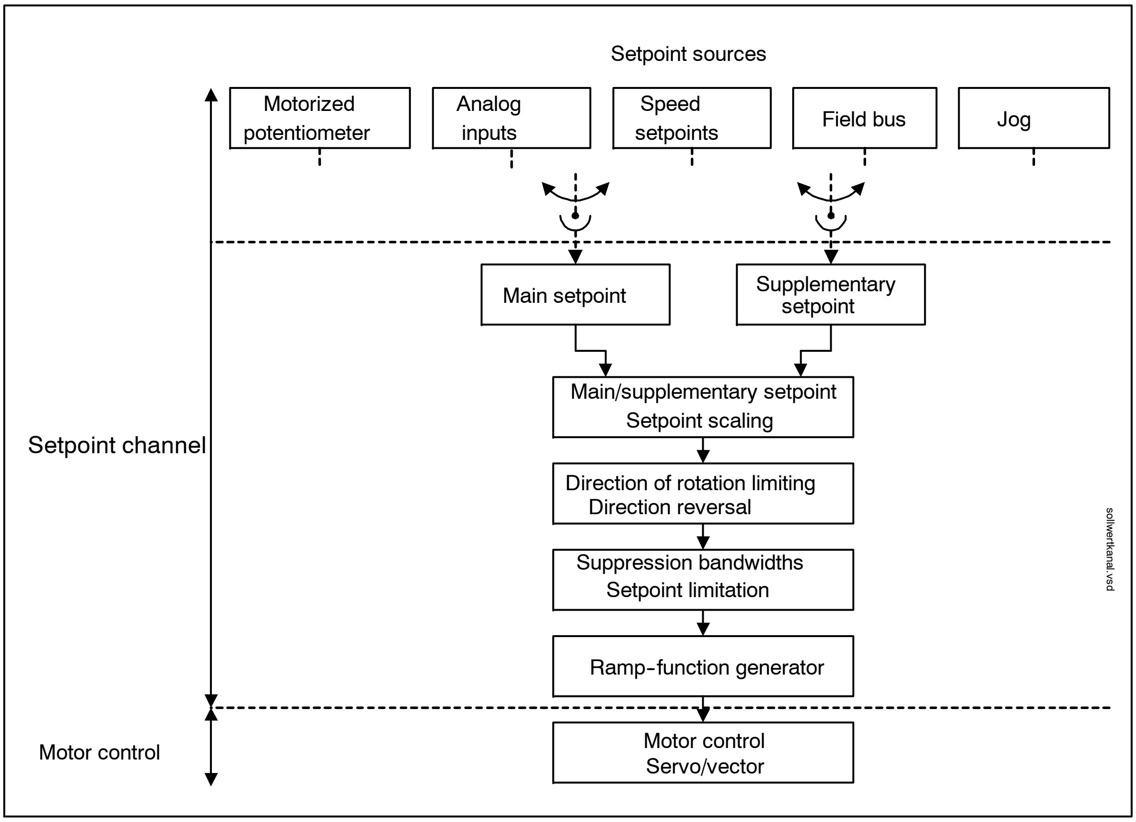


Fig. 2-1 Extended setpoint channel

Properties of the extended setpoint channel

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

Setpoint sources

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

There are various options for setpoint input:

- Fixed speed setpoints
- Motorized potentiometer
- Jog
- Field bus
  - e.g. setpoint via PROFIBUS
- Via the analog inputs on the following components:
  - Terminal Board 30 (TB30)
  - Terminal Module 31 (TM31)

2.2.2 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 Fig. 2-3). After the jog signal has been deselected, the motor is decelerated via the set ramp of the ramp-function generator.

Caution

The jog function is not PROFIdrive compatible!

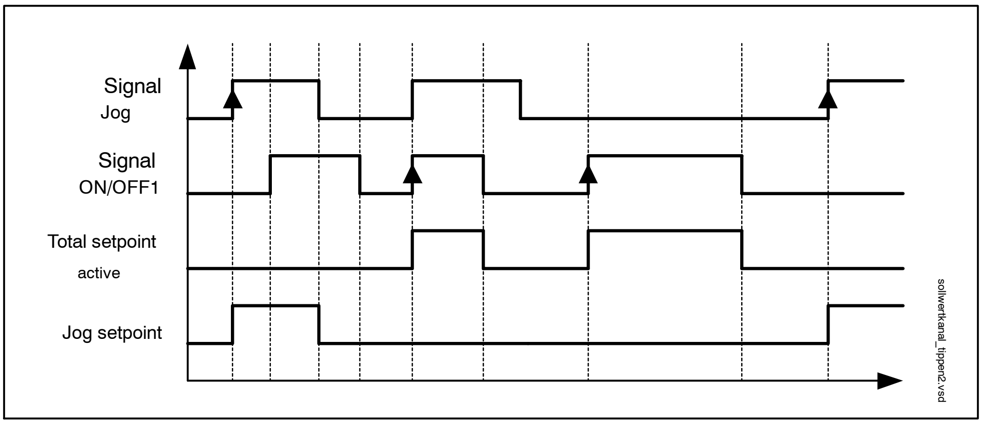


Fig. 2-2 Function chart: jog and OFF1

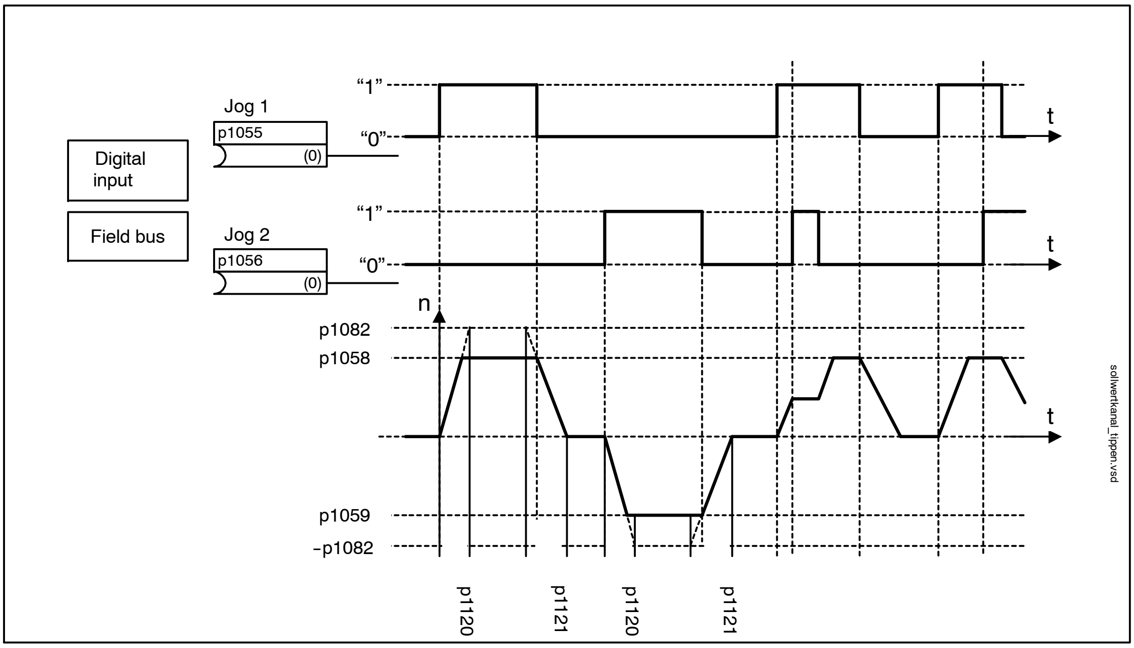


Fig. 2-3 Function chart: jog1 and jog2

Jog properties

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

Jog sequence

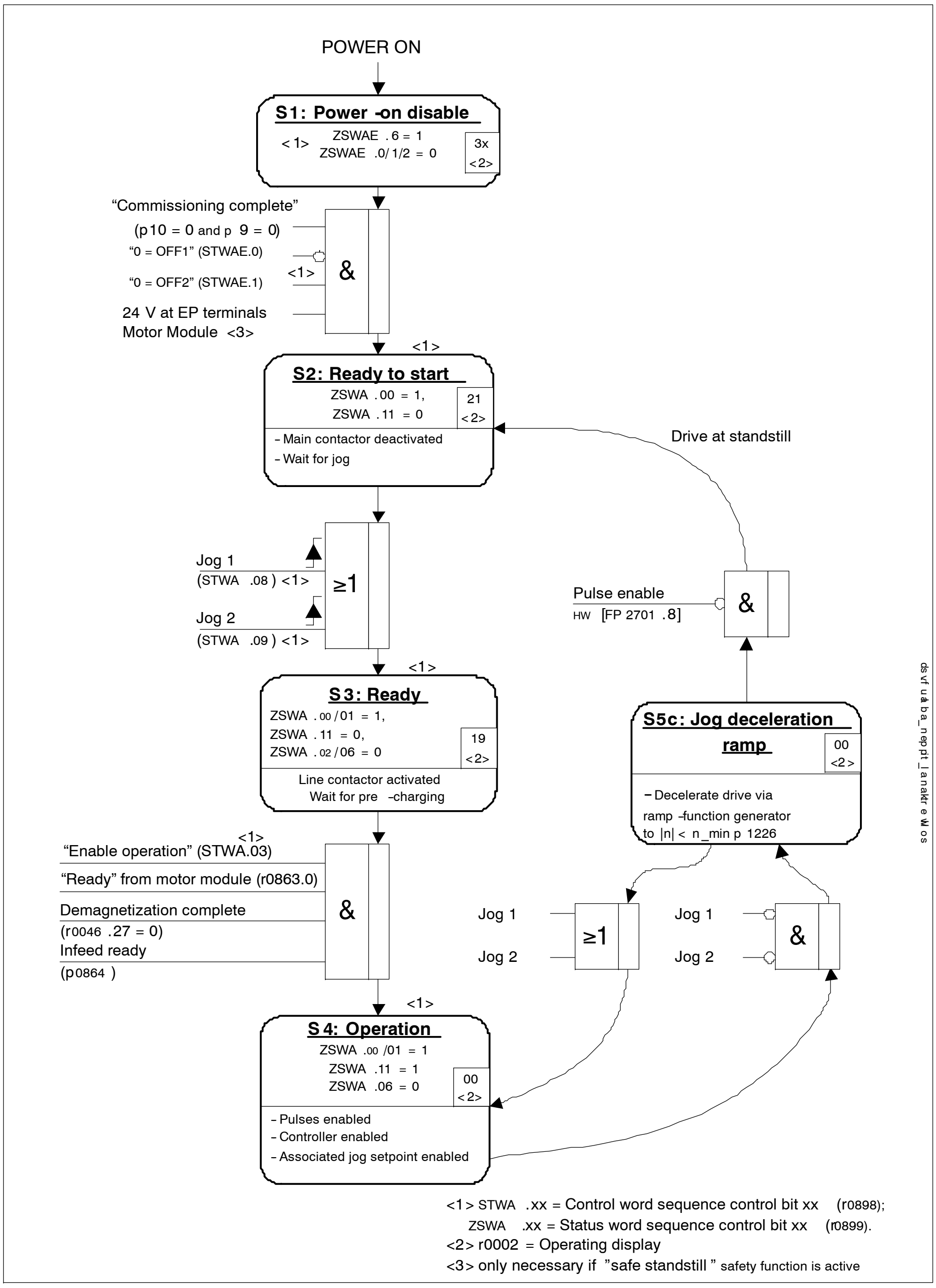


Fig. 2-4 Jog sequence

Control and status messages

Table 2-1 Jog control

Signal name	Internal control word	Binector Input	PROFIBUS telegram 2 ... 106
0 = OFF1	STWA.0	p0840 ON/OFF1	STW1.0
Enable operation	STWA.3	p0852 Enable operation	STW1.3
Jog 1	STWA.8	p1055 Jog bit 0	STW1.8
Jog 2	STWA.9	p1056 Jog bit 1	STW1.9

Table 2-2 Jog status message

Signal name	Internal status word	Parameter	PROFIBUS telegram 2 ... 106
Ready to start	ZSWA.0	r0899.0	ZSW1.0
Ready	ZSWA.1	r0899.1	ZSW1.1
Operation enabled	ZSWA.2	r0899.2	ZSW1.2
Power-up inhibit	ZSWA.6	r0899.6	ZSW1.6
Pulses enabled	ZSWA.11	r0899.11	ZSW1.11

Function diagram overview (see List Manual)

- 2610 Sequence control – Control Unit
- 3030 Main/added setpoint, setpoint scaling, jogging

Parameter overview (see 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 icon in the toolbar of the STARTER commissioning tool:

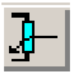


Fig. 2-5 STARTER icon for “speed setpoint”

2.2.3 Fixed speed setpoints

Description

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

Properties

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

Function diagram overview (see List Manual)

- 1550 Overviews – setpoint channel
- 2503 Status word sequence control
- 3010 Fixed speed setpoints

Parameter overview (see List Manual)

Adjustable parameters

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

Visualization parameters

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

Parameterization with STARTER

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

2.2.4 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.

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).

Properties for manual mode (p1041 = "0")

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

Properties for automatic mode (p1041 = "1")

- The input setpoint is specified via a connector input (p1042).
- The motorized potentiometer acts like a "normal" ramp-function generator.
- Configurable ramp-function generator, e.g.:
  - Switch on/off (p1030.1)
  - Ramp-up/ramp-down time (p1047/p1048)
  - Setting value (p1047/p1048)
  - Initial rounding-off active/not active (p1030.2)
- Non-volatile storage of the setpoints via p1030.3
- Configurable setpoint for Power On (p1030.0)
  - Starting value is the value in p1040 (p1030.0 = 0)
  - Starting value is the stored value (p1030.0 = 1)

Function diagram overview (see List Manual)

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

Parameter overview (see List Manual)

- p1030[D] Motorized potentiometer, configuration
- p1035[C] BI: Motorized potentiometer, setpoint, raise
- p1036[C] BI: Motorized potentiometer, lower setpoint
- 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.

2.2.5 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.

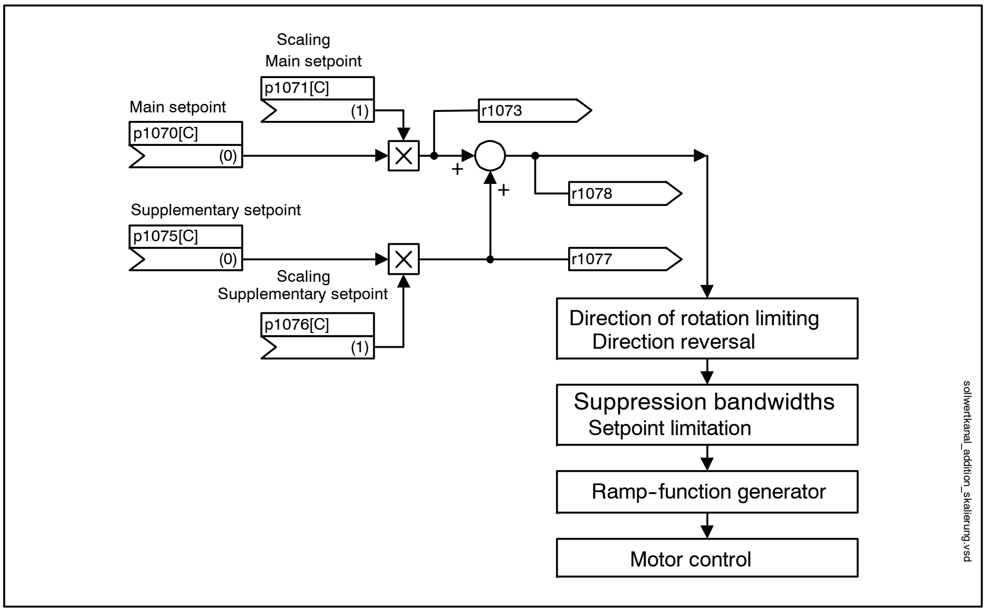


Fig. 2-6 Setpoint addition, setpoint scaling

Function diagram overview (see List Manual)

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

Parameter overview (see List Manual)

Adjustable parameters

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

Visualization parameters

- r1073[C] CO: Main setpoint effective
- r1077[C] CO: Supplementary setpoint effective
- r1078[C] CO: Total setpoint effective

Parameterization with STARTER

The “speed setpoint” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

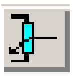


Fig. 2-7 STARTER icon for “speed setpoint”

2.2.6 Direction of rotation limiting and direction of rotation changeover

Description

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

If, on the other hand, a negative or positive setpoint is not to be preselected via the setpoint channel, this can be prevented via parameter p1110[C] or p1111[C].

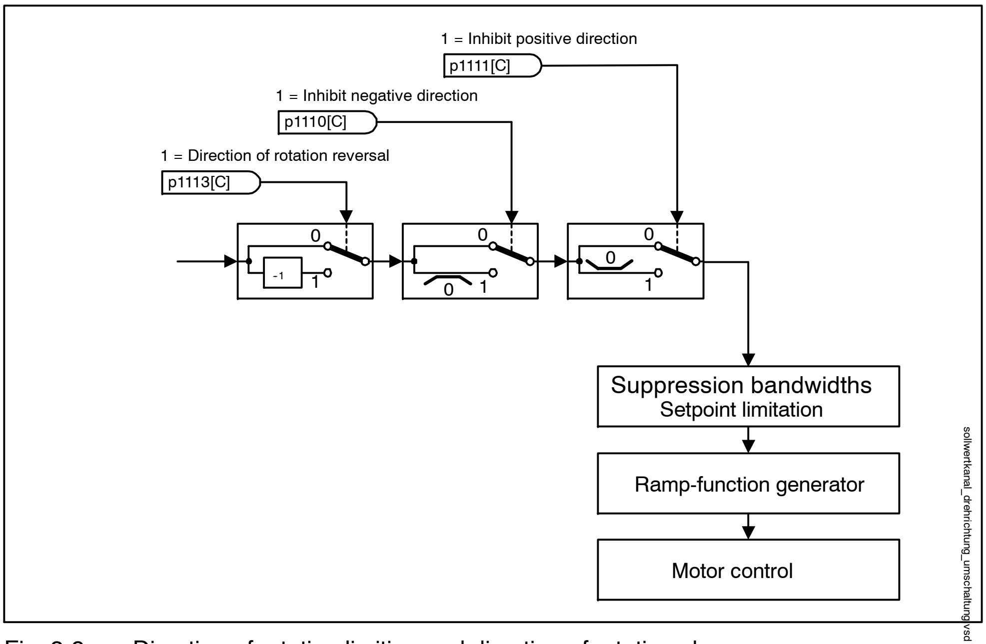


Fig. 2-8 Direction of rotation limiting and direction of rotation changeover

Function diagram overview (see List Manual)

- 1550 Setpoint channel
- 3040 Direction of rotation limiting and direction of rotation changeover

Parameter overview (see List Manual)

Adjustable parameters

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

Parameterization with STARTER

The “speed setpoint” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

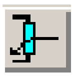


Fig. 2-9 STARTER icon for “speed setpoint”

2.2.7 Suppression bandwidths and setpoint limitation

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]. These limits can also be changed during operation with connectors p1085[C] and p1088[C].

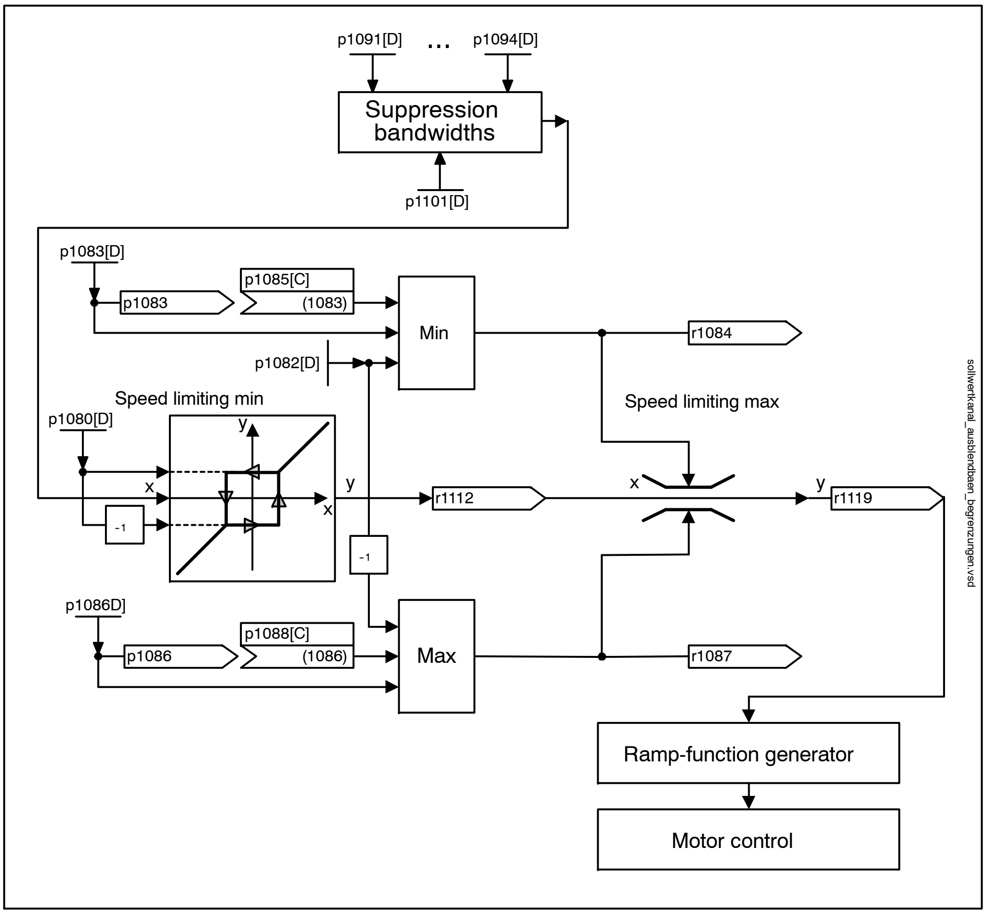


Fig. 2-10 Suppression bandwidths, setpoint limitation

Function diagram overview (see List Manual)

- 1550 Setpoint channel
- 3050 Suppression bandwidth and speed limiting

Parameter overview (see List Manual)

Setpoint limitation

- p1080[D] Minimum speed
- p1082[D] Maximum speed
- p1083[D] CO: Speed limit in positive direction of rotation
- r1084 Speed limit positive effective
- p1085[C] CI: Speed limit in positive direction of rotation
- p1086[D] CO: Speed limit negative direction of rotation
- r1087 Speed limit negative effective
- p1088[C] DI: Speed limit negative direction of rotation
- r1119 Ramp-function generator setpoint at the input

Suppression bandwidths

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

Parameterization with STARTER

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

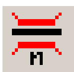


Fig. 2-11 STARTER icon for “speed limitation”

2.2.8 Ramp-function generator

Description

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

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

There are two types of ramp-function generator:

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

Note

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

Properties of the simple ramp-function generator

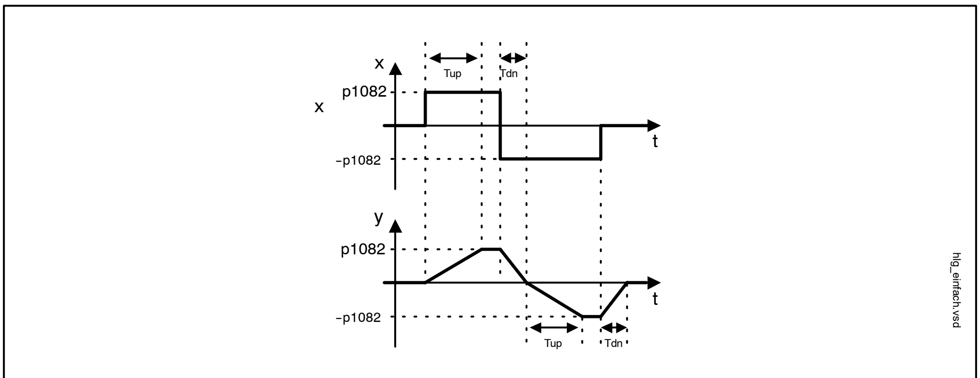


Fig. 2-12 Ramp-up and ramp-down with the simple ramp-function generator

- RFG ramp-up time Tup p1120[D]
- RFG ramp-down time Tdn p1121[D]
- OFF 3 deceleration ramp
  - OFF3 ramp-down time p1135[D]

Properties of the extended ramp-function generator

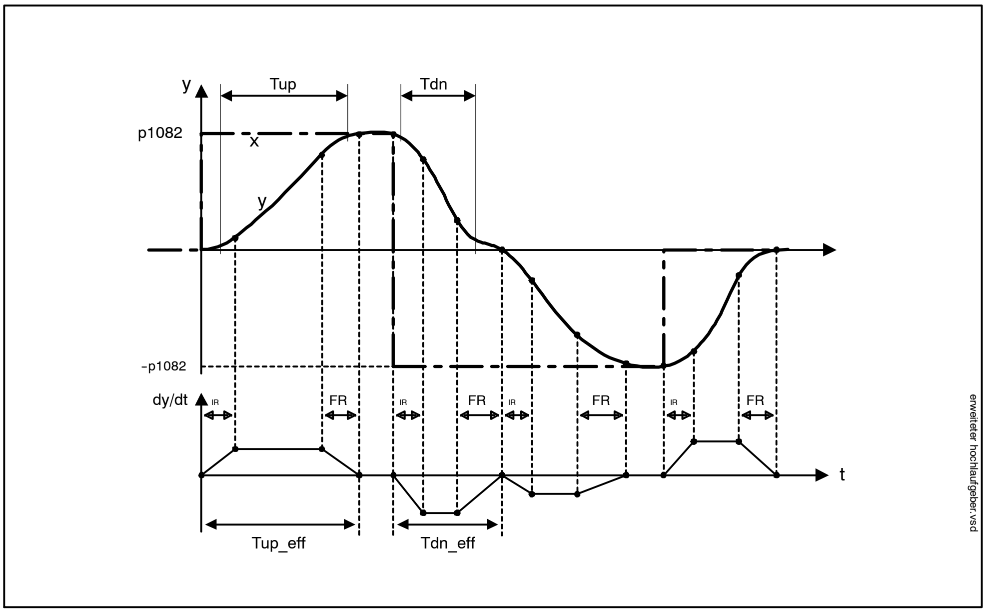


Fig. 2-13 Extended ramp-function generator

- RFG ramp-up time Tup — p1120[D]
- RFG ramp-down time Tdn — p1121[D]
- Initial rounding-off time IR — p1130[D]
- Final rounding-off time 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)
- OFF 3 deceleration ramp
  - OFF3 ramp-down time — p1135[D]
  - OFF3 initial rounding-off time — p1136[D]
  - OFF3 final rounding-off time — p1137[D]
- Set ramp-function generator
  - Ramp-function generator setting value — p1144[C]
  - Set ramp-function generator signal — p1143[C]
- Ramp-function generator rounding-off type — p1134[D]
  - p1134 = "0": Rounding is always active. Can result in overshoot.
  - p1134 = "1": Final rounding-off is not active if the input word is reduced abruptly during ramp-up.

Ramp-function generator tracking

Ramp-function generator tracking allows the speed setpoint to be corrected in line with the actual speed value. p1145 can be used to deactivate ramp-function generator tracking (p1145 = 0) or set the permissible following error (p1145 > 0). If the permissible following error is exceeded, the minimum speed is defaulted that results in the maximum torque.

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

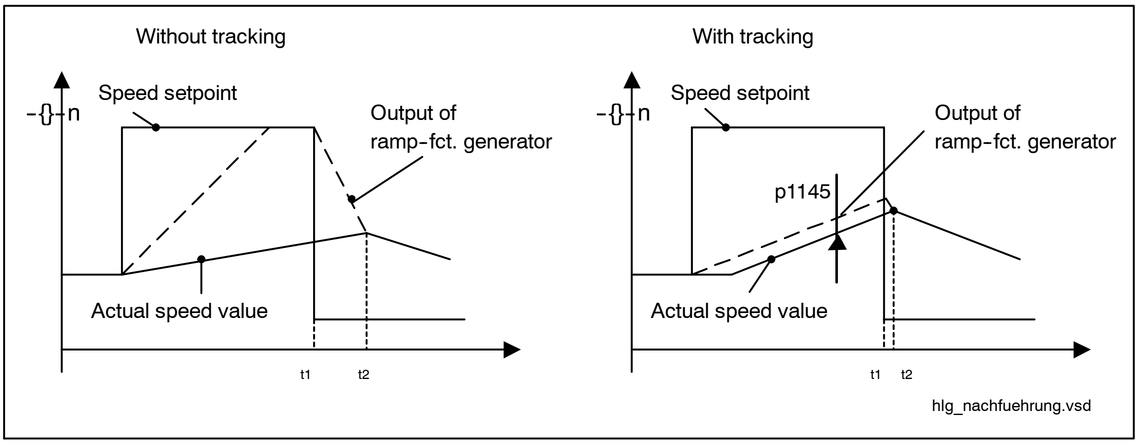


Fig. 2-14 Ramp-function generator tracking

Without ramp-function generator tracking

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

With ramp-function generator tracking

- p1145 > 0
- Ramp-function generator output leads setpoint by only a small margin
- t1 and t2 almost identical

Function diagram overview (see List Manual)

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

Signal overview (see List Manual)

- Control signal STW1.2 OFF3
- Control signal STW1.4 Enable ramp-function generator
- Control signal STW1.5 Start/stop ramp-function generator

- Control signal STW1.6 Enable setpoint
- Control signal STW2.1 Bypass ramp-function generator

Parameterization with STARTER

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

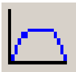


Fig. 2-15 STARTER icon for “ramp-function generator”

Parameter overview (see List Manual)

Adjustable parameters

- p1115 Ramp-function generator selection
- 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-off time
- p1131[D] Ramp-function generator final rounding-off time
- p1134[D] Ramp-function generator rounding-off type
- p1135[D] OFF3 ramp-down time
- p1136[D] OFF3 initial rounding-off time
- p1137[D] OFF3 final rounding-off time
- p1140[C] BI: Enable the ramp-function generator
- p1141[C] BI: Start 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

Visualization parameters

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

■

Operating Modes 3

Contents of Chapter "Operating Modes"

3.1 Servo control

This type of control enables operation with an extremely high dynamic response and precision for a motor with a motor encoder.

3.1.1 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.

Limitations

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.

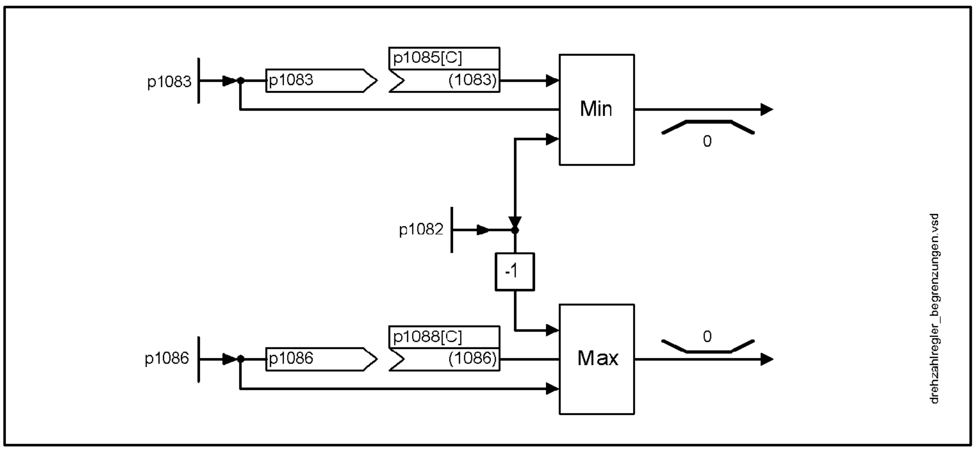


Fig. 3-1 Speed limits

3.1.2 Speed setpoint filter

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

- Band-stop
- 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.

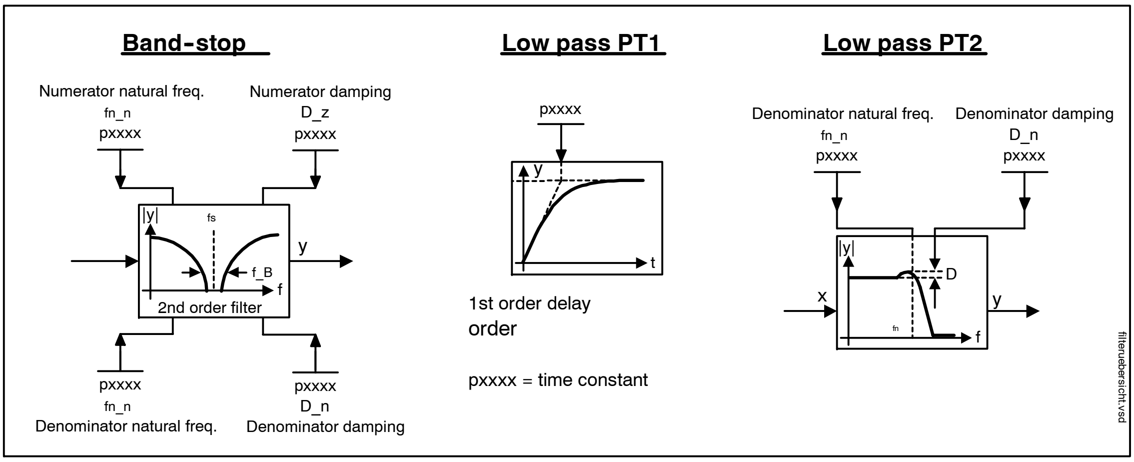


Fig. 3-2 Filter overview for speed setpoint filters

Parameter overview for speed setpoint filter (see List Manual)

Adjustable parameters

- 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

Function diagram overview (see List Manual)

- 5020 Speed setpoint filter and speed pre-control

Parameterization

The “speed setpoint filter” parameter screen is selected via the following icon in the toolbar of the STARTER commissioning tool:

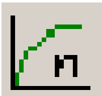


Fig. 3-3 STARTER icon for “speed setpoint filter”

3.1.3 Speed controller adaptation

Description

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

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

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

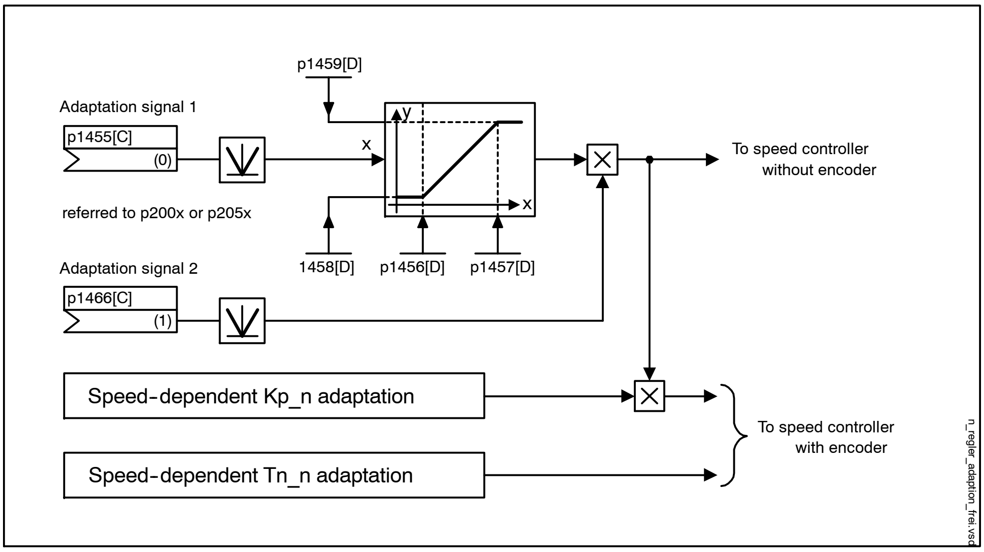


Fig. 3-4 Free Kp_n adaptation

Example of speed-dependent adaptation

Note

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

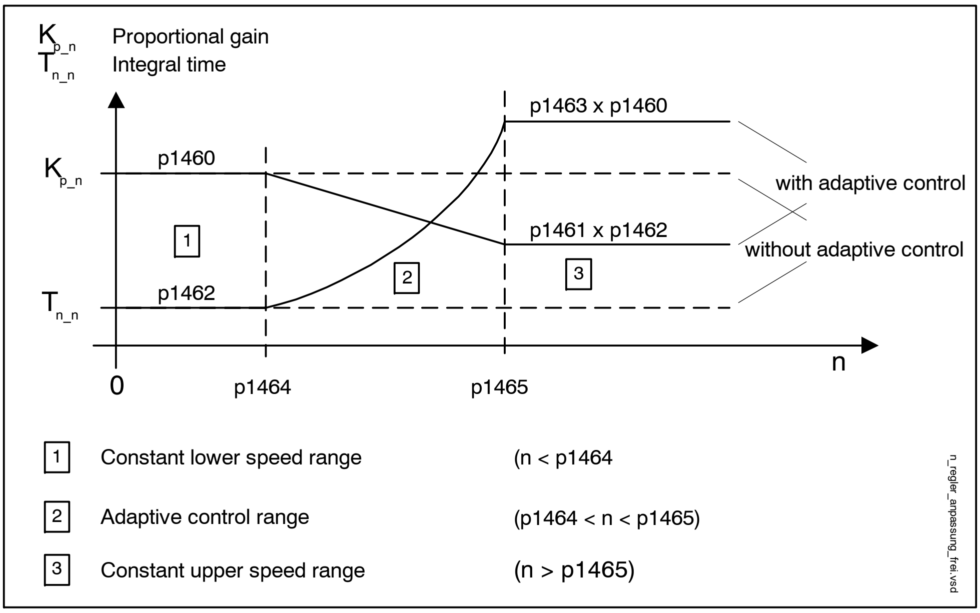


Fig. 3-5 Speed controller Kp_n/Tn_n adaptation

Parameterization

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

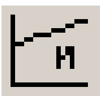


Fig. 3-6 STARTER icon for "speed controller"

Parameter overview for speed controller adaptation (see List Manual)

Free Kp_n adaptation

- p1455[0...n] CI: Speed controller P gain adaptation signal
- p1456[0...n] Lower starting point adaptation P gain
- p1456[0...n] Speed controller P gain adaptation application point upper
- p1458[0...n] Lower adaptation factor
- p1459[0...n] Adaptation factor, upper

Speed-dependent Kp_n/Tn_n adaptation

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

Function diagram overview (see List Manual)

- 5050 Kp_n and Tn_n adaptation

3.1.4 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 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)

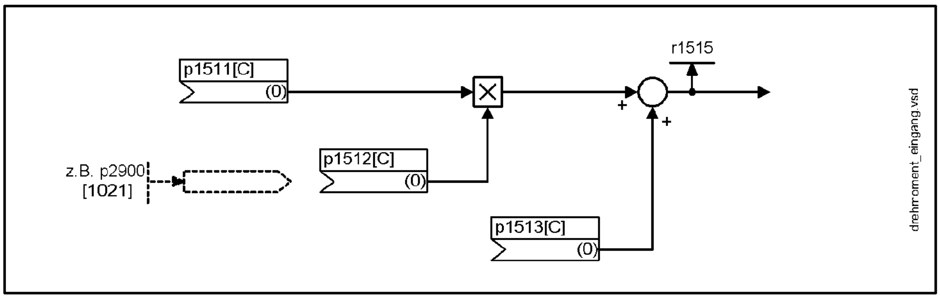


Fig. 3-7 Torque setpoint

3. Activate enable signals

OFF responses

- OFF1 and p1300 = 23
  - Reaction as for OFF2
- OFF1, p1501 = “1” signal and p1300 $\neq$ 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. Zero speed is detected if the actual speed drops below the threshold in p1226 or if the monitoring time (p1227) started when speed setpoint <= speed threshold (p1226) has expired.
  - Power-on disable is activated.
- OFF2
  - Instantaneous pulse suppression, the drive “coasts” to a standstill.
  - The motor brake (if parameterized) is closed immediately.
  - Power-on disable is activated.
- OFF3
  - Switch to speed-controlled operation
  - n_set=0 is input immediately to brake the drive along the OFF3 deceleration ramp (p1135).
  - When zero speed is detected, the motor brake (if parameterized) is closed.
  - The pulses are suppressed when the motor brake application time (p1217) has elapsed. Zero speed is detected if the actual speed drops below the threshold in p1226 or if the monitoring time (p1227) started when speed setpoint <= speed threshold (p1226) has expired.
  - Power-on disable is activated.

Function diagrams for torque-controlled operation (see List Manual)

- 5060 Torque setpoint, control mode switchover
- 5610 Torque limitation/reduction/interpolator

Signal overview (see List Manual)

- r1406.12 Torque control active

Parameterization

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

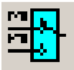


Fig. 3-8 STARTER icon for “torque setpoint”

Parameters for torque-controlled operation (see List Manual)

Adjustable parameters

- p1300 Open-loop/closed-loop control operating mode
- p1501[C] BI: Changeover 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

Visualization parameters

- r1515 Supplementary torque total

3.1.5 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.

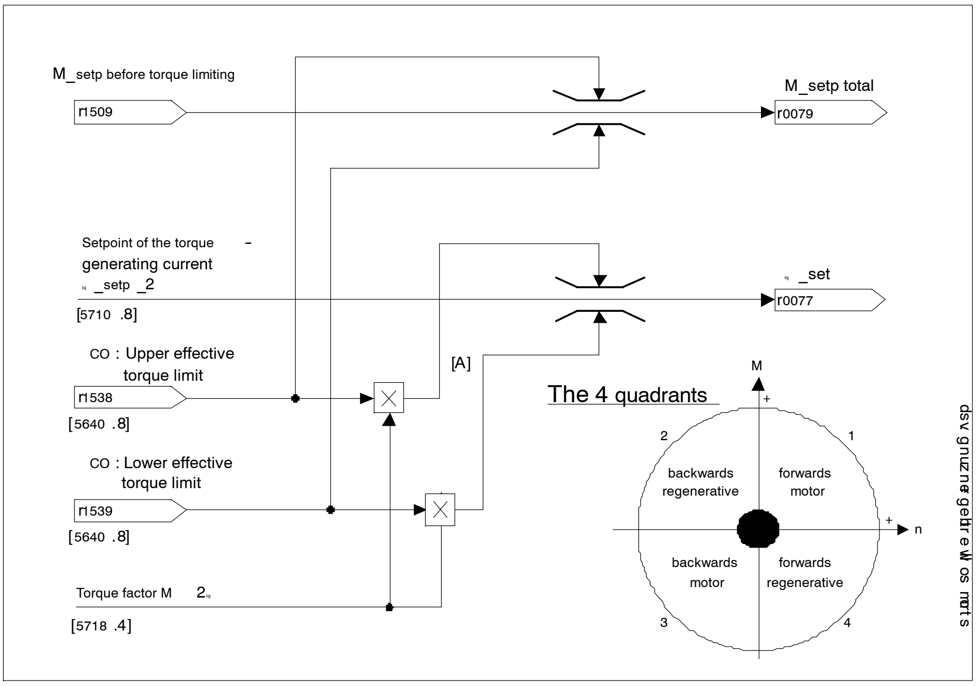


Fig. 3-9 Current/torque setpoint limitation

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 Fig. 3-10)
- The following torque limits are displayed via parameters:
  - Lowest of all upper torque limits with and without offset
  - Highest of all lower torque limits with and without offset

Fixed and variable torque limit settings

Table 3-1 Fixed and variable torque limit settings

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

Variants of torque limitation

The following variants are available:

1. No settings entered:

   The application does not require any additional restrictions to the torque limits.
2. Fixed limits are required for the torque:
   - The fixed upper and lower limits or alternatively the fixed motor and regenerative limits can be specified separately by different sources.
3. Dynamic limits are required for the torque:
   - The dynamic upper and lower limit or, alternatively, the dynamic motor and regenerative limit can be specified separately by different sources.
   - Parameters are used to select the source of the current limit.
4. A torque offset can be parameterized.
5. In addition, the power limits can be parameterized separately for motor and regenerative mode.

Notice

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

Example: Torque limits with or without offset

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

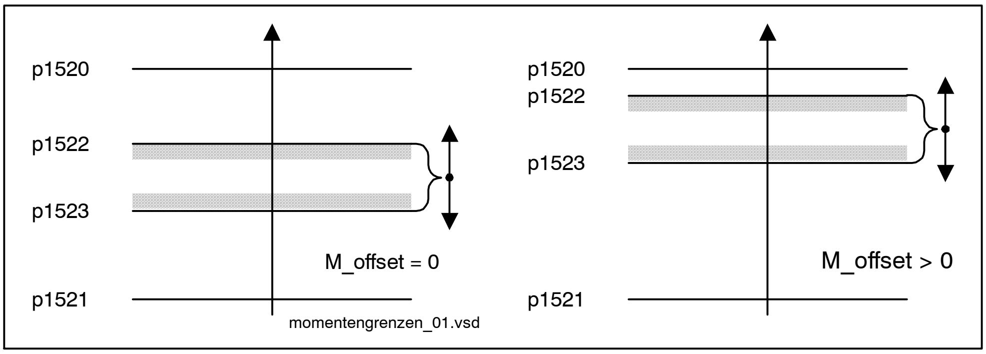


Fig. 3-10 Example: Torque limits with or without offset

Activating the torque limits

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

Examples

- Travel to fixed stop (see Subsection 3.1.13)
- Tension control for continuous goods conveyors and winders

Function diagrams for torque setpoint limitation (see List Manual)

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

Parameterization

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

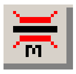


Fig. 3-11 STARTER icon for “torque limit”

Parameters for torque setpoint limitation (see 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 Upper torque limit of all torque limits without offset

- r1527 Lower torque limit all torque limits without offset
- p1528[0...n] CI: Torque limit, upper/motoring, scaling
- p1529[0...n] CI: Torque limit, lower/regenerating scaling
- p1530[0...n] Motor mode power limit
- p1531[0...n] Power limit, regenerative mode
- p1532[0...n] Torque offset torque limit
- r1533 Maximum torque-generating current of all current limits
- r1534 CO: Torque limit, upper total
- r1535 CO: Torque limit, lower total
- r1536 Maximum motor-mode torque-generating current limit
- r1537 Minimum regenerative-mode torque-generating current
- r1538 CO: Upper effective torque limit
- r1539 CO: Lower effective torque limit

3.1.6 Current controller

Properties

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

Current control

No settings are required for operating the current controller. The controller can be optimized for special applications (see Subsection 3.1.8).

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.

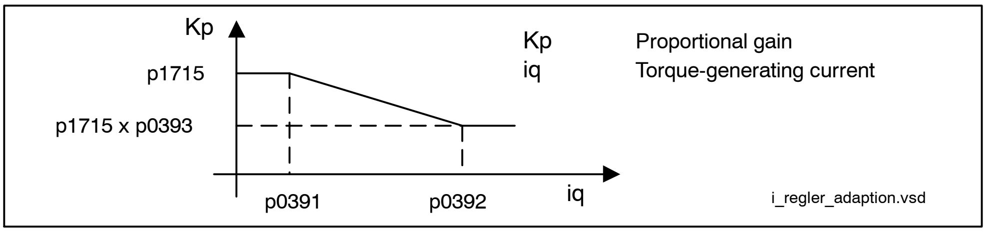


Fig. 3-12 Current controller adaptation

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 for the current controller (see List Manual)

- 5710 Current setpoint filter
- 5714 Iq and Id controllers
- 5718 Interface to the Motor Module (gating signals, current actual values)
- 5722 Field current input, flux controller

Parameters for current controller (see List Manual)

Current control

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

Current and torque limitation

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

Visualization parameters

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

Current controller adaptation

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

3.1.7 Current setpoint filter

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

- Low-pass 2nd order (PT2): –40dB/decade)
- General filter 2nd order
  Band-stop and low-pass with reduction are converted to the parameters of the general filter 2nd order via STARTER.
  - Band-stop
  - 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.

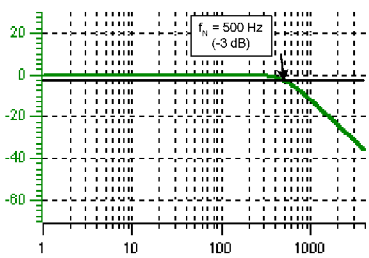
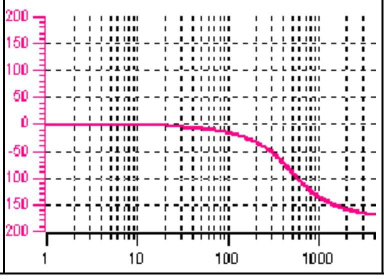
General 2nd-order filter

Transfer function:

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

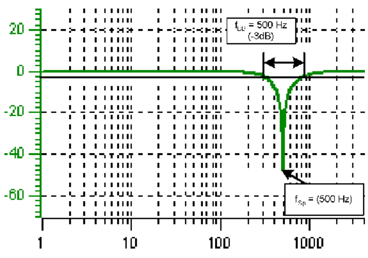
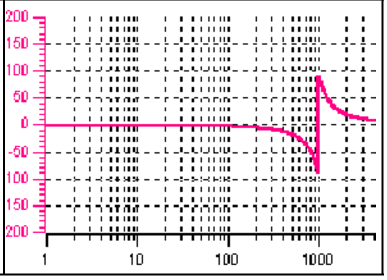
Characteristic frequency f_N
Damping D_N

Table 3-2 Example of a PT2 filter

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

Band-stop with infinite notch depth

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

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

Simplified conversion to parameters for general order filters:

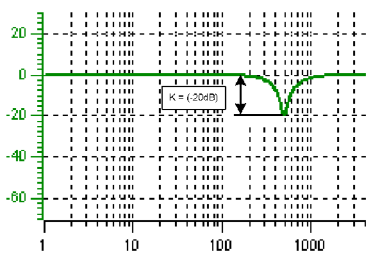
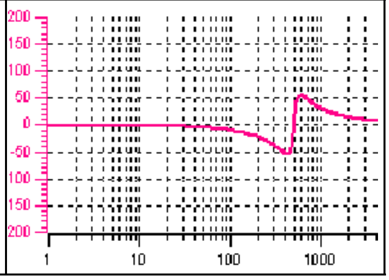
Reduction or increase after the blocking frequency (Abs)

Infinite notch depth at the blocking frequency

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

Band-stop with defined notch depth

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

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

Simplified conversion to parameters for general order filters:

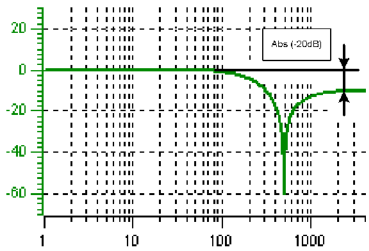
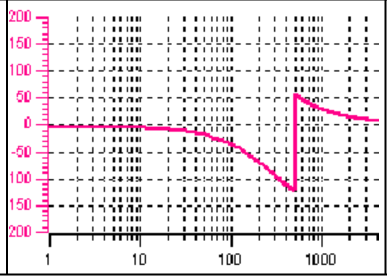
No reduction or increase after the blocking frequency

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

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

Band-stop with defined reduction

Table 3-5 Example of band-stop

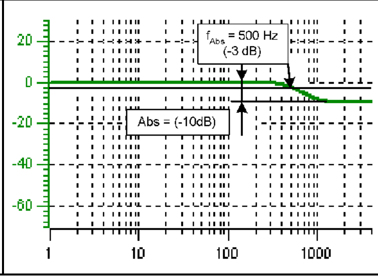
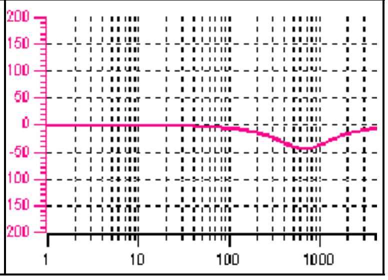
<table>
<tr><th>STARTER filter parameters</th><th>Amplitude log frequency curve</th><th>Phase frequency curve</th></tr>
<tr><td>Blocking frequency 500 Hz
Bandwidth 500 Hz
Notch depth infinite dB
Reduction -10 dB</td><td>
</td><td>
</td></tr>
</table>

General conversion to parameters for general order filters:

- Numerator frequency $f_Z = \frac{\omega_Z}{2\pi} = f_{Sp}$
- Numerator damping $D_Z = 10^{\frac{K}{20}} \cdot \frac{1}{2} \cdot \sqrt{\left(1 - \frac{1}{10^{\frac{Abs}{20}}}\right)^2 + \frac{f_{BB}^2}{f_{Sp}^2 \cdot 10^{\frac{Abs}{10}}}}$
- Denominator frequency $f_N = \frac{\omega_N}{2\pi} = f_{Sp} \cdot 10^{\frac{Abs}{40}}$
- Denominator damping $D_N = \frac{f_{BB}}{2 \cdot f_{Sp} \cdot 10^{\frac{Abs}{40}}}$

General low-pass with reduction

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

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

Conversion to parameters for general order filters

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

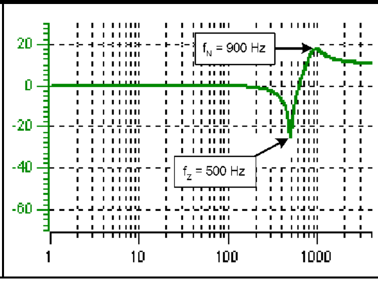
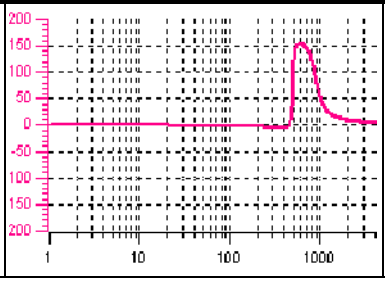
Transfer function general 2nd-order filter

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

$$s = j\omega = j \cdot 2\pi f$$

- Numerator frequency f_Z
- Numerator damping D_Z
- Denominator frequency f_N
- Denominator damping D_N

Table 3-7 Example of general 2nd-order filter

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

Parameterization

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

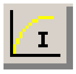


Fig. 3-13 STARTER icon for “current setpoint filter”

Parameter overview (see List Manual)

- p1656[0...n] Activates current setpoint filter
- 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

Function diagram overview (see List Manual)

- 5710 Current setpoint filter

3.1.8 Optimizing the current and speed controller

General

Caution

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

The following tools are available for optimizing the controllers:

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

Optimizing the current controller

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

Optimizing the speed controller

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

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.

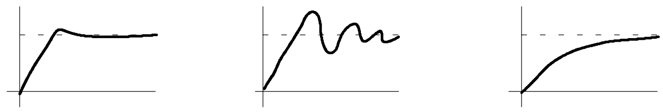


Fig. 3-14 Setting the proportional gain K_p

Parameter overview

See Section “Speed controller”.

3.1.9 V/f Control for Diagnostics

Description

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

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

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

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

- Induction motors
- Synchronous motors

Caution

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

Note

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

Note

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

Structure of V/f control

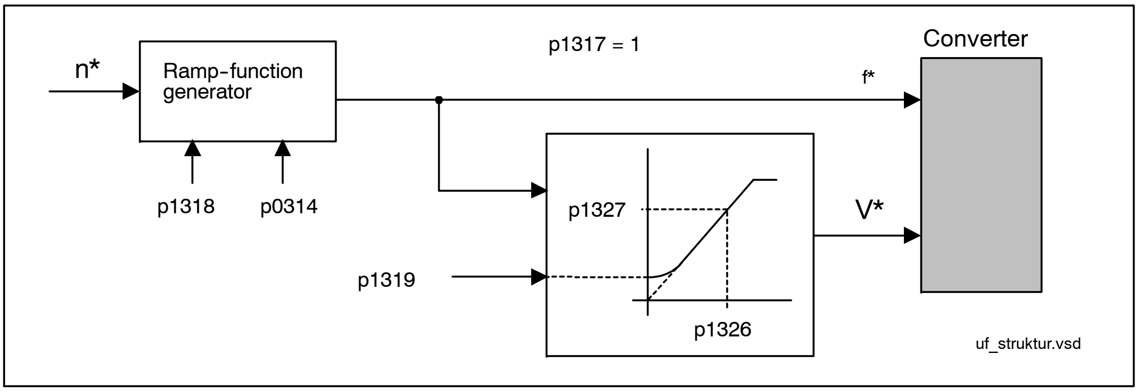


Fig. 3-15 Structure of V/f control

Prerequisites for V/f control

1. Initial commissioning has been performed:

   The parameters for V/f control have been initialized with appropriate values.

2. Initial commissioning has not been performed:

   The following relevant motor data must be checked and corrected:

   - r0313 Motor pole pair number, actual (or calculated)
   - p0314 Motor pole pair number
   - p1318 V/f control ramp-up/ramp-down time
   - p1319 V/f control voltage at zero frequency
   - p1326 V/f control programmable characteristic frequency 4
   - p1327 V/f control programmable characteristic voltage 4

V/f control can now be commissioned.

Note

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

Commissioning V/f control

1. Verify the preconditions for V/f control mode.
2. Set p0311 --> rated motor speed
3. Set p1300 = 0 --> activates the function
4. Activate the enable signals for operation
5. Specify the speed setpoint --> evaluate the diagnostic function

V/f characteristic

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

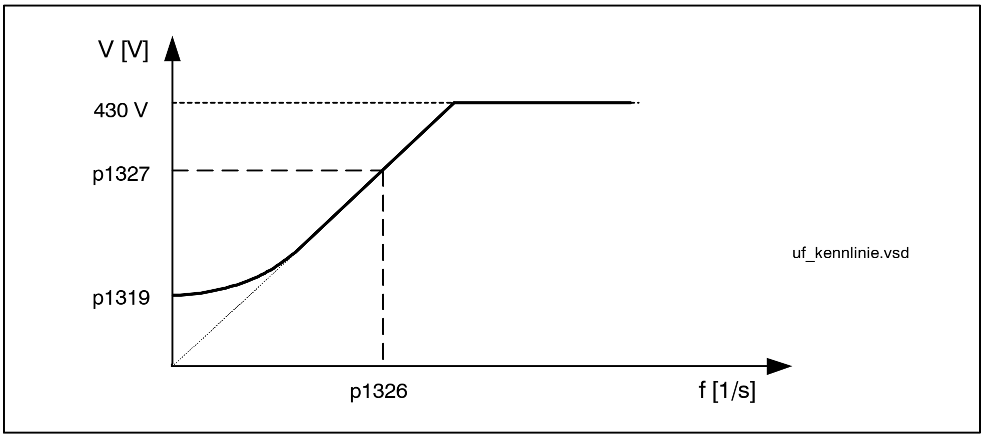


Fig. 3-16 V/f characteristic

Function diagrams for V/f control (see List Manual)

- 5300 V/f control for diagnostics

Parameters for V/f control (see List Manual)

Adjustable parameters

- p0304[0...n] Rated motor voltage
- p0310[0...n] Rated motor frequency
- p0311[0...n] Rated motor speed
- p0314[0...n] Number of motor pole pairs
- 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
- p1300[0...n] Open-loop/closed-loop control operating mode
- p1318[0...n] V/f control ramp-up/ramp-down time
- p1319[0...n] V/f control voltage at zero frequency

Visualization parameters

- r0313[0...n] Number of motor pole pairs current (or calculated)

3.1.10 Operation without encoder

Description

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

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

For torque pre-control, a torque smoothing time can be parameterized via p1517.
The speed controller must be optimized for operation without an encoder via p1470 (P gain) and p1472 (integral time) due to the reduced dynamic response.

At low speeds during operation without an encoder, the actual speed value, orientation, and the actual flux can no longer be calculated due to the accuracy of the measured values and the sensitivity of the parameters in this procedure.
For this reason, the system switches to current/frequency control.
The switchover threshold is parameterized via p1755 and the hysteresis via p1756.

To accommodate a high load torque in open-loop control, 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 motors) of the rated motor current (p0305). When parameterizing the motor current (p1612), you must take into account the thermal motor load.

Note

Operation without an encoder is not permitted for vertical axes or similar, nor is it suitable for higher-level position control.

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

Behavior once pulses have been canceled

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

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

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

Warning

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

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

Operation without an encoder is activated via parameter setting p1300 = 20.

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

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

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

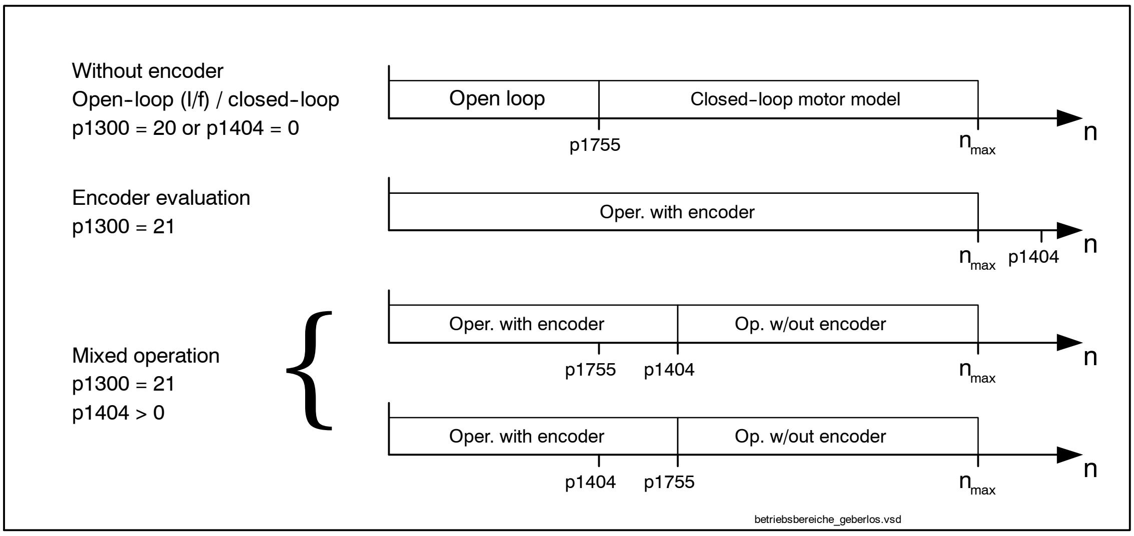


Fig. 3-17 Operation switchovers

Note

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

Series reactor

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

Parameter overview (see List Manual)

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

Function diagram overview (see List Manual)

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

3.1.11 Pole position identification

Description

The pole position identification function determines the electrical pole position of synchronous motors, which is required for field-oriented closed-loop control. The electrical pole position is normally provided by a mechanically-adjusted encoder with absolute information. In this case, pole position identification is not necessary. Pole position identification is not necessary with the following encoder properties:

- Absolute value encoder (e.g. EnDat)
- Encoder with C/D track and number of pole pairs $\leq$ 8
- Hall sensor
- Resolver with integral ratio of number of motor pole pairs to number of encoder pole pairs
- Incremental encoder with integral ratio of number of motor pole pairs to encoder pulse number

Pole position identification is used for:

- Determining the pole position (p1982 = 1)
- Supports commissioning when determining the commutation angle offset (p1990 = 1)
- Carrying out plausibility checks for encoders with absolute information (p1982 = 2)

Warning

With non-braked motors, the measurement can cause the motor to rotate or move via the specified current.
The degree of movement depends on the specified current intensity and the moment of inertia of the motor and load.

Notes regarding methods of pole position identification

The relevant method can be selected using parameter P1980. The following methods can be used for identifying the pole position:

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

The following general conditions apply for the saturation-based methods:

- These methods can be used for both braked and non-braked motors.
- They can only be used if the speed setpoint = 0 or from standstill.
- The specified currents (p0325, p0329) must be strong enough to generate a significant measuring signal.
- The pole position of ironless motors cannot be determined using the saturation-based methods.
- The method based on the 2nd harmonic (p1980 = 0, 4) must not be used for 1FN3 motors.
- The two-step method (p1980 = 4) must not be used for 1FK7 motors. The value in p0329, which is set automatically, must not be reduced.

The following general conditions apply for the movement-based method:

- The motor must move freely and must not be affected by any external forces (no vertical axes)
- This method can only be used if the speed setpoint = 0 or from standstill.
- If a motor brake is installed, it must be open (p1215 = 2).
- The specified current (p1993) must be sufficient to move the motor.

Warning

Before the pole position identification function is used, the control direction of the speed control loop must be set correctly (p0410.0).

For linear motors, refer to the Commissioning Manual.

In the case of rotating motors, the actual speed value (r0061) and the speed setpoint (r1438) must have the same sign in “operation without encoder” mode and with a low positive speed setpoint (10 r.p.m).

Determining the pole position with zero marks

Pole position identification provides a means of performing coarse synchronization. If zero marks have been defined, the pole position can be compared automatically with the zero mark position once the zero mark(s) has/have been passed (fine synchronization). The zero mark position must be compared mechanically or electrically (p0431). If permitted by the encoder system, fine synchronization is recommended (p0404.15 = 1) because it avoids measurement variations and enables the pole position determined to be checked.

Suitable zero marks:

- One zero mark across the entire traversing range
- Equidistant zero marks, whose relative positions are identical with respect to the commutation
- Distance-coded zero marks

Determining a suitable method of pole position identification

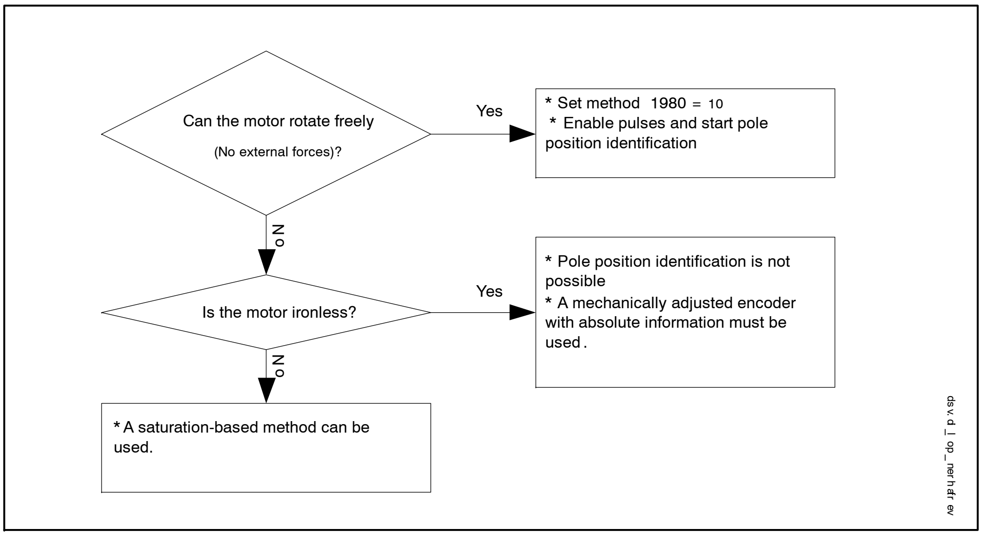


Fig. 3-18 Selection of method

Parameters for pole position identification

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

Commutation angle 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:

- One-off comparison of pole position for encoders with absolute information (exception: The Hall sensor must always be adjusted mechanically).
- Comparison of zero mark position for fine synchronization

Table 3-8 Function of p0431

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

Note

If fault F07414 occurs, p1990 is started automatically if p1980 is not 99 and p0301 does not refer to a list motor with a factory-adjusted encoder.

3.1.12 Vdc control

Description

Vdc control can be activated if overvoltage or undervoltage is present in the DC link line-up. In the line-up, one or more drives can be used to relieve the DC link. This prevents a fault from occurring due to the DC link voltage and ensures that the drives are always ready to use.
This function is activated by means of the configuration parameter (p1240). It can be activated if an overvoltage or undervoltage is present. The torque limits of the motors at which the Vdc controller is active can be affected if discrepancies in the DC link voltage are significant enough. The motors may no longer be able to maintain their setpoint speed or the acceleration/braking phases are prolonged.

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

The recommended setting for the P gain is p1250 = 0.5*DC link capacitance[mF]. Once the DC link has been identified (p3410), the DC link capacitance can be read in parameter p3422 in the Infeed Module.

Note

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

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

Description of Vdc_min control (p1240 = 2, 3)

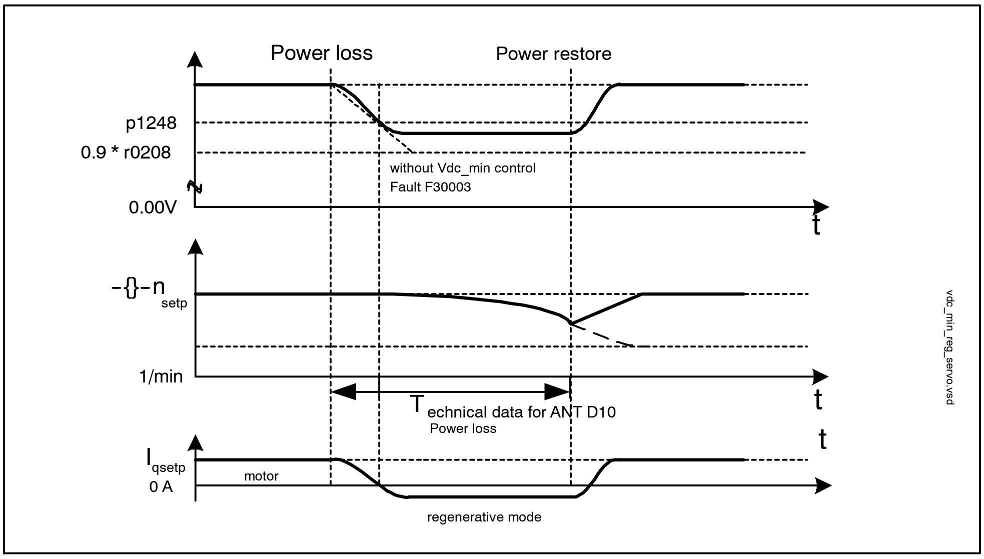


Fig. 3-19 Switching Vdc_min control on/off (kinetic buffering)

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 (recommended: 50 V below the DC link voltage). When the power supply is reestablished, the Vdc controller is automatically deactivated and the drives approach the speed setpoint again. If the power supply cannot be reestablished, the DC link voltage collapses if the kinetic energy of the drives is exhausted with an active Vdc_min controller.

Note

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

Description of Vdc_max control (p1240 = 1, 3)

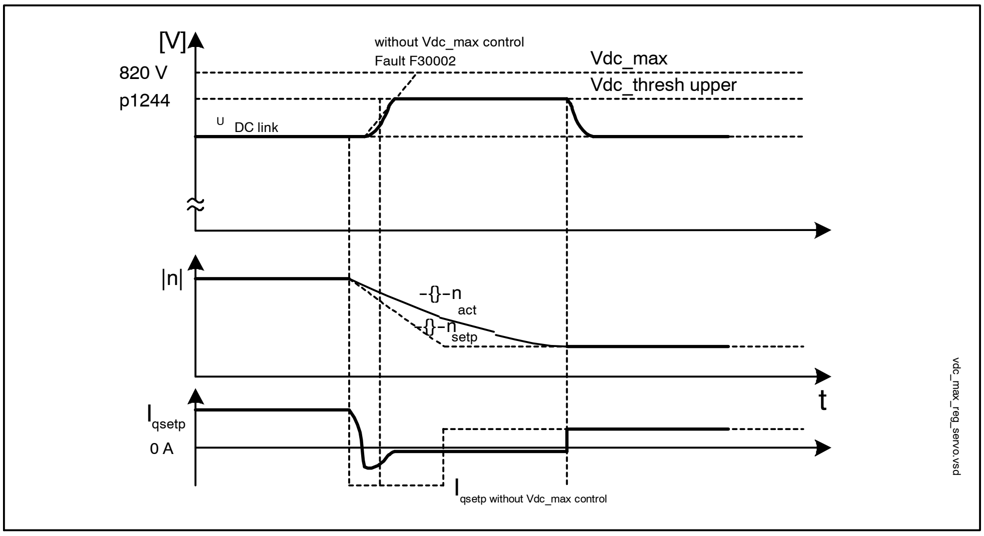


Fig. 3-20 Switching Vdc_max control on/off

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 specified 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.

Vdc controller monitoring functions

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 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 with a parameterizable voltage threshold (p1244). This is carried out by activating the Vdc_max monitoring function (p1240 = 4, 6).

Function diagram for Vdc controller (see List Manual)

- 5650 Vdc_max controller and Vdc_min controller

Parameters for Vdc controller (see List Manual)

Adjustable parameters

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

Visualization parameters

- r0056.14 Vdc_max controller active
- r0056.14 Vdc_max controller active

3.1.13 Travel to fixed stop

Description

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

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

Application examples

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

Signals

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

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

Also with PROFIBUS telegrams 102 to 106:

- Process data T_Der to the torque limit scaling factor

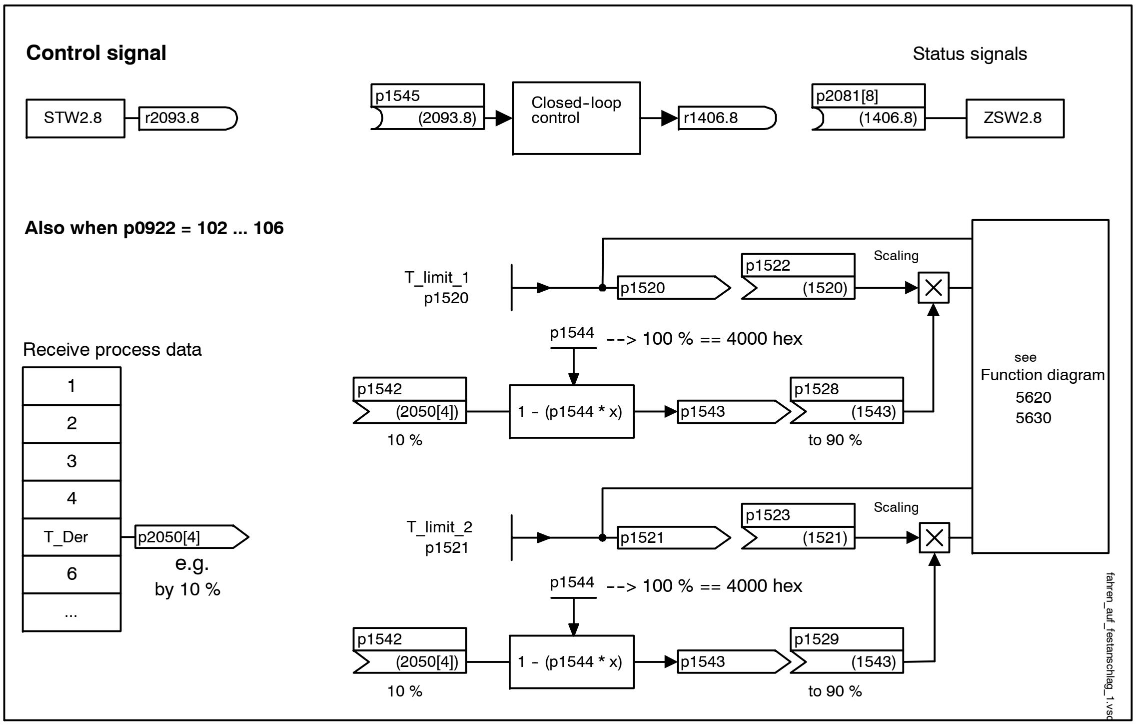


Fig. 3-21 Signals for “Travel to fixed stop”

When PROFIBUS 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

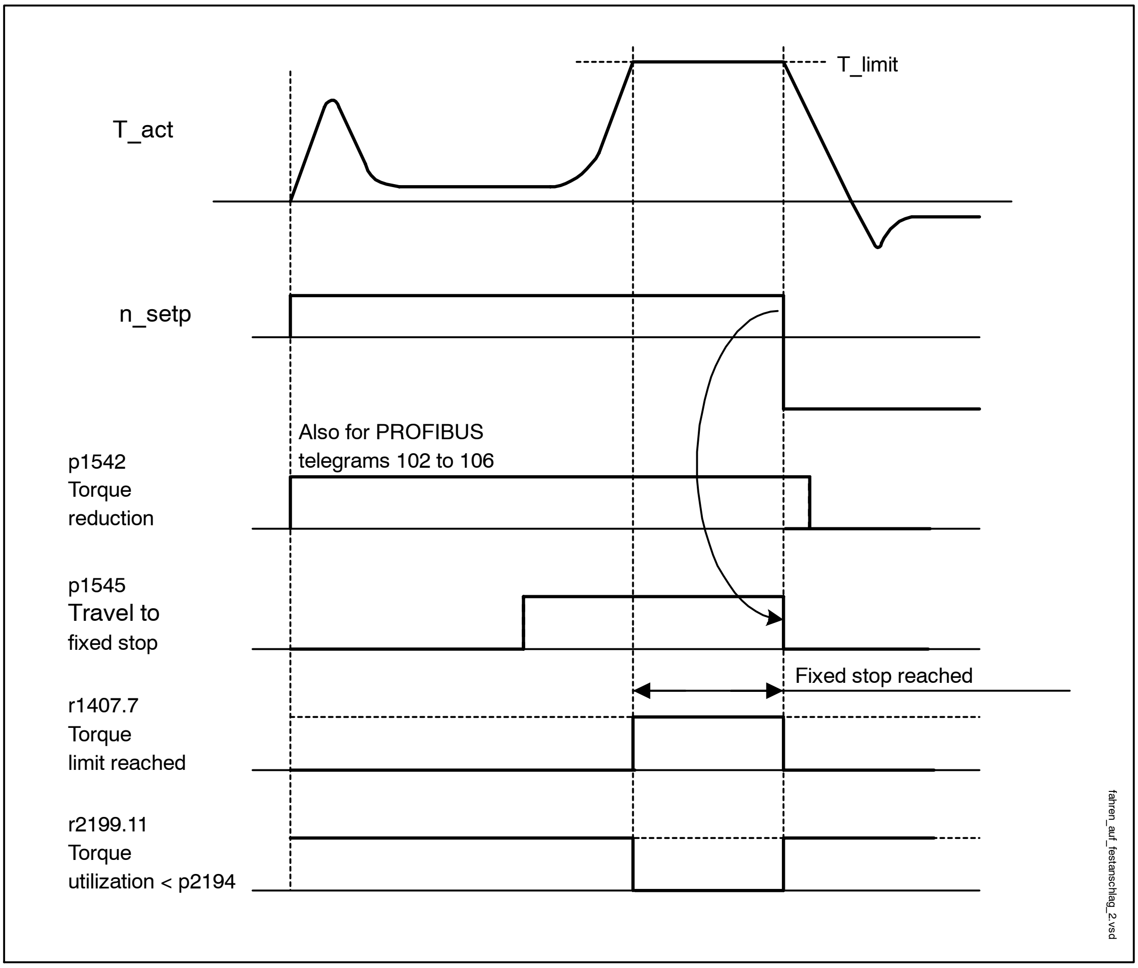


Fig. 3-22 Signal chart for “Travel to fixed stop”

Commissioning

1. Activate travel to fixed end stop

   Set p1545 = “1”

2. Set the desired 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 3-9 Control: travel to fixed end stop

Signal name	Internal control word STW n-reg	Binector input	PROFIBUS p0999 = 102 ... 106
Activates travel to a fixed endstop	8	p1545 Activates travel to a fixed endstop	STW2.8

Table 3-10 Status message: travel to fixed end stop

Signal name	Internal status word ZSW n_ctrl	Parameters	PROFIBUS p0999 = 102 ... 106
Torque limits reached	ZSW n_ctrl.7	r1407.7	ZSW1.0

Function diagram overview (see List Manual)

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

Parameter overview (see List Manual)

- p1400[0...n] Speed control configuration
- r1407.7 BO: Torque limit reached
- p1520[0...n] CO: Torque limit, upper/motoring
- p1521[0...n] CO: Torque limit, lower/regenerative
- p1522[0...n] CI: Torque limit, upper/motoring
- p1523[0...n] CI: Torque limit, lower/regenerative
- r1526 Upper torque limit of all torque limits without offset
- r1527 Lower torque limit all torque limits without offset
- p1532[0...n] Torque offset torque limit
- p1542[0...n] CI: Travel to a fixed endstop, torque reduction
- r1543 CO: Travel to fixed endstop, torque scaling
- p1544 Travel to a fixed endstop, evaluate torque reduction
- p1545[0...n] BI: Activates travel to a fixed endstop
- p2194[0...n] Torque threshold 2
- p2199.11 BO: Torque utilization < Torque threshold 2

3.1.14 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.

Overview of key parameters (see List Manual)

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

Function diagram overview (see List Manual)

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

3.2 Vector control

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

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

Vector control can be used with or without an encoder.

The following criteria indicate when an encoder is required:

- High speed accuracy is required
- High dynamic response requirements
  - Better command behavior
  - Better disturbance characteristic
- Torque control in a range greater than 01:10:00 AM is required
- 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:

- Closed-loop speed control
- Torque/current control (in short: torque control)

3.2.1 Vector control without encoder (SLVC)

Notice

Vector control without an encoder can only be carried out with induction motors.

In vector control without an encoder (SLVC), the position of the flux and actual speed must be determined via the electric motor model. The model is buffered by the incoming currents and voltages. At low frequencies (approx. 0 Hz), the model cannot determine the speed. For this reason and due to uncertainties in the model parameters or inaccurate measurements, the system is switched from closed-loop to open-loop operation in this range.

The switchover is governed via time and frequency conditions (p1755, p1756, and p1758). 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) simultaneously.

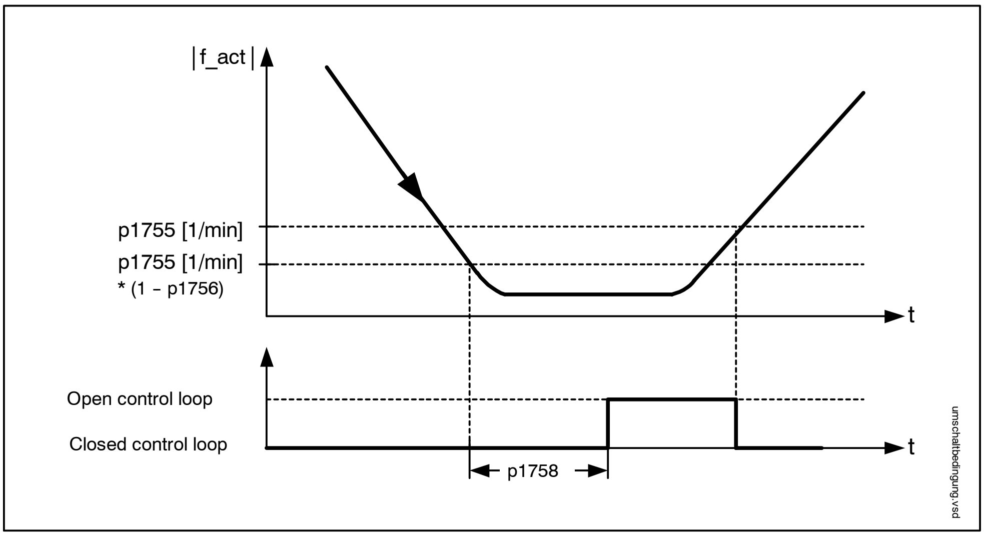


Fig. 3-23 Switchover conditions for SLVC

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

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

- Closed-loop operation up to approx. 1 Hz output frequency
- Start-up in closed-loop operation (directly after drive is energized)

Note

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

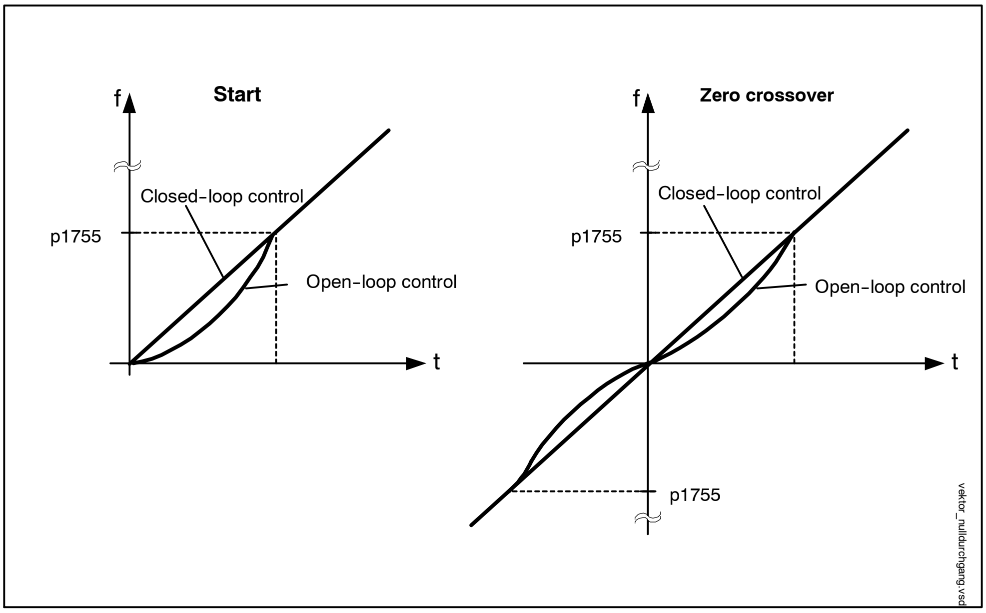


Fig. 3-24 Start-up and passing through 0 Hz in closed-loop operation

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

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

Note

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

Function diagram overview (see List Manual)

- 6730 Interface with Motor Module for induction motor (p0300 = 1)

Parameter overview (see List Manual)

- p0305[0...n] Rated motor current
- r0331[0...n] Motor magnetizing current/short-circuit current (actual)
- p1610[0...n] Torque setpoint static (SLVC)
- p1611[0...n] Supplementary accelerating torque (SLVC)
- p1750[0...n] Motor model configuration
- p1755[0...n] Motor model without encoder, changeover speed
- p1756 Motor model changeover speed hysteresis
- p1758[0...n] Motor model changeover delay time, open/closed-loop control

3.2.2 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

3.2.3 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:

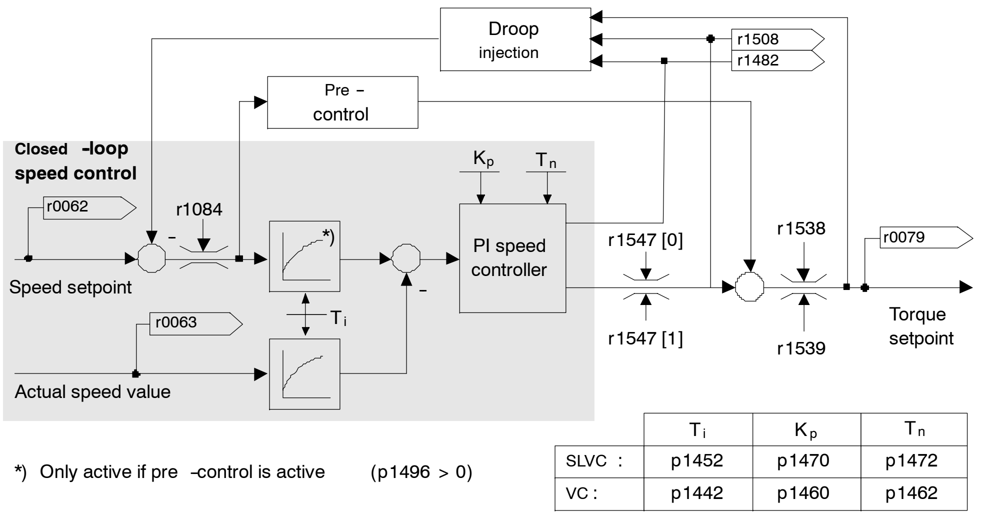
- PI controller
- Speed controller pre-control
- Droop function

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 the droop function 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.



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

Fig. 3-25 Speed controller

The optimum speed controller setting can be determined via the automatic speed controller optimization function (p1900 = 1, rotating measurement) (see also Subsection 3.2.11).

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.

Parameter overview (see List Manual)

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

Function diagram overview

- 6040 Speed controller with / without encoder

3.2.4 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 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.

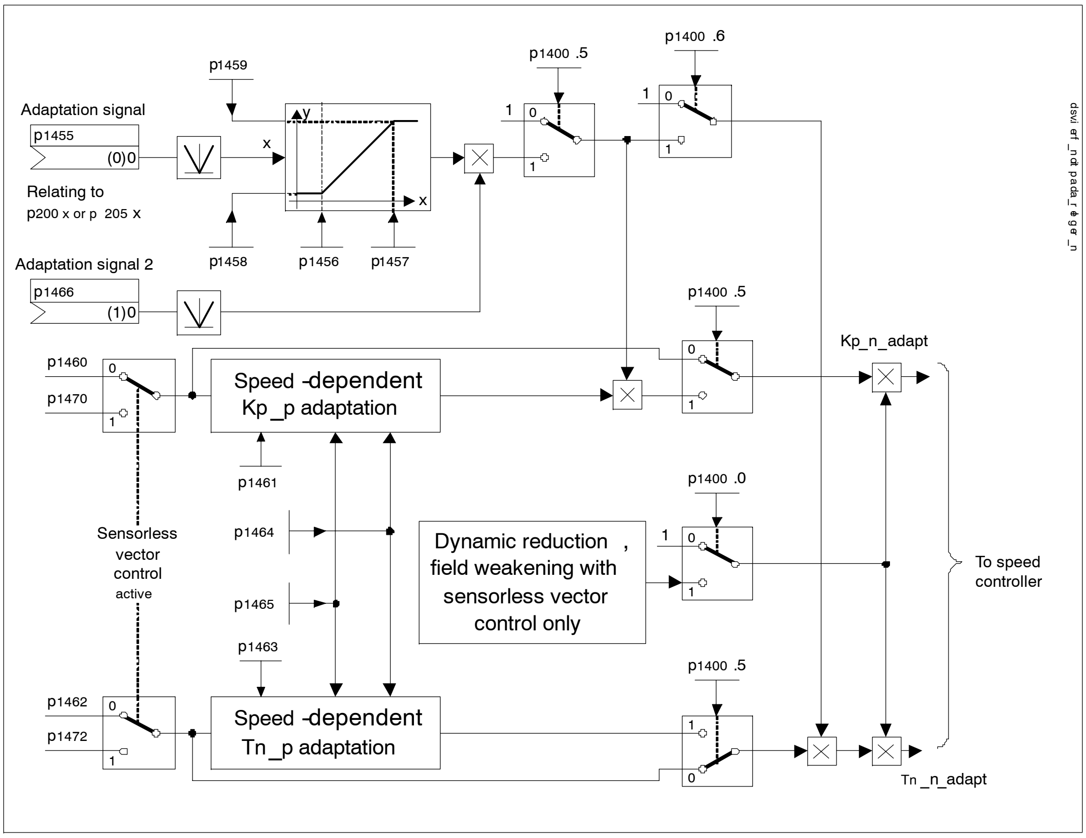


Fig. 3-26 Free KP adaptation

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

Example of speed-dependent adaptation

Note

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

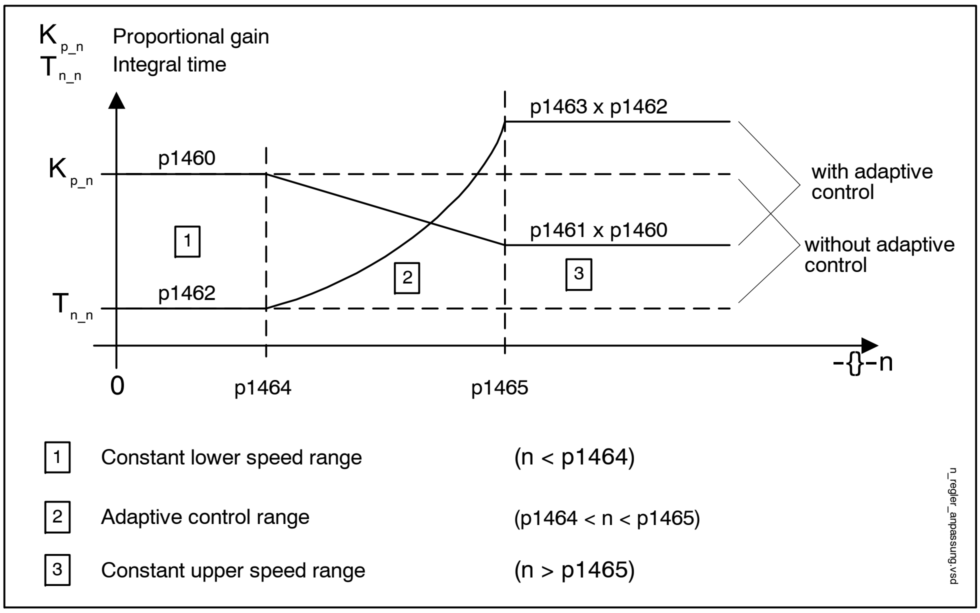


Fig. 3-27 Speed controller Kp_n/Tn_n adaptation

Parameterization

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

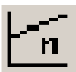


Fig. 3-28 STARTER icon for “speed controller”

Parameter overview for speed controller adaptation (see List Manual)

- p1400.5[0...n] Speed control configuration: Kp/Tn adaptation active

Free Kp_n adaptation

- p1455[0...n] CI: Speed controller P gain adaptation signal
- p1456[0...n] Lower starting point adaptation P gain
- p1457[0...n] Speed controller P gain adaptation application point upper
- p1458[0...n] Lower adaptation factor
- p1459[0...n] Adaptation factor, upper
- p1470[0...n] Speed controller sensorless operation P-gain

Speed-dependent Kp_n/Tn_n adaptation (VC only)

- p1460[0...n] Lower adaptation speed P gain speed controller
- p1461[0...n] Upper adaptation speed P gain speed controller
- p1462[0...n] Speed controller integral action time adaptation speed, lower
- p1463[0...n] Integral time upper adaptation speed speed controller
- p1464[0...n] Lower adaptation speed speed controller
- p1465[0...n] Upper adaptation speed speed controller
- p1466[0...n] CI: Speed controller P-gain scaling

Dynamic response reduction field weakening (SLVC only)

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

Function diagram for speed controller adaptation (see List Manual)

- 6050 Kp_n and Tn_n adaptation

3.2.5 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:

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

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.

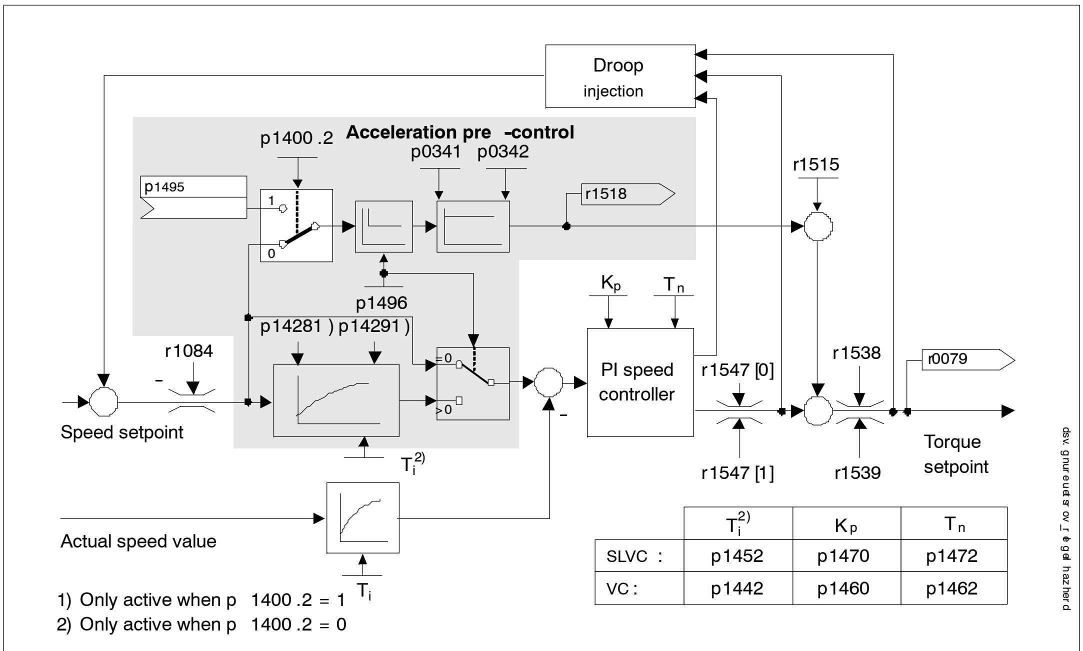


Fig. 3-29 Speed controller with pre-control

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 ramp-function generator rounding-off p1130 – p1133.

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

$$r0345 = T_{Start} = J \times \frac{(2\pi \times n_{Mot,rated})}{(60 \times M_{mot,rated})} = p0341 \times p0342 \times \frac{(2\pi \times p0311)}{(60 \times r0333)}$$

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

Note

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

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

Reference model

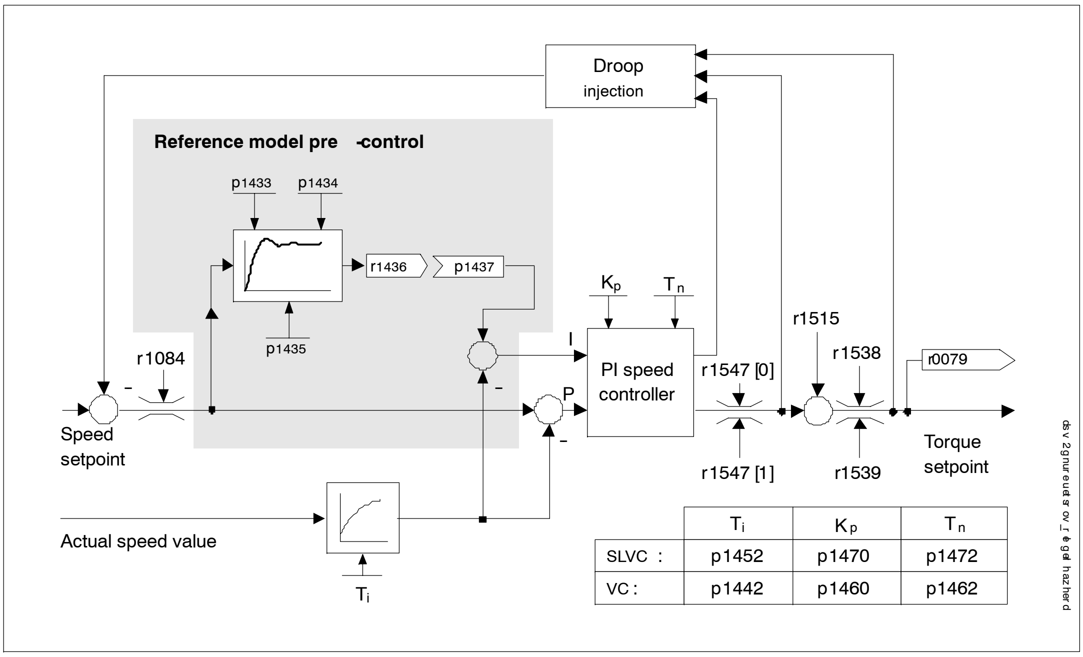


Fig. 3-30   Reference model

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

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

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

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

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

Function diagram overview for speed controller pre-control

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

Parameter overview for speed controller pre-control

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

For reference model

- p1400.3[0...n] Reference model speed setpoint I component
- p1433[0...n] Speed controller reference model natural frequency
- p1434[0...n] Speed controller reference model damping
- p1435[0...n] Speed controller reference model deadtime
- p1436 CO: Speed controller reference model speed setpoint output
- p1437[0...n] CI: Speed controller, reference model I component input

3.2.6 Droop function

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

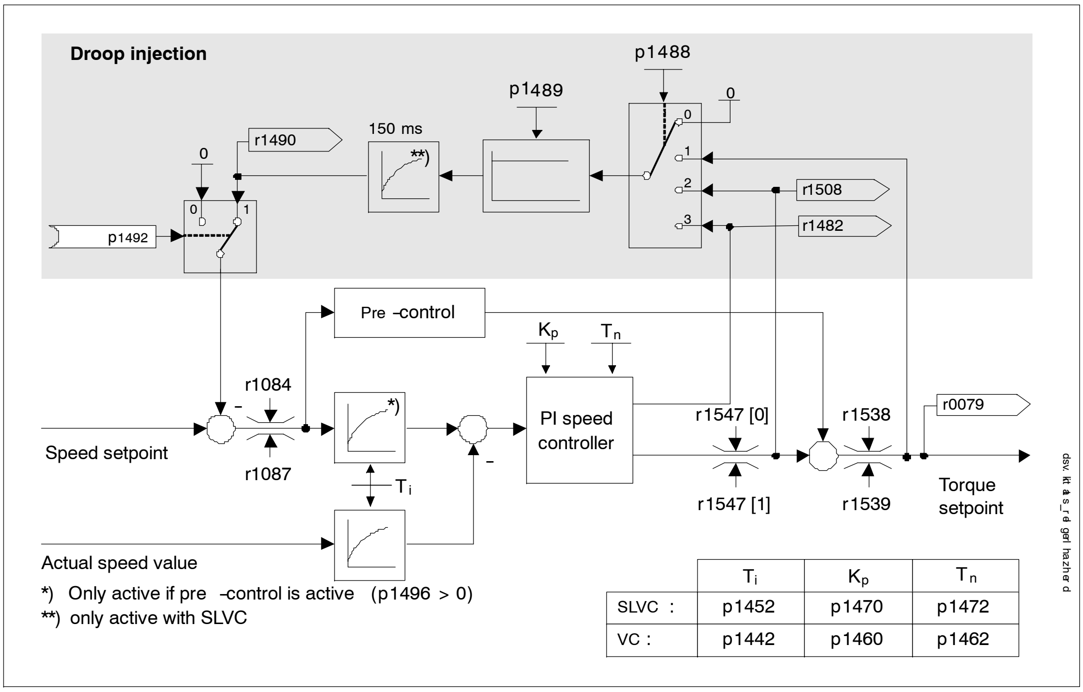


Fig. 3-31 Speed controller with droop function

Drooping is the most straightforward way of controlling load balancing. This type of control can only be applied, however, if the drives are operated in motor mode and the speed is steady state. This method is only suitable to a limited extent for drives that are accelerated and braked with significant changes in speed.

This simple type of load balancing control 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. The droop function compensates for 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).
- The ramp-function generator ramp-up and ramp-down times must be the same for all drives.

Function diagram overview for droop function (see List Manual)

- 6030 Speed setpoint, droop, acceleration model

Parameter overview for droop function (see 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
- p1512 CI: Supplementary torque 1 scaling
- p1513 CI: Supplementary torque 2

3.2.7 Closed-loop torque control

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

Note

For safety reasons, assignments to fixed torque setpoints are currently not possible.

When regenerative energy occurs that cannot be fed back into the supply, a Braking Module with a connected braking resistor must be used.

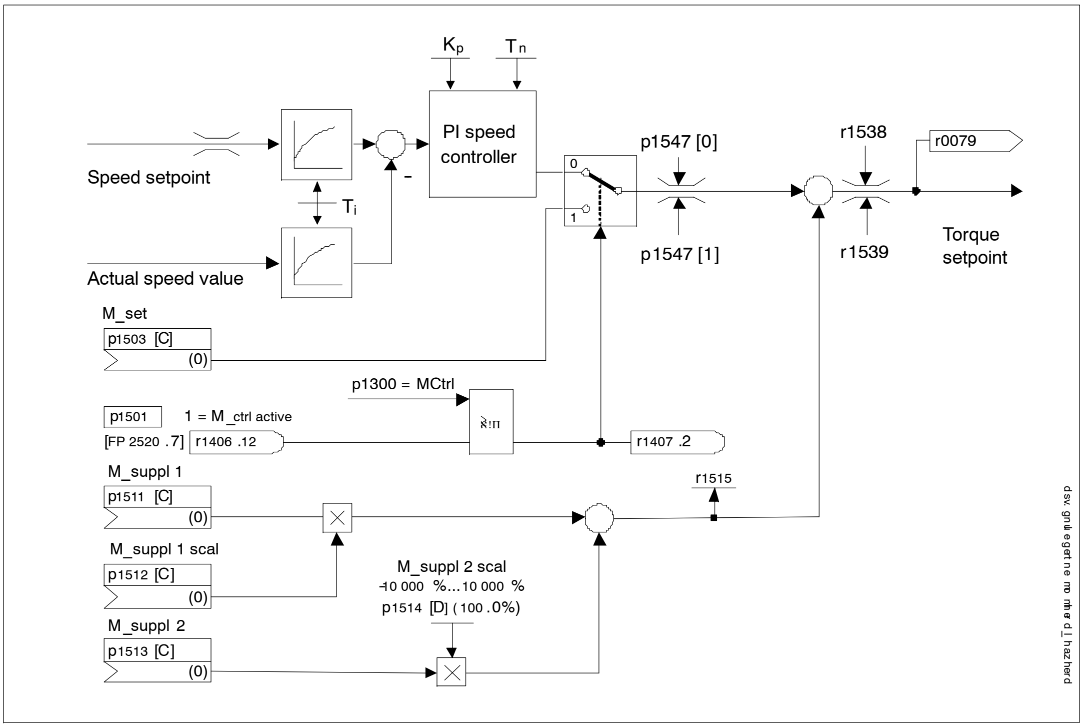


Fig. 3-32 Closed-loop speed/torque control

The total of the two torque setpoints is limited in the same way as the speed control torque setpoint. At speeds in excess of the maximum speed (p1182), a speed limiter reduces the torque limits to prevent the drive from being accelerated further.

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

OFF responses

- OFF1 and p1300 = 22, 23
  - Response as for OFF2
- OFF1, p1501 = “1” signal and p1300 $\neq$ 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. Zero speed is detected if the actual speed drops below the threshold in p1226 or if the monitoring time (p1227) started when speed setpoint <= speed threshold (p1226) has expired.
  - Power-on disable is activated.
- OFF2
  - Instantaneous pulse suppression, the drive “coasts” to a standstill.
  - The motor brake (if parameterized) is closed immediately.
  - Power-on disable is activated.
- OFF3
  - Switch to speed-controlled operation.
  - n_set=0 is input immediately to brake the drive along the OFF3 deceleration ramp (p1135).
  - When zero speed is detected, the motor holding brake (if parameterized) is closed.
  - The pulses are suppressed when the brake application time (p1217) expires. Zero speed is detected if the actual speed drops below the threshold in p1226 or if the monitoring time (p1227) started when speed setpoint <= speed threshold (p1226) has expired.
  - Power-on disable is activated.

Function diagrams for torque setpoint limitation (see List Manual)

- 6060 Torque setpoint

Parameters for torque control (see List Manual)

- p0341[0...n] Motor moment of inertia
- p0342[0...n] Ratio between the total moment of inertia and that of the motor
- p1300[0...n] Open-loop/closed-loop control operating mode
- p1499[0...n] Acceleration for torque control (SLVC) scaling
- p1501[0...n] BI: Change over between closed-loop speed/torque control
- p1503[0...n] CI: Torque setpoint
- p1511[0...n] CI: Supplementary torque 1
- r1512 CI: Supplementary torque 1 scaling
- r1513 CI: Supplementary torque 2
- r1514 Supplementary torque 2 scaling
- r1515 Supplementary torque total

3.2.8 Torque limiting

Description

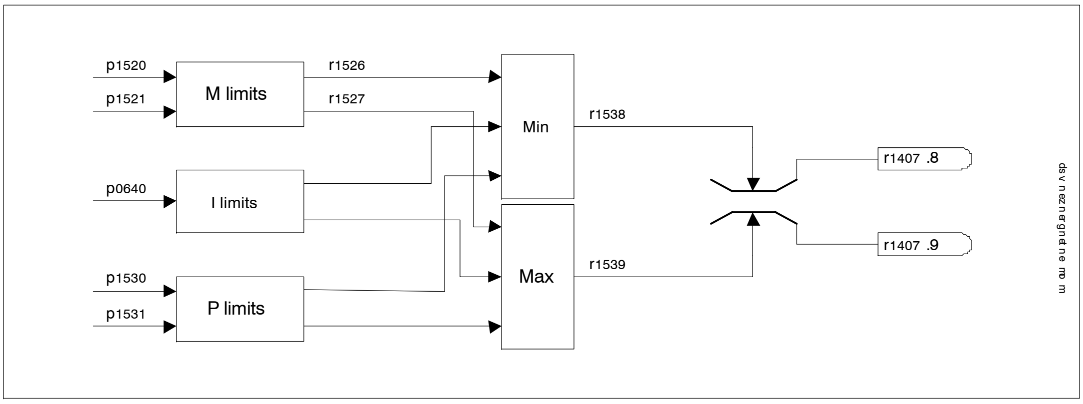


Fig. 3-33 Torque limiting

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

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

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

- r0067 Maximum drive output current
- r1526 Upper torque limit of all torque limits without offset
- r1527 Lower torque limit all torque limits 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 and indicate the maximum torque currently possible. 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

Function diagrams for torque setpoint limitation (see List Manual)

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

3.2.9 Vdc control

Description

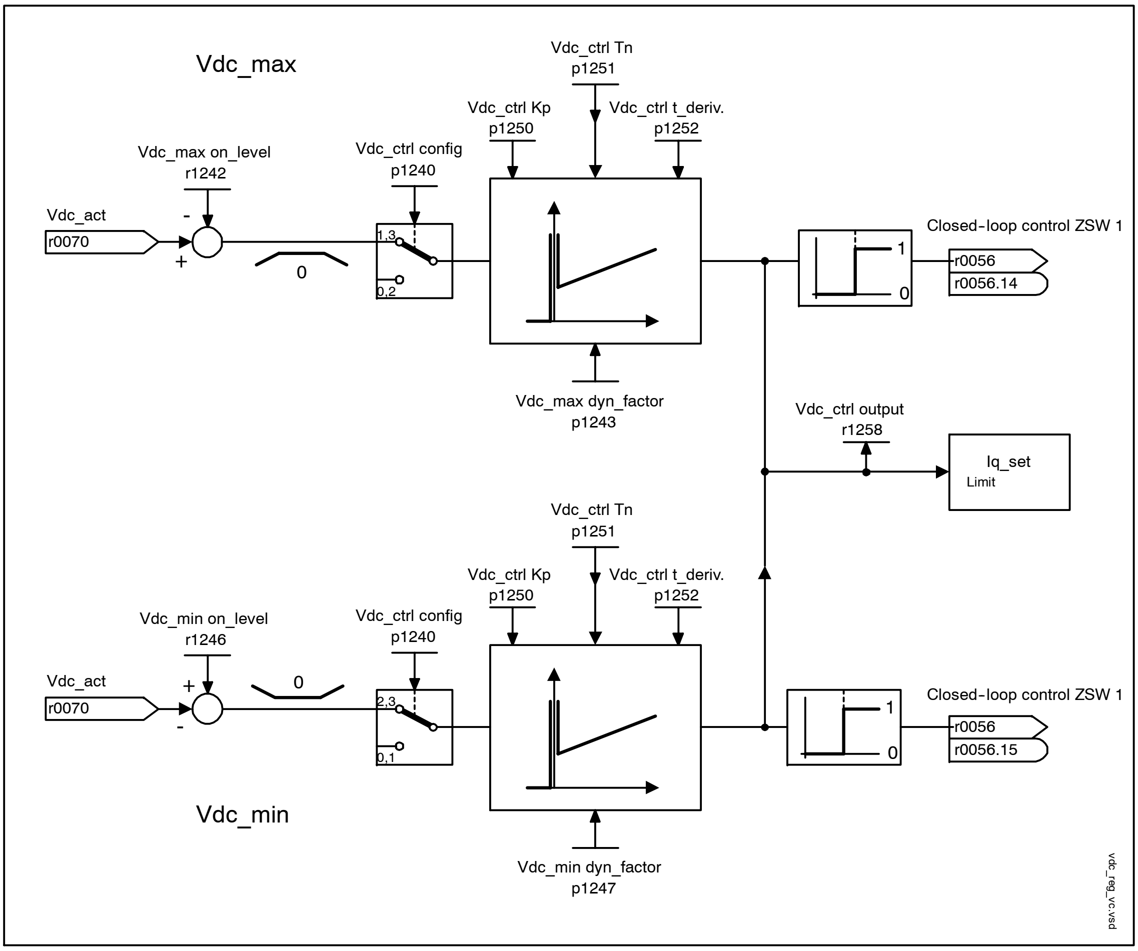


Fig. 3-34 Vdc control vector

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

- Overvoltage in the DC link
  - Typical cause

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

    Reduce the regenerative torque to maintain the DC link voltage within permissible limits.
- Undervoltage in the DC link
  - Typical cause

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

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

Properties

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

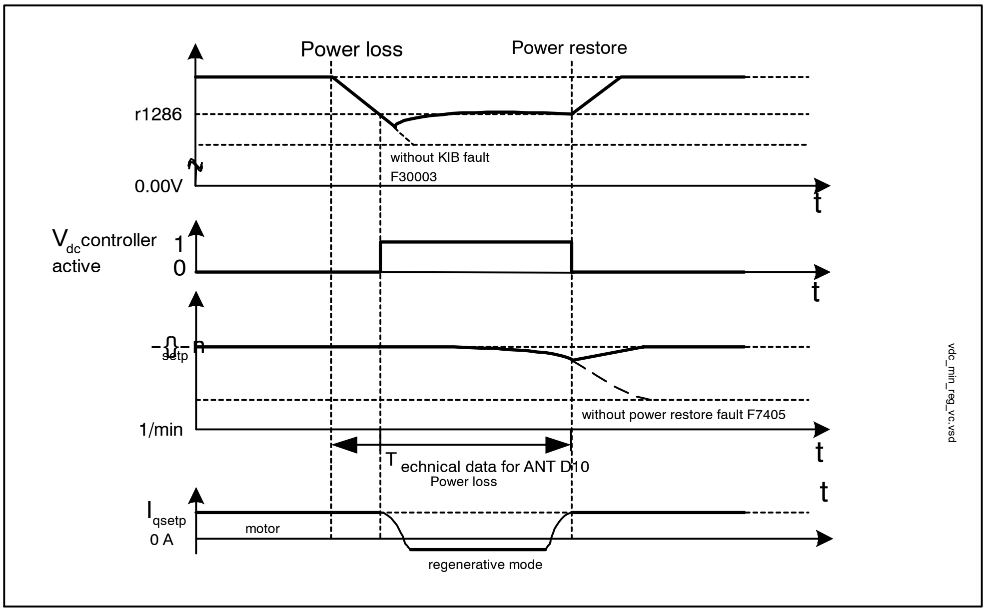


Fig. 3-35 Switching Vdc_min control on/off (kinetic buffering)

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 reestablished, the motor speed continues to drop. When the threshold in p1257 is reached, this results in a response in accordance with p1256.

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

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 be equipped with an uninterruptible power supply (UPS), for example.

Description of Vdc_max control

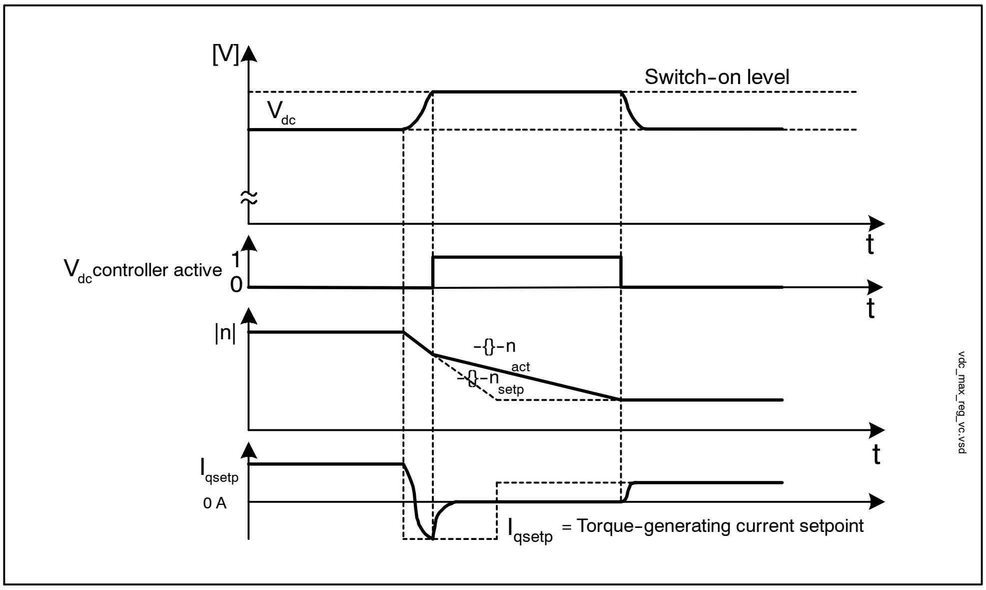


Fig. 3-36 Switching Vdc_max control on/off

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

- Automatic detection of ON level deactivated (p1254 = 0)

  r1242 = 1.15 * p0210 (device supply voltage, DC link)

- Automatic detection of ON level activated (p1254 = 1)

  r1242 = Vdc_max – 50 V (Vdc_max: overvoltage threshold of the Motor Module)

Function diagram overview (see List Manual)

- 6220 Vdc_max controller and Vdc_min controller

Parameters for Vdc controller (see 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-action time (control)
- p1252[0...n] Vdc controller derivative-action time (control)
- p1254 Vdc_max controller automatic detection ON level (control)
- p1256[0...n] Vdc_min controller response (kinetic buffering) (control)
- p1257[0...n] Vdc_min controller speed threshold (controller)
- r1258 CO: Vdc controller output (control)

3.2.10 Current setpoint filter

Description

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

- Low-pass 2nd order (PT2): –40dB/decade)
- General filter 2nd order
  Band-stop and low-pass with reduction are converted to the parameters of the general filter 2nd order via STARTER.
  - Band-stop
  - 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.

Overview of key parameters (see List Manual)

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

Function diagram overview (see List Manual)

- 6710 Current setpoint filter

3.2.11 Motor data identification and rotating measurement

Description

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

- Standstill measurement with p1910 (motor identification)
- Rotating measurement with p1960 (determining the saturation characteristic)

These can be selected more easily via p1900. 1900 = 2 selects the standstill measurement (motor not rotating). p1900 = 1 also activates the rotating measurement; p1900 = 1 sets p1910 = 1 and p1960 in accordance with the current control type (p1300).

If a permanent-magnet synchronous motor is used (p0300 = 2), encoder adjustment is activated automatically (p1990 = 1) when the rotating measurement is performed (p1960 > 0 or p1900 = 1). The method used can be set in p1980 (see also Subsection 3.2.12).

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 via p1900 are started in the following sequence after the drive has been enabled:

- Standstill measurement, pulse inhibit and parameter 1910 reset to 0 after the measurement has been successfully completed.
- Encoder adjustment, pulse inhibit and parameter 1990 reset to 0 after the measurement has been successfully completed.
- Rotating measurement, pulse inhibit and parameter 1960 reset to 0 after the measurement has been successfully completed.
- Once all the measurements activated via p1900 have been successfully completed, the parameter is reset to 0.

Note

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

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.

Standstill measurement (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 (not recommended with permanent-magnet synchronous motors)

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

Table 3-11 Determining data via 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) • Converter valve threshold voltage (p1825) • Compensation valve interlocking time phase (p1828 ... p1830)	• Stator resistance (p0350) • Stator leakage inductance q-axis (p0356) • Stator leakage inductance d-axis (p0357) • Converter valve threshold voltage (p1825) • Compensation valve interlocking time phase (p1828 ... p1830)
p1910 = 3	• Saturation characteristic (p0362 ... p0366)	Not recommended

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

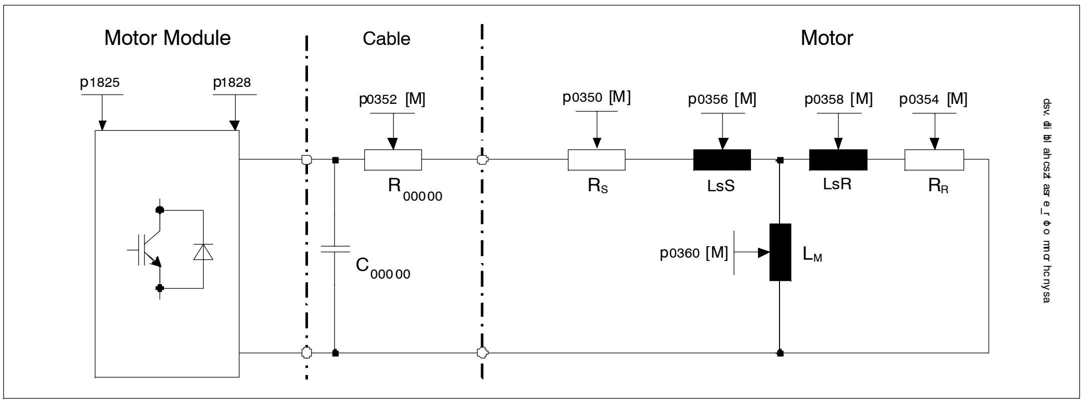


Fig. 3-37 Equivalent circuit diagram for induction motor and cable

In addition to the equivalent circuit diagram data, motor data identification (p1910 = 3) can be used to determine the magnetization characteristic of induction motors. Due to the greater accuracy, the magnetization characteristic should, whenever possible, be determined during the rotating measurement (with encoder: p1960 = 1, 3; with encoder:
p1960 = 2, 4). If the drive is operated in the field-weakening range, this characteristic should be determined during vector control. The magnetization characteristic can be used to calculate the field-generating current in the field-weakening range more accurately, thereby increasing torque accuracy.

Note

Speed controller optimization (p1960) allows the rated magnetization current and saturation characteristic to be determined more accurately for induction motors.

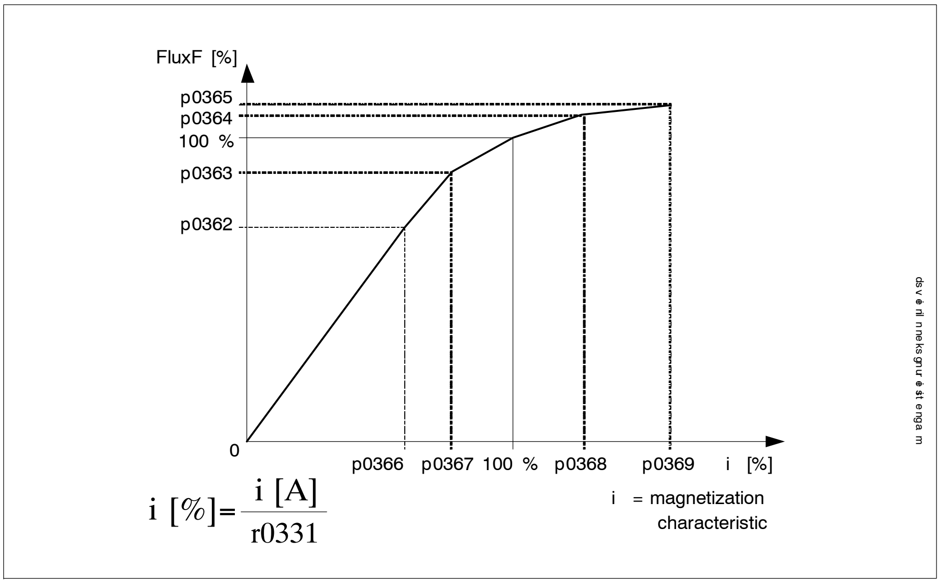


Fig. 3-38 Magnetization characteristic

Note

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

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.

Rotating measurement (p1960)

Different data is identified during the rotating measurement. Speed controller optimization determines the data required (e.g. moment of inertia) for setting the speed controller. It also measures the saturation characteristic and rated magnetization current of induction motors.

Speed control can be activated via p1960 or p1900 = 1.

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.

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 the the drive cannot operate in a stable manner with the specified dynamic factor, 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 the load is connected, 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 carried out by selecting parameter p1960 (without encoder: p1960 = 3; with encoder: p1960 = 4).

When permanent-magnet synchronous motors are commissioned, speed controller optimization (p1960 = 2/4) should be carried out when the load is connected.

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.

- Only with induction motors:
  - Encoder test
  - 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 (p1774 and p1775)
- Speed controller optimization
  - p1470 and p1472, when p1960 = 1 (operation without encoder)
  - p1460 and p1462, when p1960 = 2 (operation with encoder)
  - Kp adaptation switch-off
- Acceleration pre-control setting (p1496)
- Setting for ratio between the total moment of inertia and that of the motor (p0342)

Note

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

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.

Overview of key parameters (see List Manual)

- p1300[0...n] Open-loop/closed-loop control operating mode
- p1900 Motor data identification and rotating measurement
- p1900 Speed controller optimization configuration

Rotating measurement

- 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 method
- p1990 Encoder adjustment selection

Motor data identification at standstill

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

3.2.12 Automatic encoder adjustment

Description

The rotor-oriented closed-loop control of the synchronous motor requires information on the rotor angular displacement. Automatic encoder adjustment must be used when the rotor position encoders are not adjusted mechanically and after the motor encoder has been replaced.

Automatic encoder adjustment requires encoders with absolute position identification. The following encoders are supported:

- Encoder with C/D track
- Resolver
- Absolute value encoder (e.g. EnDat)
- Incremental encoder with zero mark

Encoder adjustment via zero mark

if an incremental encoder with a zero mark is used, the position of the zero mark can be compared once it has been passed. Commutation with the zero mark is activated via p0404.15.

Commissioning

Automatic encoder adjustment is activated with p1990 = 1. The measurement is performed the next time a pulse is enabled and the angle difference determined (p1984) is entered in p0431. When p1990 = 2, the angle difference determined (p1984) is not entered in p0431 and does not affect motor control. This function can be used to check the angle difference entered in p0431.

Warning

The measurement causes the motor to rotate. The motor completes at least one full revolution.

Integration

Automatic encoder adjustment is integrated in the system as follows:

Overview of key parameters:

- p0404.15 Commutation with zero mark
- p0431 Commutation angle offset
- p1990 Encoder adjustment selection

3.2.13 Pole position identification

Description

Pole position identification is used to determine the pole position. Two pole position identification methods are available:

- p1980 = 4, voltage pulsation, two stage

  This method is used with magnetically unbalanced motors. The motor must be at a standstill when the measurement is being performed. The measurement is performed when the next pulse is enabled.

- p1980 = 10, direct current injection

  This method can be used with all motors but takes longer than the measurement via p1980 = 4. The motor must be able to rotate during the measurement. The measurement is performed when the next pulse is enabled.

Integration

Pole position identification is integrated in the system as follows:

Overview of key parameters:

- p0325 Pole position identification current, 1st phase
- p0329 Pole position identification current
- p1980 Pole position identification method
- p1982 Pole position identification selection
- r1984 Pole position identification angle difference
- r1985 Pole position identification saturation curve
- r1987 Pole position identification trigger curve

3.3 Vector V/f control (r0108.2 = 0)

The simplest solution for a control procedure is the V/f curve, whereby the stator voltage for the induction motor or synchronous motor is controlled proportionately to the stator frequency. This method has proved successful in a wide range of applications with low dynamic requirements, such as:

- Pumps and fans
- Belt drives

and other similar processes.

V/f control aims to maintain a constant flux ϕ in the motor, whereby the flux is proportionate to the magnetization current $I\mu$ or the ratio of voltage (U) to frequency (f).

$\phi \sim I\mu \sim U/f$

The torque (M) generated by the induction motors is, in turn, proportionate to the product (or, more precisely, the vector product $\underline{\phi} \times \underline{I}$) of the flux and current.

$M \sim \phi \times I$

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 also be changed in proportion to the frequency (f) to ensure a constant magnetization current ($I\mu$). V/f characteristic control is derived from these basic premises.

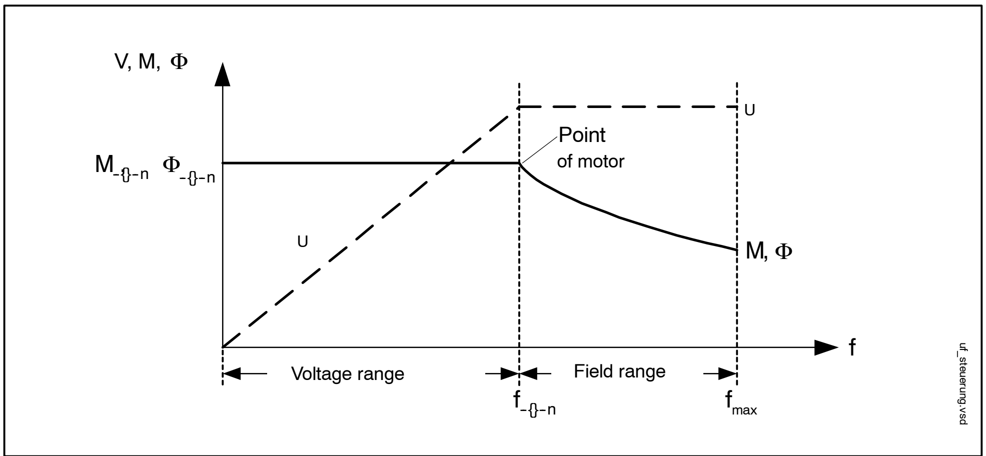


Fig. 3-39 Operating areas and characteristic curves for the induction motor with converter supply

Several variations of the V/f characteristic exist, which are shown in the following table.

Table 3-12 V/f characteristic (p1300)

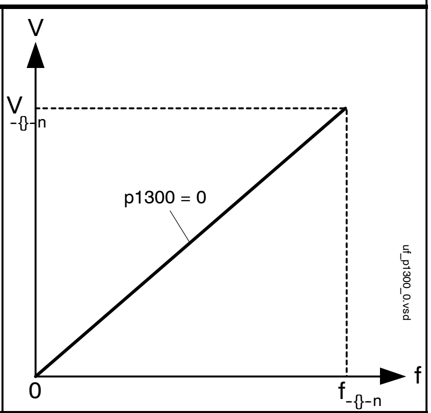
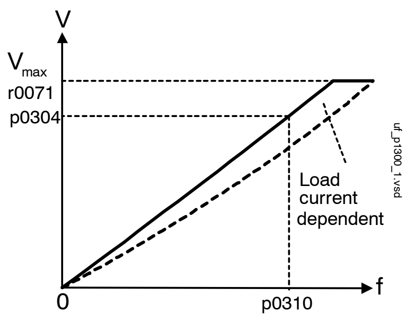
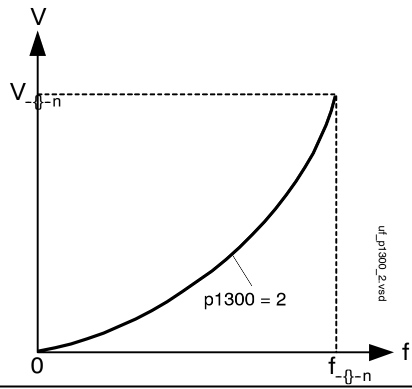
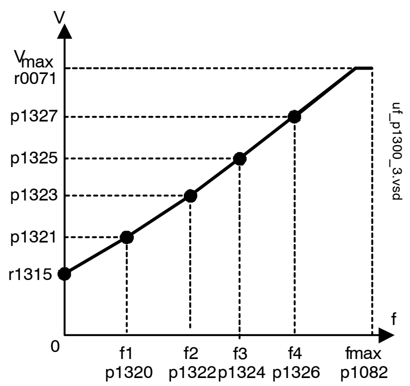
Parameter values	Meaning	Application / property	
0	Linear characteristic	Standard (w/o voltage boost)	
1	Linear characteristic with flux current control (FCC)	Characteristic that compensates for voltage drops in the stator resistance for static / dynamic loads (flux current control FCC). This is particularly useful for small motors, since they have a relatively high stator resistance.	
2	Parabolic characteristic	Characteristic that takes into account the motor torque characteristic (e.g. fan/pump). a) Quadratic characteristic (n^2 characteristic) b) Energy saving because the low voltage also results in small currents and drops.	
3	Programmable characteristic	Characteristic that takes into account the motor / machine torque characteristic (e.g. synchronous motor).	

Table 3-12 V/f characteristic (p1300), Fortsetzung

Parameter values	Meaning	Application / property
5	Precise frequency drives	Characteristic that takes into account the technological particularity of an application (e.g. textile applications): a) whereby 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 current limitation (Imax controller) only affects the output voltage and not the output frequency, or b) by disabling slip compensation Voltage drops in the stator resistance for static / dynamic loads are also compensated (flux current control FCC). This is particularly useful for small motors, since they have a relatively high stator resistance.
19	Independent voltage setpoint	The user can define the output voltage of the Motor Module independently of the frequency using BICO parameter p1330 via the interfaces (e.g. analog input AI0 of a Terminal Board 30 –> p1330 = r4055[0]).

3.3.1 Voltage boost

With an output frequency of 0 Hz, the V/f characteristics yield an output voltage of 0 V. The voltage boost must be entered to:

- Magnetize the induction motor.
- Maintain the load.
- Compensate for the losses (ohmic losses in the winding resistors) in the system
- Generate a breakaway/acceleration/braking torque.

The voltage boost can be increased permanently (p1310) or during acceleration (p1311).

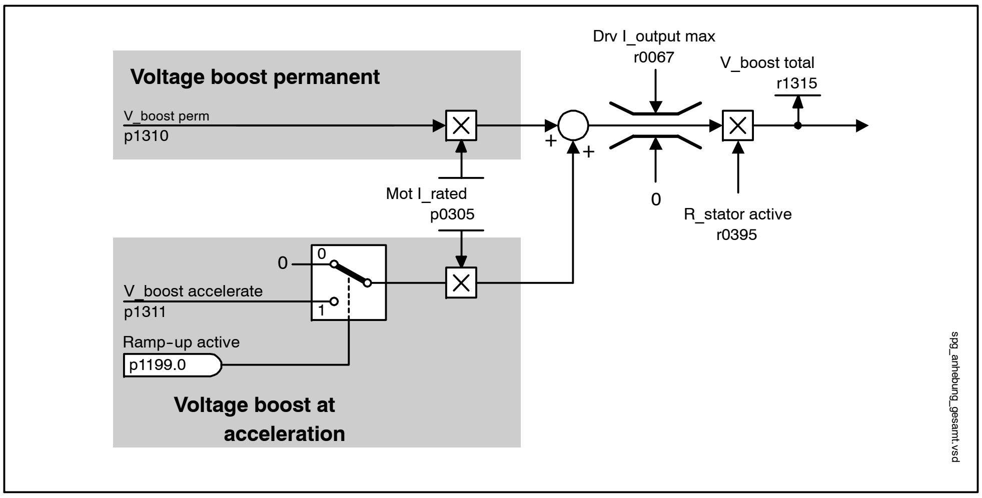


Fig. 3-40 Voltage boost total

Note

The voltage boost affects all V/f characteristics (p1300).

Notice

If the voltage boost value is too high, this can result in a thermal overload of the motor winding.

Permanent voltage boost (p1310)

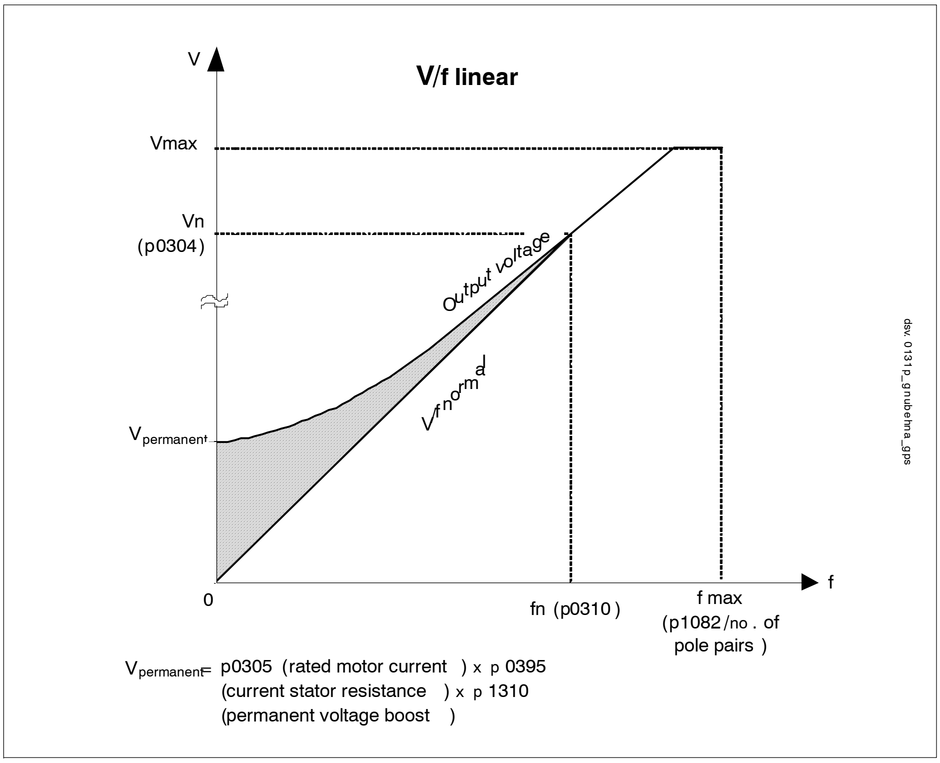


Fig. 3-41 Permanent voltage boost (example: p1300 and p1311 = 0)

Voltage boost at acceleration (p1311)

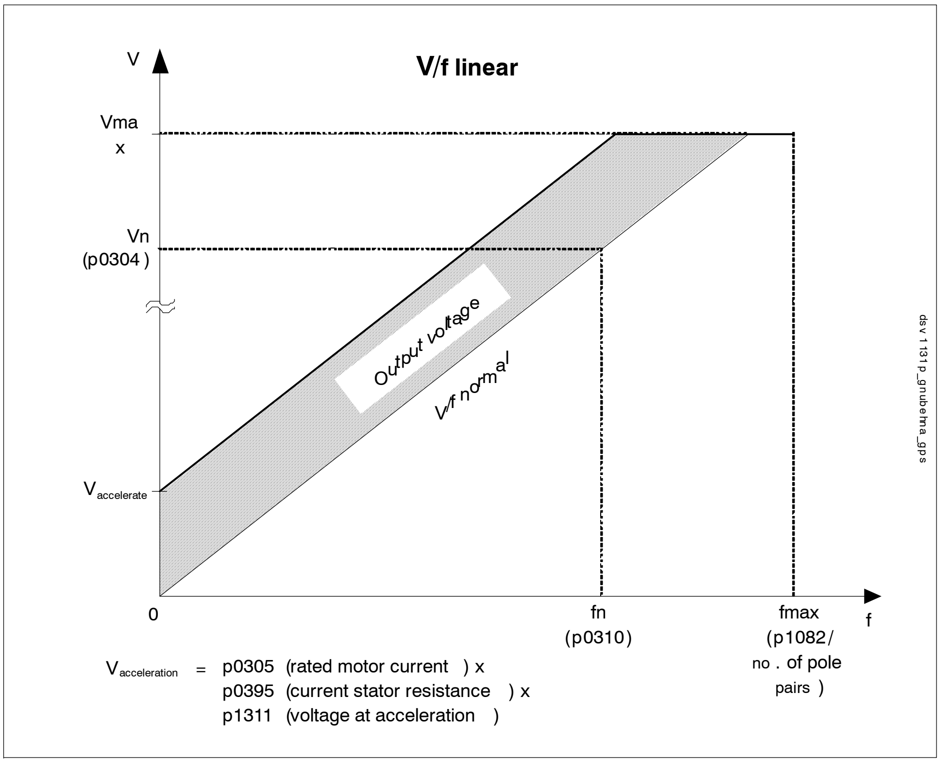


Fig. 3-42 Voltage boost at acceleration (example: p1300 and p1311 = 0)

Function diagram for voltage boost (see List Manual)

- 6300 V/f characteristic and voltage boost

Parameters for voltage boost (see List Manual)

- p0304[0...n] Rated motor voltage
- p0305[0...n] Rated motor current
- p0395[0...n] Stator resistance current
- p1310[0...n] Voltage boost permanent
- p1311[0...n] Voltage boost at acceleration
- r1315 Voltage boost total

3.3.2 Slip compensation

Description

Slip compensation is an additional V/f control function. It ensures that the speed of induction motors is maintained at a constant level irrespective of the load.

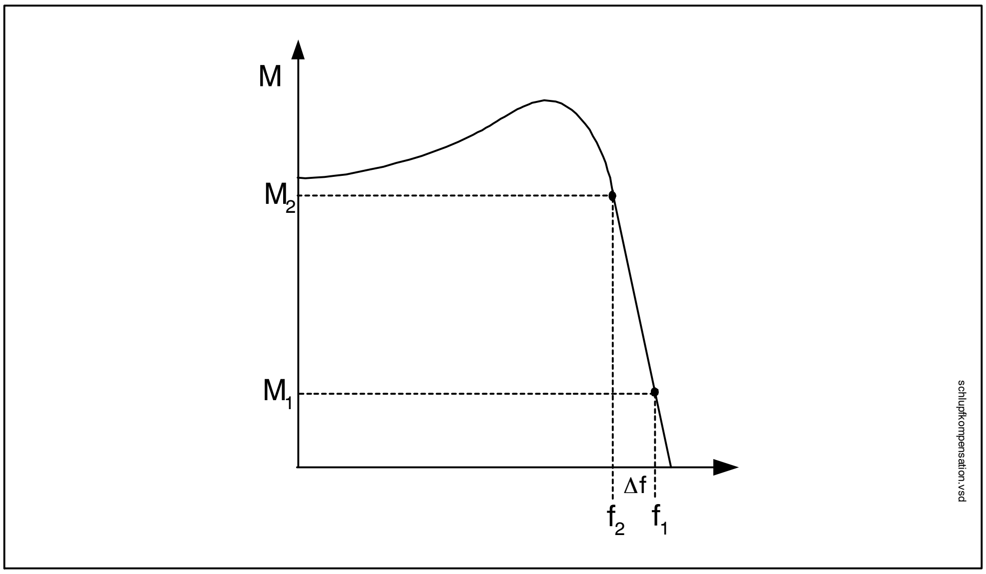


Fig. 3-43 Slip compensation

Overview: important parameters for slip compensation

- p1335[0...n] Slip compensation
  - p1335 = 0.0 %: slip compensation is deactivated.
  - p1335 = 100.0 %: slip is fully compensated.
- p1336[0...n] Slip compensation limit value
- r1337[0...n] Actual slip compensation

3.3.3 Vdc control

Description

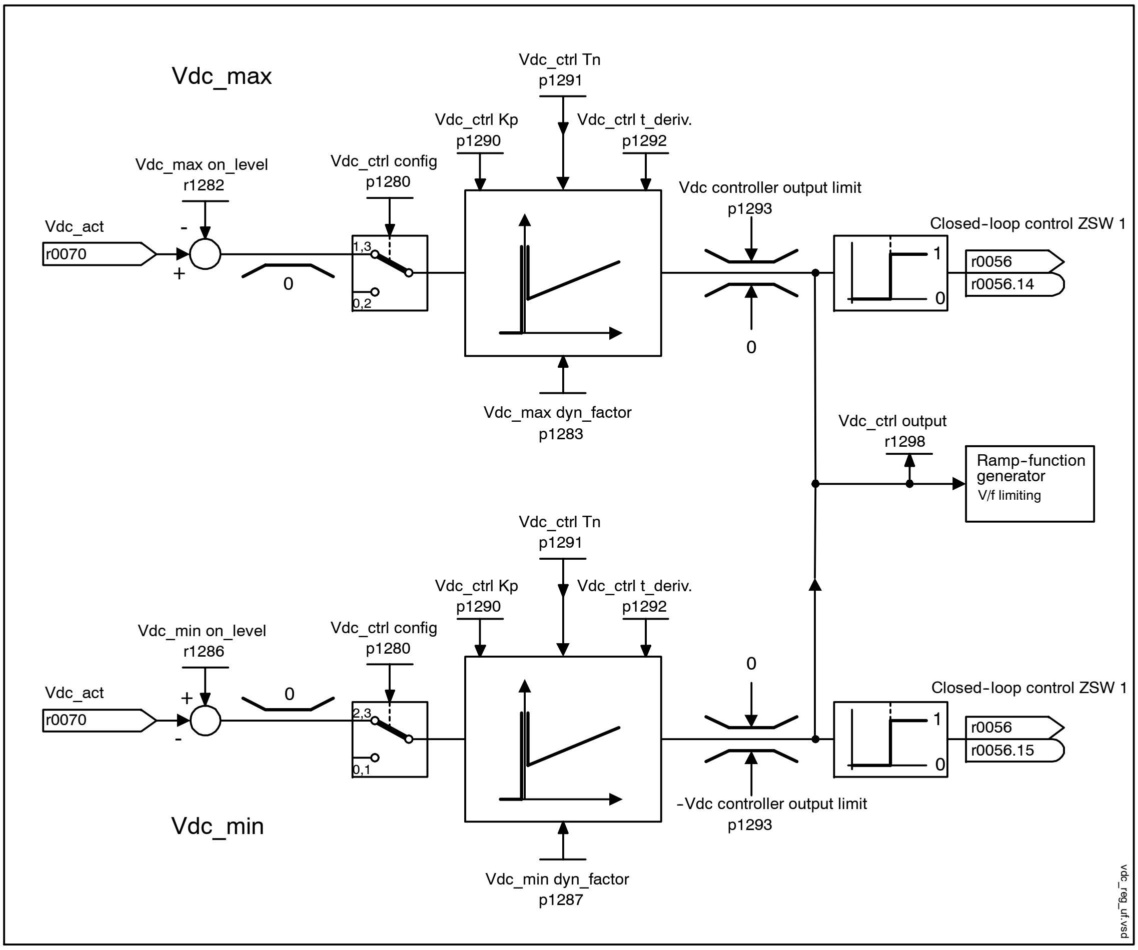


Fig. 3-44 Vdc control V/f

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

Description of Vdc_min control

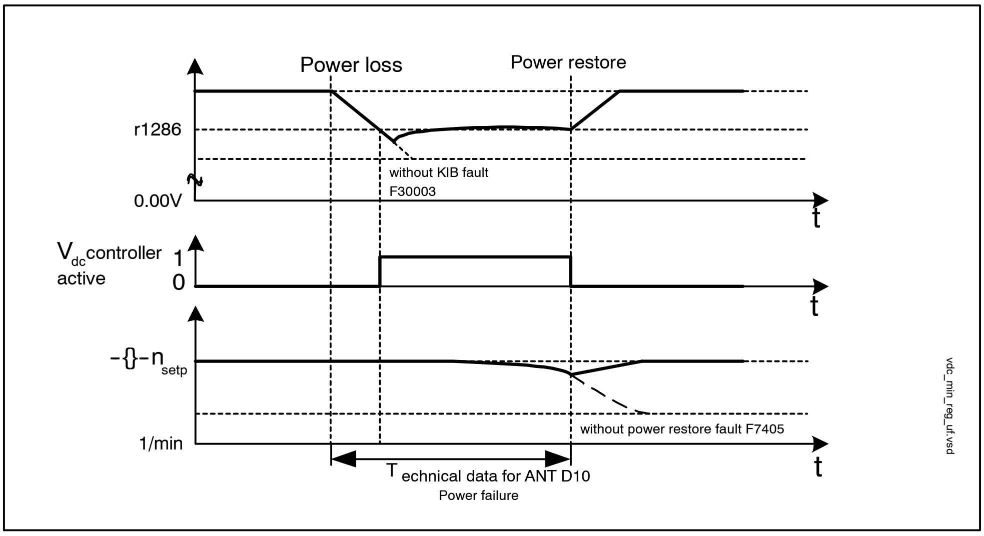


Fig. 3-45 Switching Vdc_min control on/off (kinetic buffering)

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

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

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

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

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 be equipped with an uninterruptible power supply (UPS), for example.

Description of Vdc_max control

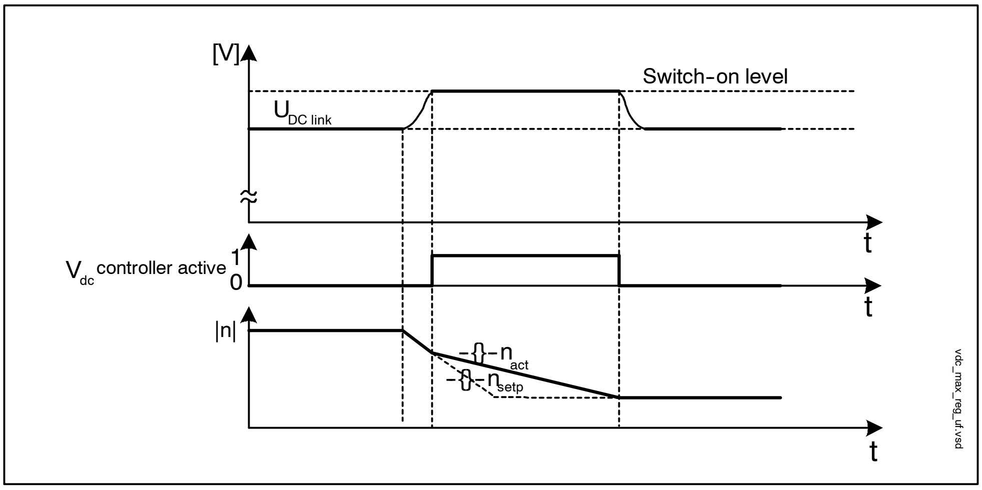


Fig. 3-46 Switching Vdc_max control on/off

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

- Automatic detection of ON level deactivated (p1294 = 0)

  r1282 = 1.15 * p0210 (device supply voltage)

- Automatic detection of ON level activated (p1294 = 1)

  r1282 = Vdc_max – 50 V (Vdc_max: overvoltage threshold of the Motor Module)

Function diagram for Vdc controller (see List Manual)

- 6320 Vdc_max controller and Vdc_min controller

Overview: important parameters for the Vdc controller (see 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)

3.4 Notes on commissioning vector motor types

Equivalent circuit diagram for induction motor vector and cable

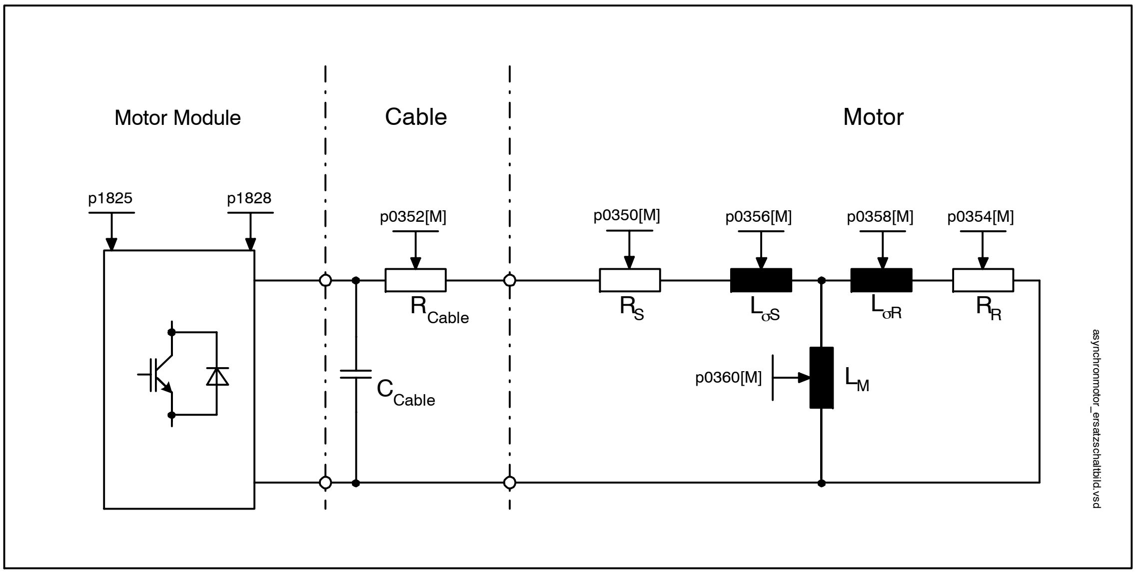


Fig. 3-47 Equivalent circuit diagram for induction motor vector and cable

Equivalent circuit diagram for synchronous motor vector and cable

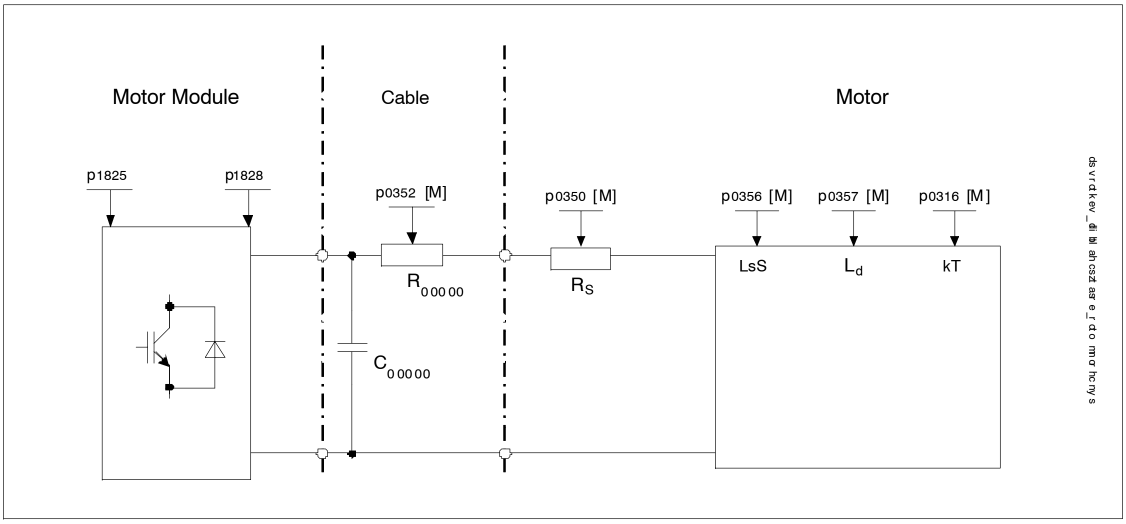


Fig. 3-48 Equivalent circuit diagram for synchronous motor vector and cable

Induction motors (rotary)

The following parameters can be entered when the commissioning Wizard is run in STARTER:

Table 3-13 Motor data type plate

Parameters	Description	Note
p0304	Rated motor voltage	If this value is not known, “0” can also be entered. This value enables the stator leakage inductance (p0356, p0357) to be calculated more accurately.
p0305	Rated motor current	–
p0307	Rated motor power	–
p0308	Rated motor power factor	–
p0310	Rated motor frequency	–
p0311	Rated motor speed	–
p0335	Motor cooling type	–

The following optional parameters can be entered:

Table 3-14 Optional motor data

Parameters	Description	Note
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 and that of the motor	–
p0344	Motor weight	–
p0350	Motor stator resistance, cold	–
p0352	Cable resistance (component of the stator resistance)	
p0354	Motor rotor resistance, cold	–
p0356	Motor stator leakage inductance	–
p0358	Motor rotor leakage inductance	–
p0360	Motor magnetizing inductance	–
p0640	Current limit	This value is limited to maximum 4 * p0305. This value is defaulted to 1.5 * p0305 during commissioning.
p1080	Minimum speed	–

Table 3-14 Optional motor data, continued

Parameters	Description	Note
p1082	Maximum rotational speed	This value can be less than or equal to p0322.
p1120	Ramp-function generator ramp-up time	–
p1121	Ramp-function generator ramp-down time	–
p1135	OFF3 ramp-down time	–

Permanent-magnet synchronous motors (rotary)

Permanent-magnet synchronous motors are supported that are equipped with a position encoder.
Typical applications include direct drives with torque motors that can operate at low speeds thanks to a high torque. In certain applications, these drives can do away with the need for gear boxes and, in turn, mechanical components that are subject to wear.

Temperature protection can be implemented by means of a temperature sensor (KTY/PTC). A KTY temperature sensor is recommended in order to achieve a high level of torque accuracy.

Warning

As soon as the motor starts rotating, voltage is generated. When work is carried out on the converter, the motor must be properly disconnected If this is not possible, the motor must be secured by means of a holding brake, for example.

Features

- Field weakening up to approx. 1.2 * rated speed (depending on the supply voltage of the converter and the motor data; see also “General conditions”)
- Flying restart
- Vector speed and torque control
- Vector V/f control for diagnostics
- Motor Identification
- Automatic rotary transducer adjustment (comparison with zero position of encoder)
- Speed controller optimization (rotating measurement)
- Thermal protection via temperature sensors (PTC/KTY)

General conditions

- The maximum speed/torque depend on the available converter output voltage and the back EMF of the motor (calculation guideline: EMF must not exceed rated converter voltage)
- Calculating the maximum speed:

  $$n_{max} = V_{nom,AC} * \frac{\sqrt{3} * 30}{k_T * \pi}$$

  Calculating k_T – see “Commissioning”
- For the maximum torque as a function of the terminal voltage and duty cycle, see the motor data sheets/planning guides.
- A motor encoder must be used in operation.
  - All encoders that can be connected to an SMC10 or SMC20 are supported.

Commissioning

The following steps are recommended for commissioning:

- Commissioning Wizard in STARTER

  Motor identification and the “rotating measurement” (p1900) can be activated when the commissioning Wizard is run in STARTER. Encoder adjustment (p1990) is activated automatically together with the motor identification routine.
- Motor identification (standstill measurement (p1910))

  Further information: See Subsection 3.2.11
- Encoder adjustment (p1990)

  Further information: See Subsection 3.2.12

Warning

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

- Rotating measurement (p1960)

  Further information: See Subsection 3.2.11

The following parameters can be entered when the commissioning Wizard is run in STARTER:

Table 3-15 Motor data

Parameters	Description	Note
p0304	Rated motor voltage	If this value is not known, “0” can also be entered. This value enables the stator leakage inductance (p0356, p0357) to be calculated more accurately.
p0305	Rated motor current	–
p0311	Rated motor speed	–
p0314	Motor pole pair number	–
p0316	Motor torque constant	–

If the torque constant k_T is not specified on the type plate or on the data sheet, it can be calculated as follows using the rated motor data or the standstill current I_o and standstill torque M_o):

$$k_T = \frac{M_N}{I_N} = \frac{60\frac{s}{min} * P_N}{2\pi * n_N * I_N} \text{ or}$$

$$k_T = \frac{M_o}{I_o}$$

Table 3-16 Optional data

Parameters	Description	Note
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
p0328	PE spindle, reluctance torque constant	–
p0341	Motor moment of inertia	For speed controller pre-control
p0342	Ratio between the total and motor moment of inertia	–
p0344	Motor weight	For thermal motor model, not relevant for synchronous motors
p0350	Motor stator resistance, cold	–
p0356	Motor stator leakage inductance Lq	–
p0357	Motor stator leakage inductance Ld	–

Table 3-16 Optional data, continued

Parameters	Description	Note
p0640	Current limit	This value is limited to maximum 4 * p0305. This value is defaulted to 1.5 * p0305 during commissioning.
p1080	Minimum speed	–
p1082	Maximum rotational speed	This value can be less than or equal to p0322.
p1120	Ramp-function generator ramp-up time	–
p1121	Ramp-function generator ramp-down time	–
p1135	OFF3 ramp-down time	–

The optional motor data can be entered (if known). Otherwise, it can be estimated on the basis of the type plate data, or by means of motor identification or speed controller optimization.

■

Notes

4 Extended functions

Contents of Chapter “Extended Functions”

- Technology Controller function module
- Extended Monitoring Functions function module
- Simple brake control
- Extended Brake Control function module
- Runtime (operating hours counter)
- Automatic restart function (vector)
- Parallel Connection of Chassis Power Units (Vector) function module
- Friction characteristic technology function
- Motor changeover
- Simulation mode (vector)
- Parking axis and parking encoder
- Ramp-up with partial topologies
- Sinusoidal filter
- Flying restart (vector)

4.1 Technology Controller function module

4.1.1 Features

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

- Liquid level control
- Temperature control
- Dancer position control
- Pressure control
- Flow control
- Simple control without higher-level control
- Tension control

The technology controller has the following properties:

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

4.1.2 Integration

The technology controller function is integrated in the system as follows:

Function diagram overview (see List Manual)

- 7950 Fixed values (r0108.16 = 1)
- 7954 Motorized potentiometer (r0108.16 = 1)
- 7958 Open-loop control (r0108.16 = 1)

Important parameters (see List Manual)

Fixed setpoints

- p2201[0..n] CO: Technology controller, fixed value 1
- ...
- p2215[0..n] CO: Technology controller, fixed value 15
- p2220[0..n] BI: Technology controller fixed value selection bit 0
- p2221[0..n] BI: Technology controller fixed value selection bit 1
- p2222[0..n] BI: Technology controller fixed value selection bit 2
- p2223[0..n] BI: Technology controller fixed value selection bit 3

Motorized potentiometer

- p2230[0..n] Technology controller motorized potentiometer configuration
- p2235[0..n] BI: Technology controller motorized potentiometer, raise setpoint
- p2236[0..n] BI: Technology controller motorized potentiometer, lower setpoint
- p2237[0..n] Technology controller motorized potentiometer maximum value
- p2238[0..n] Technology controller motorized potentiometer minimum value
- p2240[0..n] Technology controller motorized potentiometer start value
- r2245 CO: Technology controller motorized potentiometer setpoint before RFG
- p2247[0..n] Technology controller motorized potentiometer ramp-up time
- p2248[0..n] Technology controller motorized potentiometer ramp-down time
- r2250 CO: Technology controller motorized potentiometer setpoint after RFG

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

4.1.3 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.

4.1.4 Examples

Dancer 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 the 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.

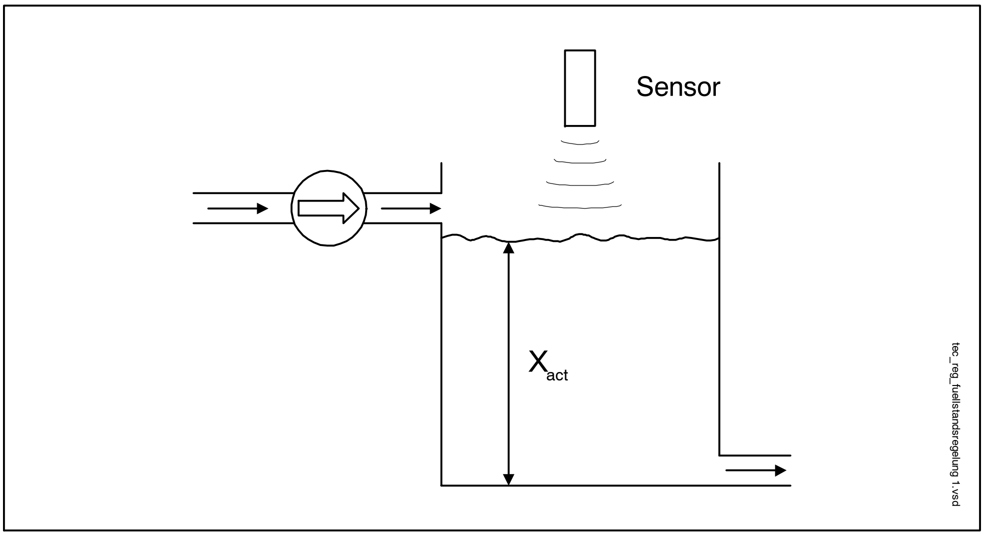


Fig. 4-1 Filling level control application

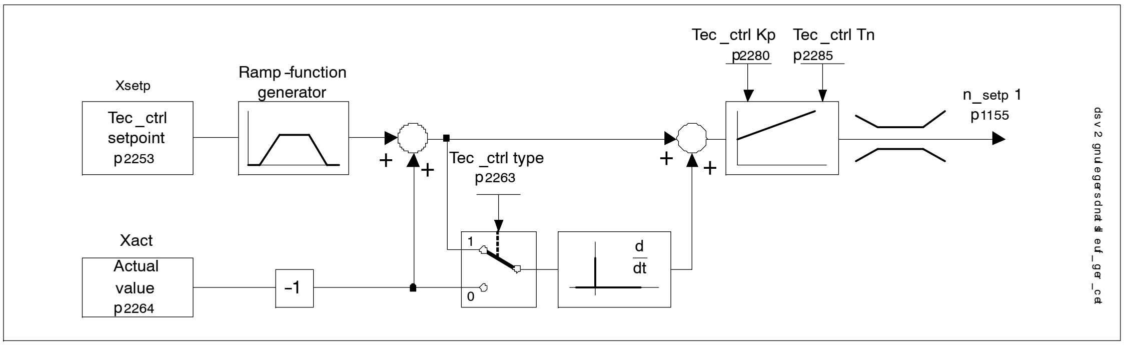


Fig. 4-2 Filling level control: Controller structure

Table 4-1 Key dancer control parameters:

Parameters	Name	Example
p1055	n_setp1 to RFG	p1055 = r2294 Tec_ctrl output_sig [FD 3080]
p2200	BI: Technology controller enable	p2200 = 1 Technology controller enabled
p2253	CI: Technology controller setpoint 1	p2253 = r2224 Fixed setpoint active [FD 7950]
p2263	Technology controller type	p2263 = 1 D component in fault signal [FD 7958]
p2264	CI: Technology controller actual value (X_{ACT})	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

4.1.5 Commissioning

The technology controller is activated when you are working through the commissioning Wizard. Parameter r0108.16 indicates whether the function module has been activated.

4.2 Extended Monitoring Functions function module

4.2.1 Features

This function module offers the following extended monitoring functions:

- Speed setpoint monitoring: |n_setp| <= p2161
- Speed setpoint monitoring: n_setp> 0
- Load monitoring

Description of load monitoring

This function monitors power transmission between the motor and the working machine. Typical applications include V-belts, flat belts, or chains that loop around the belt pulleys or cog wheels for drive and outgoing shafts and transfer the peripheral speeds and forces. Load monitoring can be used here to identify blockages in the working machine and interruptions to the power transmission.
During load monitoring, the current speed/torque curve is compared with the programmed speed/torque curve (p2182 to p2190). If the current value is outside the programmed tolerance bandwidth, a fault or alarm is triggered depending on parameter p2181. The fault or alarm message can be delayed by means of parameter p2192 to prevent false alarms caused by brief transitional states.

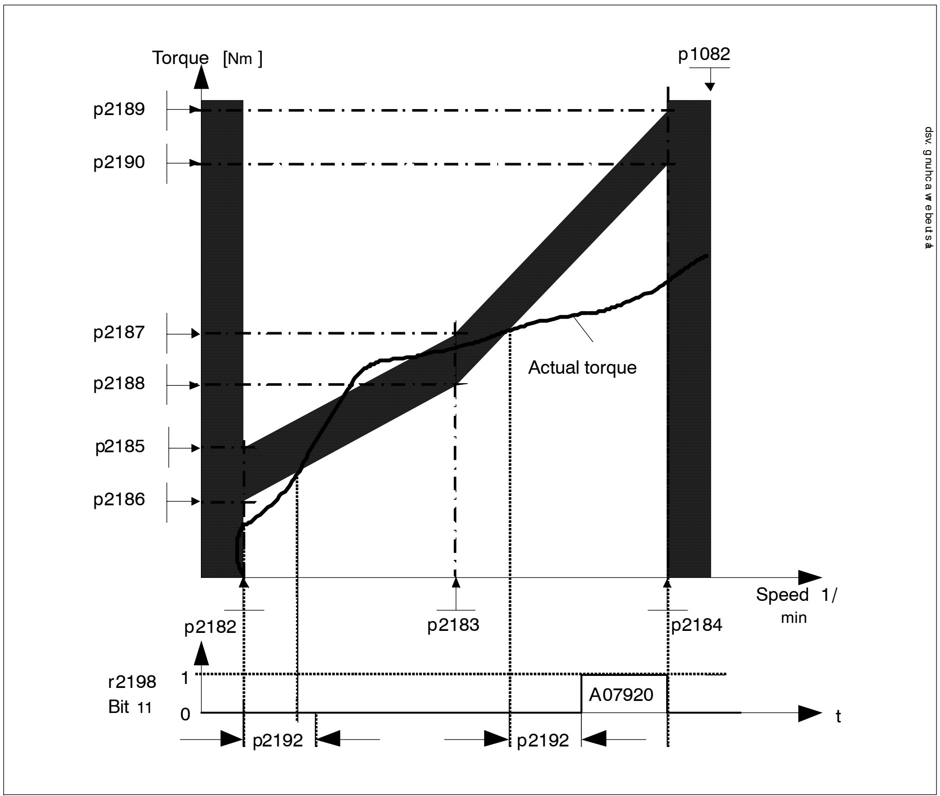


Fig. 4-3 Load monitoring

4.2.2 Integration

The extended monitoring functions are integrated in the system as follows:

Important parameters (see 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 upper
- 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

Function diagram overview (see List Manual)

- 8010 Speed messages
- 8013 Load monitoring

4.2.3 Commissioning

The extended monitoring functions are activated when you are working through the commissioning Wizard. Parameter r0108.17 indicates whether the function module has been activated.

4.3 Simple brake control

4.3.1 Features

- Automatic triggering using execution control
- Zero-speed monitoring
- Forced release of brake (p0855, p1215)
- Brake is closed when 1 signal “Unconditionally close holding brake” (p0858) is issued
- Brake is closed when the “Enable speed controller” (p0856) signal is removed

4.3.2 Integration

The simple brake control function is integrated in the system as follows:

Important parameters (see List Manual)

- r0056.4 Magnetization complete
- r0060 CO: Speed setpoint before the setpoint filter
- r0063 CO: Actual speed smoothed (servo)
- r0063[0] CO: Actual speed unsmoothed (vector)
- r0108.14 Extended braking control
- p0855[C] BI: Unconditionally release holding brake
- p0856 BI: Enable speed controller
- 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 Motor holding brake release time
- p1217 Motor holding brake closing time
- p1226 Zero-speed monitoring speed threshold
- p1227 Zero speed detection monitoring time
- p1228 Zero speed detection delay time

Function diagram overview (see List Manual)

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

4.3.3 Description

Simple brake control is used exclusively for controlling holding brakes. With the holding brake, drives can be secured against undesirable motion when deactivated.

The control command for opening and closing the holding brake is transferred directly to the Motor Module via DRIVE-CLiQ by the Control Unit that logically links and monitors the signals with the system-internal processes.

The Motor Module then performs the action and activates the output for the holding brake. Details of execution control are shown in the List Manual (FD 2701). Parameter p1215 can be used to configure operation of the holding brake.

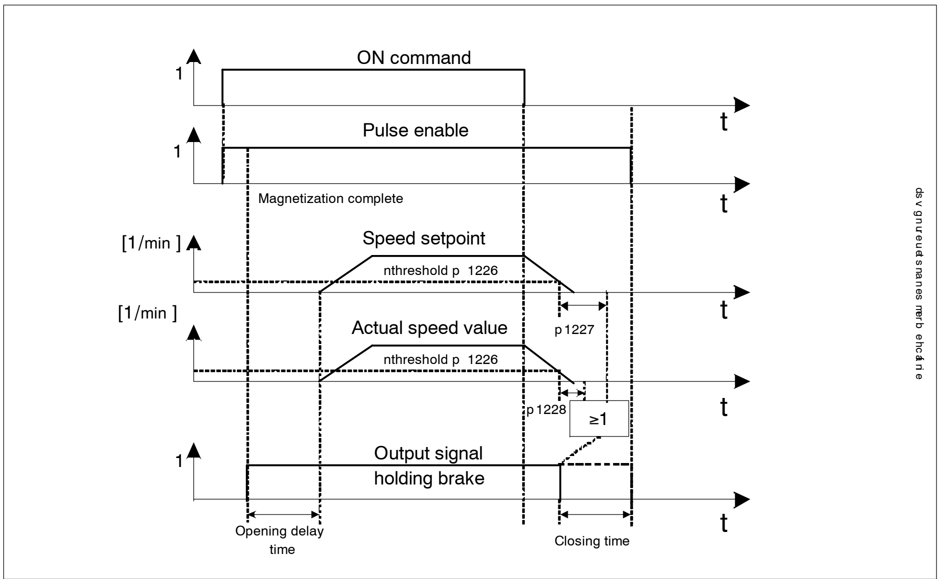


Fig. 4-4 Function chart for simple brake control

Warning

It is not permitted to use the holding brake as a working brake.

When holding brakes are used, the user is responsible for observing and complying with the specific technological and machine-specific regulations and standards to maintain the protection and safety of personnel and machinery.

The risks that can result from vertical axes, for example, must also be evaluated.

4.3.4 Commissioning

Simple brake control is activated automatically (p1215 = 1) if the component has an internal brake control function and a connected brake has been found.
If the component does not have an internal brake control function, control can be activated via parameter (p1215 = 3)

Caution

If p1215 = 0 (no brake available) is set when a brake is present, the drive runs with an applied brake. The can cause damage to the brake.

4.4 Extended Brake Control function module

4.4.1 Features

The extended brake control function has the following characteristics:

- Forced release of brake (p0855, p1215)
- Brake is closed when 1 signal “Unconditionally close holding brake” (p0858) is issued
- Binector inputs for opening and closing the brake (p1218, p1219)
- Connector input for threshold value for opening and closing the brake (p1220)
- OR/AND module each with two inputs (p1279, p1229.10, p1229.11)
- Holding and operational brakes can be activated
- Function for monitoring brake feedback signals (r1229.4, r1229.5)
- Configurable responses (A7931, A7932)
- Brake is closed when the “Enable speed controller” (p0856) signal is removed

4.4.2 Integration

The extended brake control function is integrated in the system as follows:

Important parameters (see List Manual)

- r0108.14 Extended braking control
- r0899 CO/BO: Status word sequential control

Zero-speed monitoring

- r0060 CO: Speed setpoint before the setpoint filter
- r0063 CO: Actual speed smoothed (servo)
- r0063[0] CO: Actual speed unsmoothed (vector)
- p1225 CI: Standstill detection, threshold value
- p1226 Zero-speed monitoring speed threshold
- 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 zero speed detection bypass

Release/apply brake

- p0855 BI: Unconditionally release holding brake
- p0858 BI:Unconditionally close holding brake
- p1216 Motor holding brake release time
- p1217 Motor holding brake closing time
- p1218[0..1] BI: Open motor holding brake
- p1219[0..3] BI: Immediately close motor holding brake
- p1220 CI: Motor holding brake, threshold value, brake open
- p1221 Open motor holding brake, threshold
- p1277 Motor holding brake, braking threshold delay exceeded

Free modules

- p1279 BI: Motor holding brake, OR/AND logic operation

Brake monitoring

- 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

Function diagram overview (see List Manual)

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

Control and status messages for extended brake control

Table 4-2 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 4-3 Extended brake control status message

Signal name	Parameters	Brake status word
Command, open brake (continuous signal)	r1229.1	B_ZSW.1
Pulse enable from brake control	r1229.3	B_ZSW.3
Brake does not open	r1229.4	B_ZSW.4
Brake does not close	r1229.5	B_ZSW.5
Brake threshold exceeded	r1229.6	B_ZSW.6
Brake threshold fallen below	r1229.7	B_ZSW.7
Brake monitoring time expired	r1229.8	B_ZSW.8
Pulse or speed controller 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

4.4.3 Description

Extended brake control enables complex brake controls, e.g. for motor holding brakes and operational brakes.

The brake is controlled as follows (the sequence reflects the priority):

- Via parameter p1215
- Via binector parameters p1219[0..3] and p0855
- Via zero speed detection
- Via a connector interconnection threshold value

4.4.4 Examples

Starting against applied brake

When the device is switched on, the setpoint is enabled immediately (if other enable signals are issued), even if the brake has not yet been released (p1152 = 1). The factory setting p1152 = r0899.15 must be separated here. The drive first generates torque against the applied brake. The brake is not released until the motor torque or motor current (p1220) has exceeded braking threshold 1 (p1221).

This configuration is used, for example, when the drive is connected to a belt that is under tension (loop accumulator in the steel industry).

Emergency brake

If emergency braking is required, electrical and mechanical braking is to take place simultaneously in the example. This can be achieved if OFF3 is used as a tripping signal for emergency braking:
p1219[0] = r0898.2 (OFF3 to “apply brake immediately”).

This is often used, for example, in calendar stacks, cutting tools, running gears, and presses.

4.4.5 Commissioning

Extended brake control is activated when you are working through the commissioning Wizard. Parameter r0108.14 indicates whether the function module has been activated.

If no changes have been made to the initial setting, this brake control behaves as the simple brake control.

Brake control is activated automatically (p1215 = 1) if the component has an internal brake control function and a connected brake has been found.
If the component does not have an internal brake control function, control can be activated via parameter (p1215 = 3).

Caution

If p1215 = 0 (no brake available) is set when a brake is present, the drive runs with an applied brake. The can cause damage to the brake.

4.5 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.

The count value is saved when the drive unit is powered down. When 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 is reset to 0 after 49 days.

Current motor operating time

The motor operating time counter p0650 (drive) continues when the pulses are enabled When the pulse enable is withdrawn, the counter is stopped and the value saved.
The value can only be stored with a CU320 with order number 6SL3040-....-0AA1 and version C or higher.
If p0651 = 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.

Operating hours counter for the fan

The operating hours of the fan in the power section are displayed in p0251 (drive). The number of hours operated can only be reset to 0 in this parameter (e.g. after the 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 with p0252 = 0.

4.6 Automatic restart function (vector)

Description

The automatic restart function automatically restarts the power unit after an undervoltage or a power failure. The alarms present are acknowledged automatically and the drive is restarted automatically.

The automatic restart function can also be used to acknowledge any faults and restart the device.

For brief line supply failures, the motor shaft can still be rotating when restarting. In order to restart while the motor shaft is still rotating, the “flying restart” function should be activated using p1200.

Caution

The automatic restart function only operates in vector mode. The Line Modules (apart from Smart Line Modules 5 kW and 10 kW) are not switched on automatically when the power is restored.

Warning

If p1210 is set to > 1, the motor can be restarted automatically without the need to issue the ON command.

In the event of prolonged power failures and when the automatic restart function is activated (p1210 > 1), the drive may have been at a standstill for a long time and mistakenly considered to have been switched off.

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

Mode for automatic restart function

Table 4-4 Mode for automatic restart function

p1210	Mode	Meaning
0	Disable automatic restart mode	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 once the faults have been successfully acknowledged, these are acknowledged automatically too A time of at least p1212 + 1s must elapse between the fault being successfully acknowledged and a new fault occurring when the signal ON/OFF1 (control word 1, bit 0) is set to HIGH. If the ON/OFF1 signal is set to LOW level, the time between the fault being successfully acknowledged and a new fault occurring must be at least 1s. When p1210 = 1, fault F07320 is not generated if the acknowledgement attempt was not successful due to faults that occur too frequently.
4	Automatic restart after line supply failure, no additional start attempts	When p1210 = 4, an automatic restart is only carried out if fault F30003 also occurs on the Motor Module.
6	Restart after any fault with additional start attempts	When p1210 = 6, an automatic restart is carried out after any fault. The number of further restart attempts is set using p1211.

Attempts to start (p1211) and waiting time (p1212)

p1211 is used to specify the number of start attempts. The number is decremented internally after each unsuccessful start attempt. Fault F07320 is output if the number of parameterized start attempts has been reached.

When 1211 = x, x + 1 start attempts are made.

Note

A start attempt begins once the fault that is present has been acknowledged.

The faults are automatically acknowledged after half of the waiting time has expired.

After a successful start attempt, the waiting time and the number of start attempts are reset to the start value.

Commissioning

1. Activate function
   - Automatic restart: set mode (p1210)
   - Flying restart: Activate function (p1200)
2. Set start attempts (p1211)
3. Set waiting times (p1212, p1213)
4. Check function

Automatic restart status signals

The individual status signals for the automatic restart function are available in r1214 (word and bit serial) for display and interconnection purposes.

A detailed description of the status signals can be found in:

References: /LH1/ SINAMICS S120 List Manual

Important parameters (see List Manual)

- p1210 Automatic restart mode
- p1211 Automatic restart, start attempts
- p1212 Automatic restart, delay time start attempts
- p1213 Automatic restart, monitoring time line supply return
- r1214 CO/BO: Automatic restart, status

4.7 Parallel Connection of Chassis Power Units (Vector) function module

4.7.1 Features

SINAMICS supports the parallel connection of power units on the motor and infeed side to extend the power spectrum of SINAMICS.

The main characteristics of parallel connection are:

- Parallel connection of two power units to a motor
  - With parallel connection of two power units on one motor with separate winding systems (p7003 = 1)

    Note:

    Motors with separate winding systems are recommended.
  - Parallel connection of several power units to one motor (p7003 = 0)

Caution

The minimum line lengths must be observed. If the minimum line length cannot be observed, a motor reactor must be used.

- Parallel connection of up to four power units on the infeed side (closed/open loop)
- A CU320 can implement a maximum of one parallel connection on the mains connection and one parallel connection on the infeed side.
- Simple commissioning, because no special parameterization is necessary.
- For the parallel connection, Line Modules **and** Motor Modules must always be connected parallel.
- The power units connected in parallel must be connected to the same Control Unit.
- Edge modulation is possible
- p7000ff can be used for diagnostic purposes for individual power units

4.7.2 Integration

Important parameters (see List Manual)

- p0120 Power module data set (PDS) number
- p0121 Power module component number
- p0602 Power module number, temperature sensor for parallel circuit configuration
- r7000 Parallel circuit configuration, number of active power modules
- r7001 Parallel circuit configuration, enable power modules
- r7002 Parallel circuit configuration, status power modules
- p7003 Parallel circuit, winding system
- p7010 Parallel circuit configuration, current dissymmetry alarm threshold
- p7011 Parallel circuit configuration, DC link voltage dissymmetry, alarm threshold
- ...
- p7322 Parallel circuit configuration, VSM line filter capacitance, phase W

4.7.3 Description

Parallel switching of power units is a simple means of extending the power spectrum of drives beyond the power of the individual power units.

To prevent large compensating currents between the power units, the following basic prerequisites must be observed during configuration:

- Motor Module
  - The motor supply cables must be the same length.
  - When motors with a single winding systems are used, supply cables with a minimum length or a motor reactor must be used.
  - Same power units with regard to the order number, EPROM data (r0127) and firmware version (r0128)
  - Connection to the same DC link
- Infeeds
  - Same power units with regard to the order number, EPROM data (r0127) and firmware version (r0128)
  - For Active Interface Module: Same order number and firmware version for all Voltage Sensing Modules (VSM)
  - A separate line reactor for each Basic Line Module. The parallel connection must be in front of the choke.
  - The DC links must be connected.

4.7.4 Sample applications

Parallel connection of two Motor Modules to one motor with a dual winding system

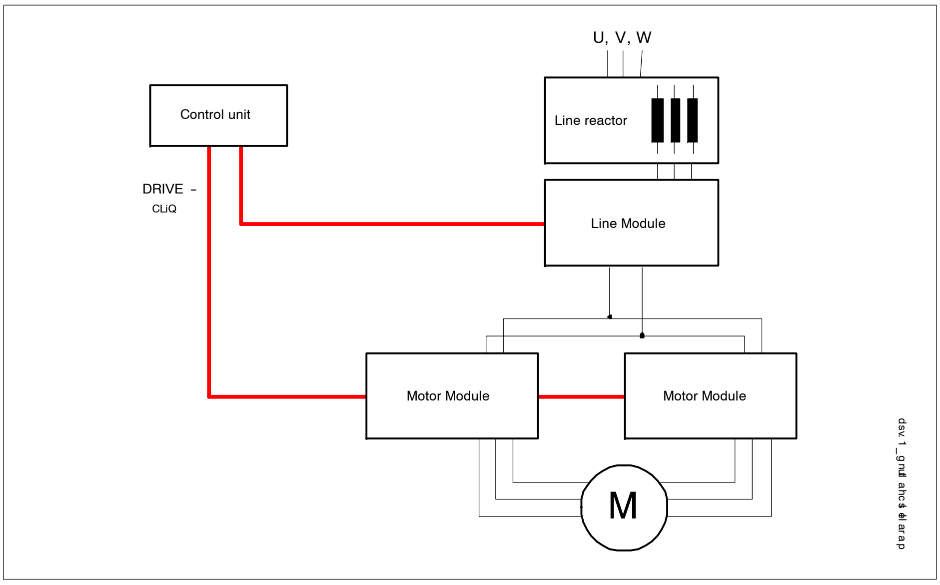


Fig. 4-5 Example 1: Parallel connection

Parallel connection of two Active Line Modules and two Motor Modules to a motor with a single winding system

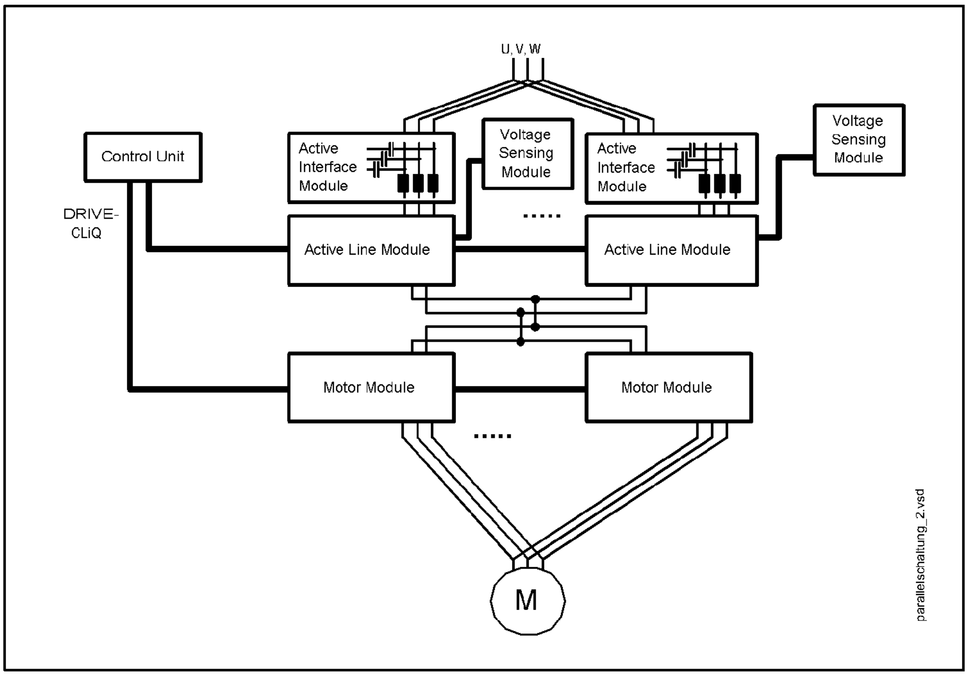


Fig. 4-6 Example 2: Parallel connection

4.7.5 Commissioning

During commissioning, power units connected in parallel are treated like a power unit on the line or motor side. With parallel connection, the parameter display for the actual values changes only slightly. Instead, suitable “total values” are derived from the individual values of the power units.

In STARTER, the parallel connection (Line Modules and Motor Modules) are activated via the Wizard. You can also select parallel connection when choosing the power unit. You then have to specify the number of power units to be connected in parallel.

4.8 Friction characteristic technology function

Description

The friction characteristic is used to compensate for the frictional torque of the motor and driven load. A friction characteristic allows the speed controller to be precontrolled and improves the control behavior.

10 points along the characteristic are used for the friction characteristic. The coordinates of every point along the characteristic are defined by a speed parameter (p382x) and a torque parameter (p383x) (point 1 = p3820 and p3830).

Features

- 10 interpolation points are available for mapping the friction characteristic curve.
- An automatic function supports the friction characteristic plot.
- A connector output (r3841) can be interconnected as friction torque (p1569).
- The friction characteristic can be activated and de-activated (p3842)

Integration

Important parameters (see List Manual)

- p3820 Friction characteristic curve value n0
- ...
- p3839 Friction characteristic curve value M9
- r3840 CO/BO: Friction characteristic, status
- r3841 CO: Friction characteristic, output
- p3842 Friction characteristic curve activation
- p3845 Friction characteristic curve record activation

Function diagram (see List Manual)

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

Commissioning using parameters

Speeds for making measurements as a function of the maximum speed p1082 are pre-assigned in p382x when commissioning the drive system for the first time. These can be appropriately changed corresponding to the actual requirements.

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 will be recorded in both directions of rotation. The result of the positive and negative measurement is averaged and entered into 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 plotting the friction characteristic, the drive causes the motor to move – the maximum motor speed can be reached.

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 commissioned via the screen under “Functions”.

4.9 Motor changeover

4.9.1 Description

Motor changeover is, for example, used for:

- Changing over between different motors
- Changing-over between different windings in a motor (e.g. star-delta changeover)
- Motor data adaptation

If several motors are operated alternately on a Motor Module, a matching number of drive data sets must be created.

Notice

Encoders cannot be switched over when motors are switched over.

Note

In order to switchover to a rotating motor, the “flying restart” function must be activated (p1200).

4.9.2 Integration

The motor changeover function is integrated in the system as follows:

Function diagram overview (see List Manual)

- 8565 Drive data sets (DDS)
- 8575 Motor data sets (MDS)

Overview of key parameters (see List Manual)

- r0051 Drive data set DDS effective
- p0130 Motor data sets (MDS) number
- p0180 Drive data sets (DDS) number
- p0186 Motor data sets (MDS) number
- 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 signal
- p0830 CO/BO: Motor changeover, status
- p0831 BI: Motor changeover, contactor feedback signal
- p0833 Motor changeover, configuration

4.9.3 Example of changing over between four motors

Requirements:

- The drive has been commissioned for the first time.
- 4 motor data sets (MDS), p0130 = 4
- 4 drive data sets (DDS), p0180 = 4
- 4 digital outputs to control the auxiliary contactors
- 4 digital inputs to monitor the auxiliary contactors
- 2 digital inputs to select the data set
- 4 auxiliary contactors with auxiliary switches (1 NO contact)
- 4 motor contactors with positively-driven auxiliary switches (3 NC contact, 1NO contact)
- 4 motors, 1 Control Unit, 1 infeed and 1 Motor Module

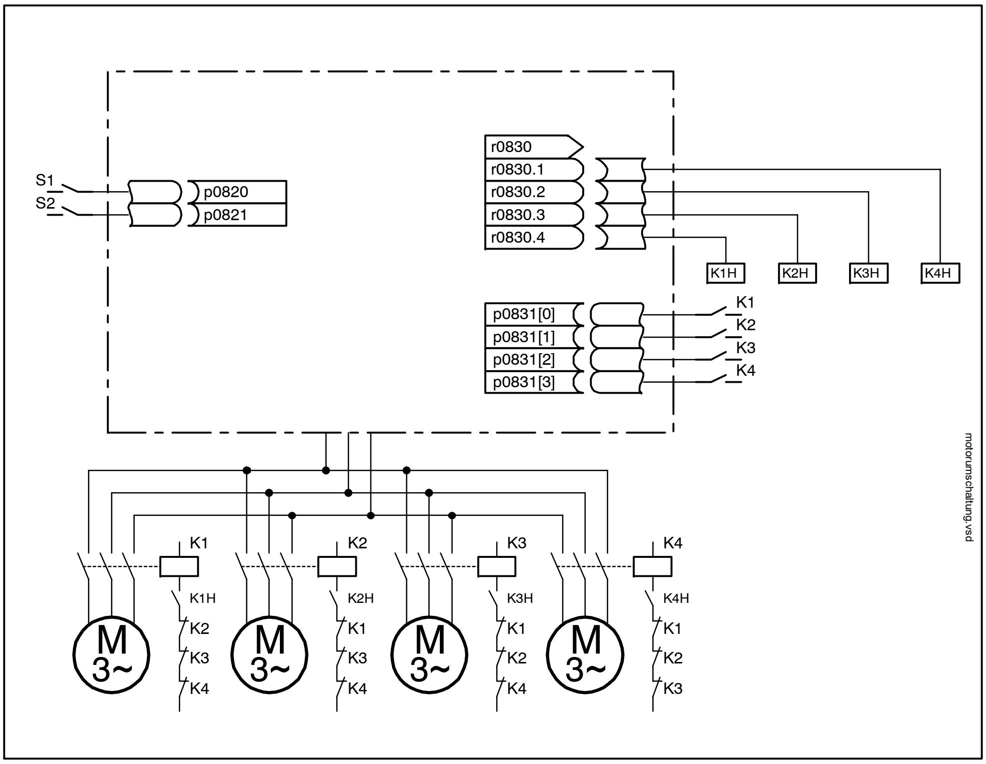


Fig. 4-7 Example of motor changeover

Table 4-5 Settings for the example

Parameters	Settings	Note
p0130	4	Configure 4 MDS
p0180	4	Configure 4 DDS
p0186[0..3]	0, 1, 2, 3	The MDS are assigned the DDS.
p0820, p0821	Digital inputs, DDS selection	The digital inputs to change over the motor are selected via DDS selection. Binary coding is used (p0820 = bit 0 etc.).
p0822 to p0824	0	
p0826[0..3]	1, 2, 3, 4	Different numbers indicate a different thermal model
p0827[0..3]	1, 2, 3, 4	The bits from p0830 are assigned to the MDS. If p0827[0] = 1, for example, bit p0830.1 is set via DDS0 when MDS0 is selected.
p0830.1 to p0830.4	Digital outputs, auxiliary contactors	The digital outputs for the auxiliary contactors are assigned bits.
p0831[0..3]	Digital inputs, auxiliary switches	The digital inputs for the feedback signal of the motor contactors are assigned.
p0833[0..1]	0, 0	The drive controls the contactors and the pulse cancellation.

Procedure for motor data set changeover

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. Cancel pulses:
   The pulses are cancelled after a new drive data set is selected using p0820 to p0824.
3. Open motor contactor:
   Motor contactor 1 is opened r0830 = 0 and the status bit “Motor changeover active” (r0835.0) is set.
4. Changeover drive data set:
   The requested data set is activated (p0051 = requested data set).
5. Energize motor contactor:
   After the feedback signal (motor contactor opened) for motor contactor 1 has been received, the appropriate bit of r0830 is set and motor contactor 2 is energized.
6. Enable pulses:
   After the feedback signal (motor contactor closed) for motor contactor 2 has been received, the bit “motor changeover active” (r0835.0) is reset and the pulses are enabled. The motor has been changed over.

4.9.4 Example of a star / delta changeover

Requirements:

- The drive has been commissioned for the first time.
- 2 motor data sets (MDS), p0130 = 2
- 2 drive data sets (DDS), p0180 = 2
- 2 digital outputs to control the auxiliary contactors
- 2 digital inputs to monitor the auxiliary contactors
- 1 free speed monitoring (p2155)
- 2 auxiliary contactors with auxiliary switches (1 NO contact)
- 2 motor contactors with positively-driven auxiliary switches (1 NC contact, 1NO contact)
- 4 motors, 1 Control Unit, 1 infeed and 1 Motor Module

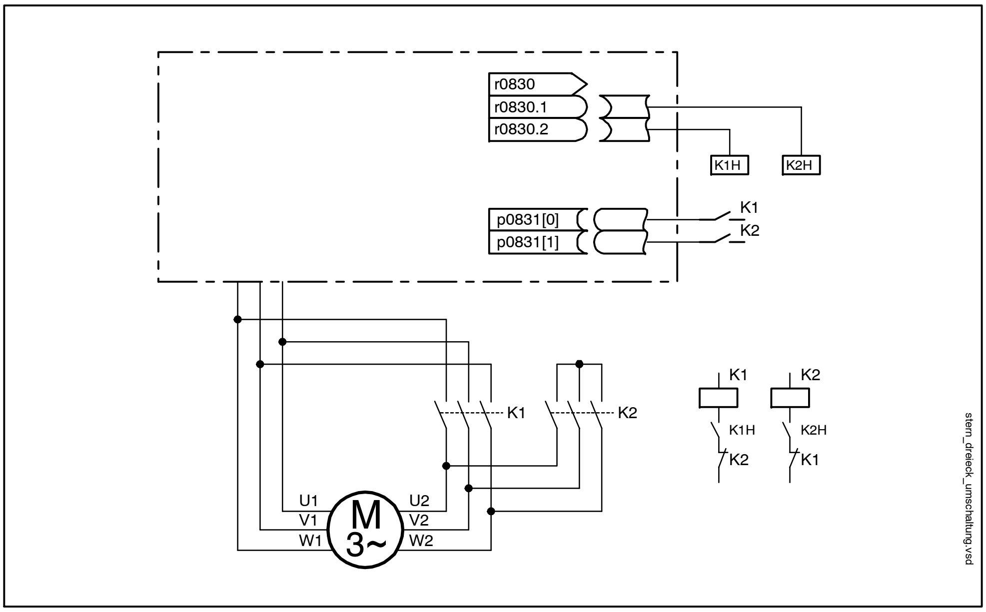


Fig. 4-8 Example of star / delta changeover

Table 4-6 Settings for the example

Parameters	Settings	Note
p0130	2	Configure 2 MDS
p0180	2	Configure 2 DDS
p0186[0..1]	0, 1	The MDS are assigned the DDS.
p0820	p2197.2	Change over to the delta circuit configuration after the speed in p2155 has been exceeded.
p0821 to p0824	0	
p0826[0.0.1]	0; 0	The same numbers indicate the same thermal model.
p0827[0..1]	1, 2	The bits from p0830 are assigned to the MDS. If p0827[0] = 1, for example, bit p0830.1 is set via DDS0 when MDS0 is selected.
p0830.1 and p0830.2	Digital outputs, auxiliary contactors	The digital outputs for the auxiliary contactors are assigned bits.
p0831[0..1]	Digital inputs, auxiliary switches	The digital inputs for the feedback signal of the motor contactors are assigned.
p0833[0..1]	0, 0	The drive controls the contactors and the pulse cancellation.
p2155	Changeover speed	Sets the speed at which the delta circuit configuration should be selected.

Star / delta changeover sequence

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. Cancel pulses:
   After a new drive data set has been selected using p0820, the pulses are cancelled.
3. Open motor contactor:
   Motor contactor 1 is opened r0830 = 0 and the status bit “Motor data set changeover active” (r0835.0) is set.
4. Changeover drive data set:
   The requested data set is activated (p0051 = requested data set).
5. Energize motor contactor:
   After the feedback signal (motor contactor opened) for motor contactor 1 has been received, the appropriate bit of r0830 is set and motor contactor 2 is energized.

6. Enable pulses:
   After the feedback signal (motor contactor closed) for motor contactor 2 has been received, the bit “motor changeover active” (r0835.0) is reset and the pulses are enabled. The changeover has been completed.

4.10 Simulation mode (vector)

4.10.1 Description

The simulation function is predominantly used to simulate the drive without a motor being connected and without a 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 lies above this threshold, the simulation mode is reset, and a fault message F07826 is issued.

Simulation mode enables communication with a higher-level automation system to be tested. If the drive is also to return actual values, then it must be ensured that during simulation operation, sensorless operation (V/f) should be selected. This means that large parts of the SINAMICS software – such as setpoint channel, sequence control, communications, technology function, etc. – can be tested in advance without a motor.

Another application is to test the correct functioning of the Power Module. Especially for drive units with higher power ratings 754 kW (690 V) and 110 kW (400 V), after repairs, it is necessary to test the gating of the power semiconductors. This is done by injecting a low DC voltage as DC link voltage (e.g. 12 V). The drive unit is then powered-up and the pulses enabled. It must be possible to run through all of the pulse patterns of the gating unit software.

This means that the software must allow the pulses to be switched-in and various frequencies approached. If a speed encoder is not being used, this is generally implemented using V/f control or sensorless closed-loop speed control.

Note

Simulation mode cannot be activated without a power unit. DRIVE-CLiQ must be used to connect a power unit.

4.10.2 Features

- Automatic deactivation with a DC link voltage greater than 40 V (measurement tolerance $\pm$16 V) with fault message F07826 and immediate pulse inhibit (OFF2)
- Can be activated via parameter p1272
- Line contactor control can be deactivated in simulation mode
- Power semiconductors can be gated at low DC link voltages and without a motor (for test purposes)
- Power unit and closed-loop control can be simulated without a motor being connected

4.10.3 Commissioning

Simulation mode can be activated using p1272 = 1; the following pre-requisites must be fulfilled:

- The drive unit must have been commissioned for the first time (default: Standard induction motors).
- The DC link voltage must be lower than 40 V (observe the tolerance of the DC link sensing).

4.11 Parking axis and parking encoder

4.11.1 Description

The parking function is used in two ways:

- Parking encoder
  - Monitoring of a certain encoder is suppressed.
  - The encoder is prepared for the “removed encoder” state.
- Parking axis
  - Monitoring of all encoders and Motor Modules assigned to the “Motor control” application of a drive are suppressed.
  - All encoders assigned to the “Motor control” application of a drive are prepared for the “removed encoder” state.
  - The Motor Module assigned to the “Motor control” application of a drive is prepared for the “removed Motor Module” state.

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 STW1.0/OFF1)
- The monitoring functions for the power section remain active (r0126 = 1).

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 encoder control/status words of the cyclic telegram (STW2.7 und ZSW2.7) or via parameters p0897 and r0896.0.
- The drive must be brought to a standstill by the higher-level control system (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).

4.11.2 Examples of parking axis and parking encoder

Example of parking axis

In the following example, an axis is parked. To ensure that 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.

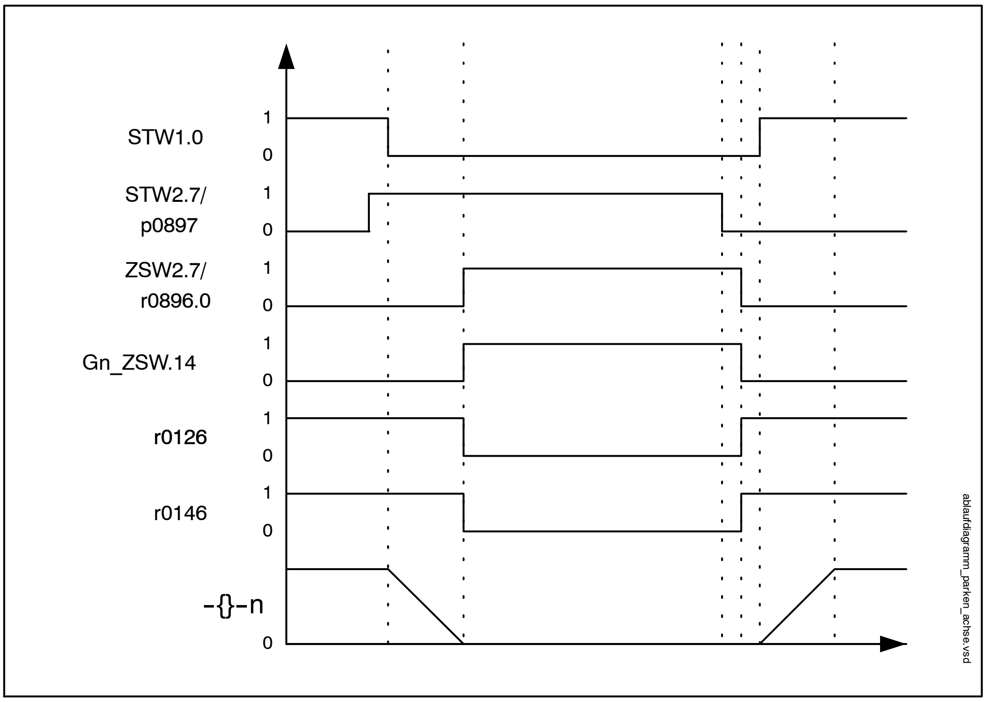


Fig. 4-9 Function chart for parking axis

Example of parking encoder

In the following example, a motor encoder is parked. To ensure that motor encoder parking is effective, the drive must be brought to a standstill (e.g. via STW1.0 (OFF1).

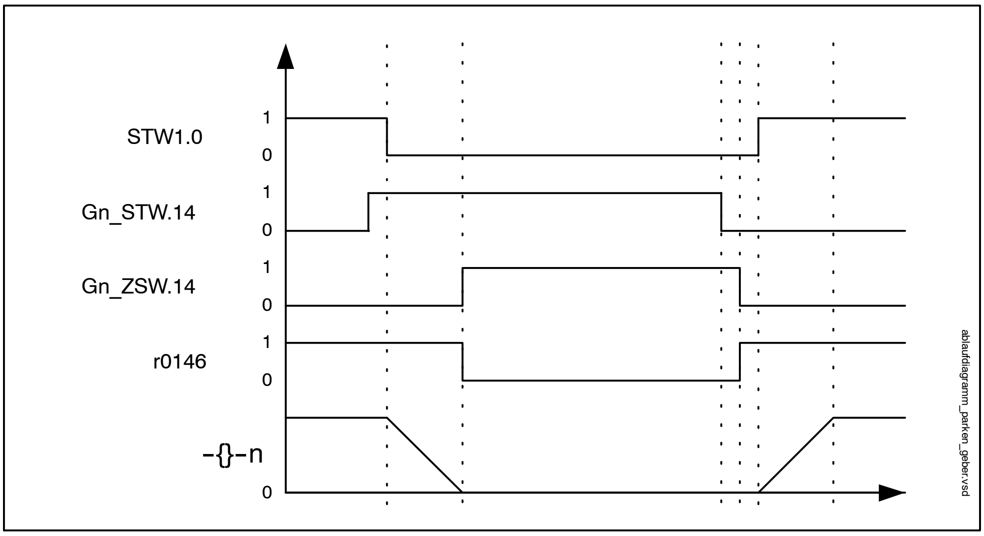


Fig. 4-10 Function chart for parking encoder

4.11.3 Integration

The “Parking axis” and “Parking encoder” functions are integrated in the system as follows:

Overview of key parameters (see 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
- p0897 BI: Parking axis selection

4.12 Ramp-up with partial topologies

4.12.1 Description

Ramp-up with partial topologies is used as follows:

- Monitoring of all components assigned to a drive object (DO) is suppressed.
- All components assigned to a drive object are prepared for the “removed component” state.

Example of ramp-up with partial topologies

The starting point here is a device that has already been commissioned with a complete actual topology:

- A drive object “Drive 1” must be replaced.
- Spare parts are not available and must be ordered.
- Drive object “Infeed 1” has BiCo connections as a sink to “Drive 1”.
- The remaining drive objects must continue running.
- After POWER OFF: DO3 is removed and the wiring modified.

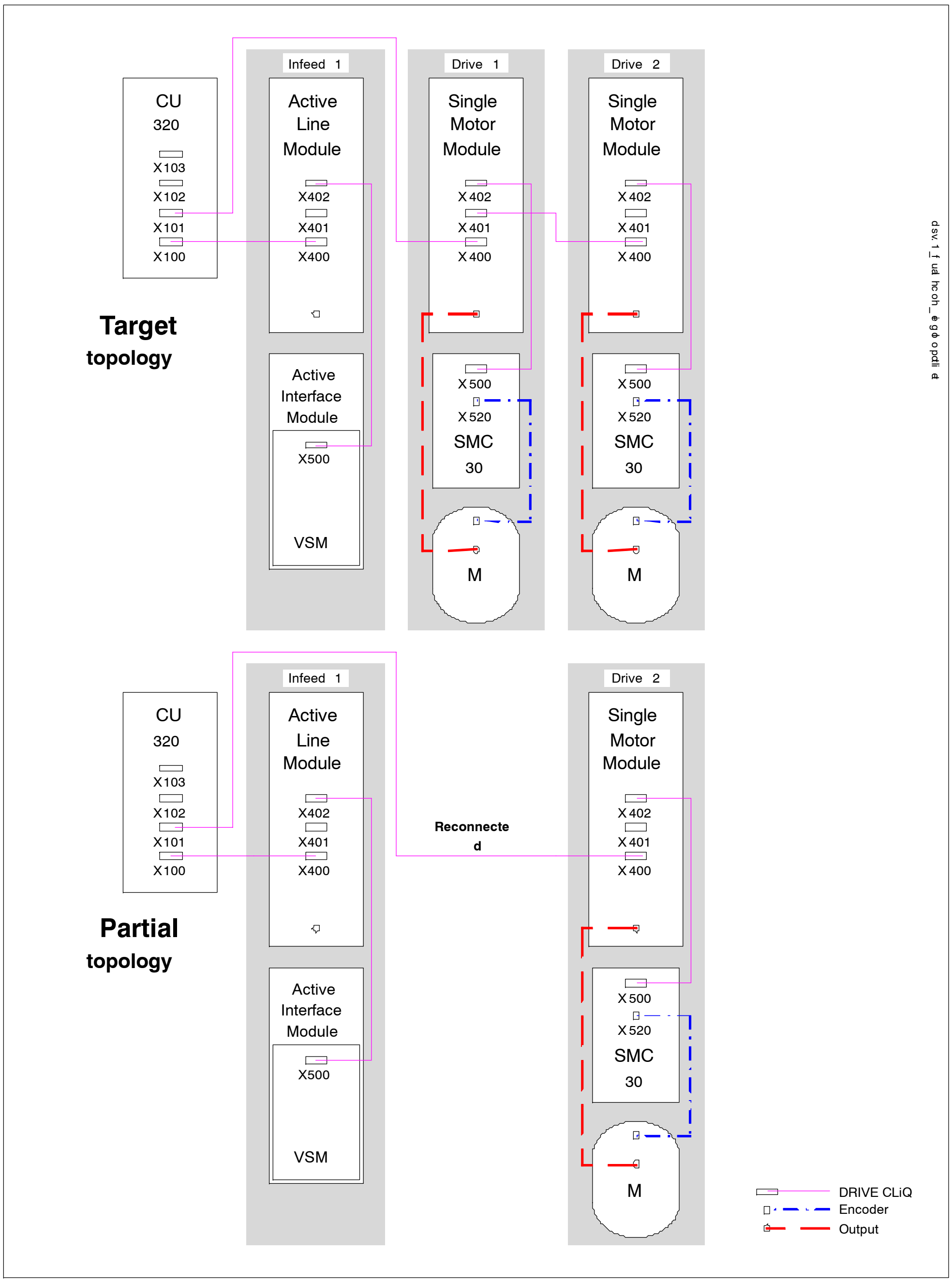


Fig. 4-11 Ramp-up with partial topology

Procedure after POWER ON with partial topology

- "Drive 1" is flagged as "not operational".
- Alarm A01315 for "Drive 1" is issued:
  "Drive object not operational: activated components missing"
- Alarm A01507 for "Infeed 1" is issued:
  "BiCo: Connections to non-operational or inactive objects"
- Note the open BiCo connections:
  p9495 ("Infeed 1") = 1 (A01507 is reset)
- Deactivate DO3: p0105 ("Drive 1") = 0 (A01315 is reset)
- "Copy RAM to ROM" must be carried out via STARTER.

Spare part for "Drive 1" is available and is installed and wired after POWER OFF. Procedure after POWER ON:

- The new serial number of "Drive 1" is copied to the target topology.
- Alarm A01316 for "Drive 1" is issued:
  "Drive object inactive and operational again"
- Alarm A01318 for "Infeed 1" is issued:
  "BiCo: Open connections exist"
- Activate "Drive 1": p0105 ("Drive 1") = 1 (A01316 is reset)
- Establish the old BICO connections:
  p9496 ("Infeed 1") = 1 (A01318 is deleted)
- "Copy RAM to ROM" must be carried out via STARTER.

Integration

The ramp-up with partial topologies function is integrated in the system as follows:

- 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 Reestablish BICO to drive objects that are now activated
- r9498[0 ... 29] BICO BI/CI parameter to deactivated drive objects
- r9499[0 ... 29] BICO BO/CO parameter to deactivated drive objects

4.13 Sinusoidal filter

Description

The sinusoidal filter limits the rate of rise of voltage and the capacitive charge/ discharge currents which usually occur with inverter operation. It also prevents additional noise caused by the pulse frequency. The service life of the motor is the same as that with direct line operation.

Caution

If a sinusoidal filter is connected to the converter, the converter must be activated during commissioning to prevent the filter from being destroyed.

Usage Restrictions for Sinusoidal Filters

The following restrictions must be taken into account when a sinusoidal filter is used:

- The output frequency is limited to 150 Hz.
- The modulation type is permanently set to space vector modulation without overmodulation. This reduces the maximum output voltage to approx. 90% of the rated output voltage.
- Maximum permissible motor cable lengths:
  - Unshielded cables: max. 150 m
  - Shielded cables: max. 100 m
- Other restrictions: Refer to the Equipment Manual

Note

If a filter cannot be parameterized (p0230 not set to 3), this means that a filter has not been provided for the cabinet unit. In this case, the cabinet unit must not be operated with a sinusoidal filter.

Table 4-7 Parameter settings for sinusoidal filters

Order No.	Name	Setting
p0233	Power module motor reactor	Filter inductance
p0234	Power module sinusoidal filter capacitance	Filter capacitance
p0290	Power module 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

4.14 Flying restart (vector)

Description

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

The flying restart function should be activated via p1200 for an overrunning load. This prevents sudden loads throughout the 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 encoder” mode, a search is first of all made for the current speed.

When the converter switches to the running motor, magnetization (p0346) must first be carried out for an induction motor.

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.

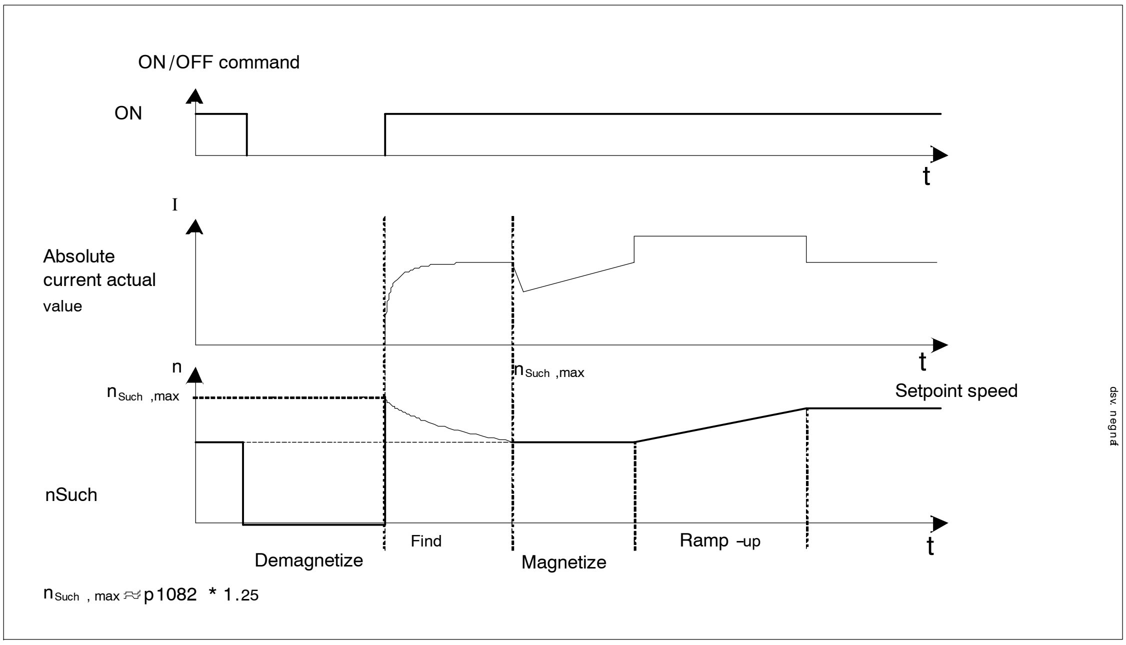


Fig. 4-12 Flying restart

Warning

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

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

Note

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

Overview of key parameters (see List Manual)

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

■

Basic information about the drive system 5

Content of chapter "Basic information about the drive system"

5.1 Parameters

Parameter types

The following adjustable and visualization parameters are available:

- Adjustable parameters (read/write)

  These parameters have a direct impact on the behavior of a function.

  Example: Ramp-up and ramp-down time of a ramp-function generator

- Visualization parameters (read only)

  These parameters are used to display internal variables.

  Example: Current motor current

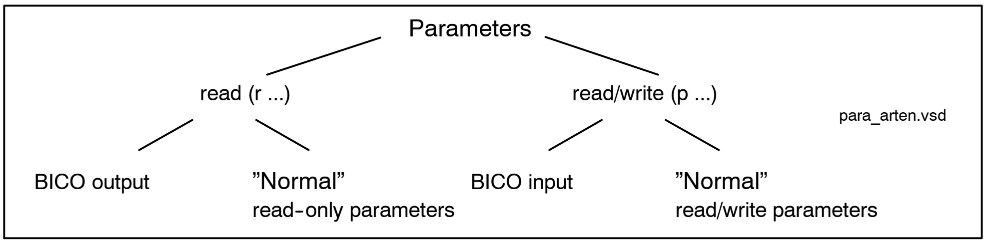


Fig. 5-1 Parameter types

All these drive parameters can be read and changed via PROFIBUS using the mechanisms defined in the PROFIdrive profile.

Parameter categories

The parameters for the individual drive objects (see Section 5.3) are categorized according to data sets as follows (see Section 5.2):

- 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 (see Section 5.2)

    By parameterizing several command data sets and switching between them, the drive can be operated with different pre-configured signal sources.

  - DDS: drive data set

    The drive data set contains the parameters for switching between different drive control configurations.

  The CDS and DDS can be switched over during normal operation. Further types of data set also exist, however these can only be activated indirectly by means of a DDS switchover.

- EDS Encoder data set
- MDS Motor data set

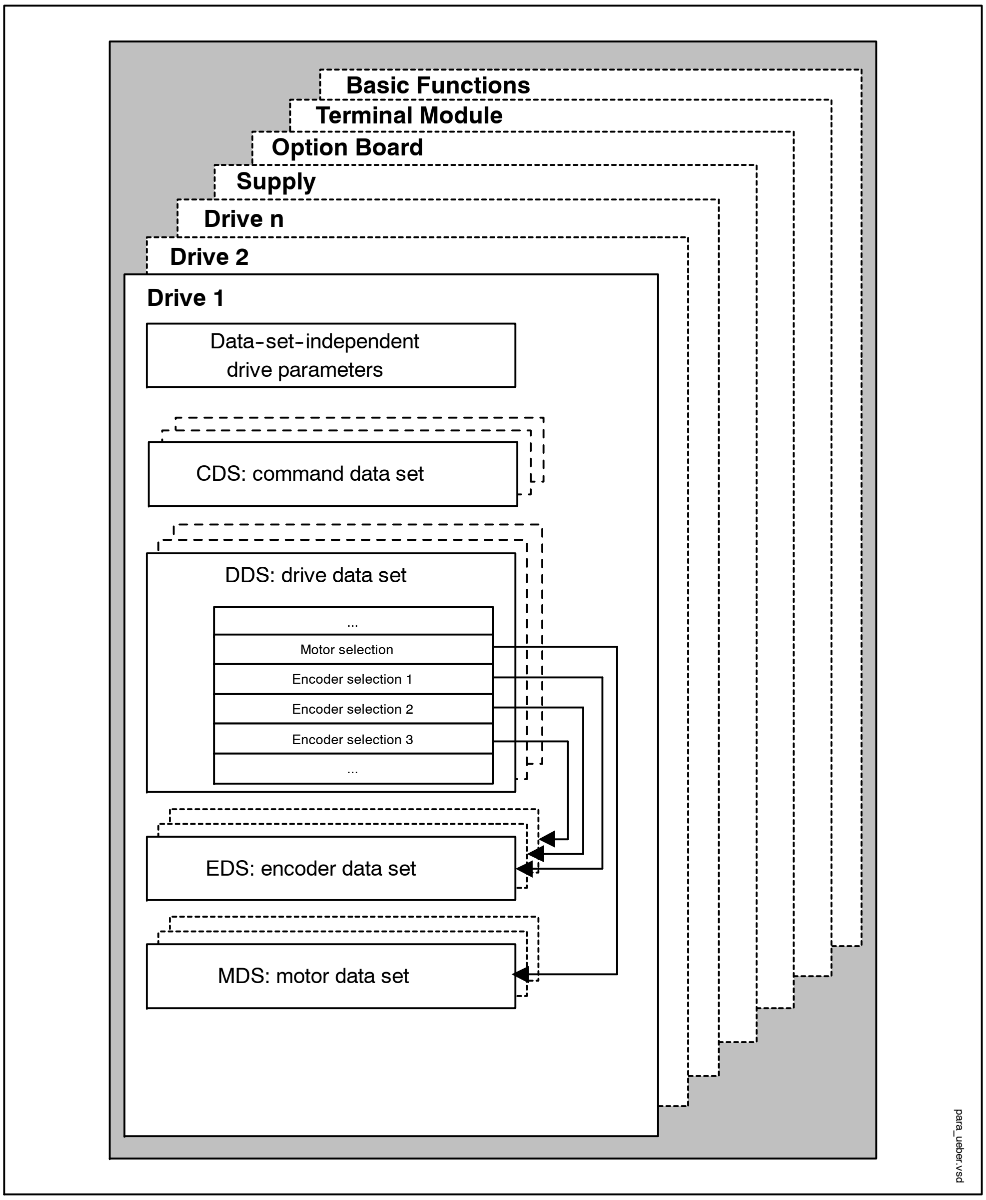


Fig. 5-2 Parameter categories

Saving parameters in a non-volatile memory

The modified parameter values are stored in the volatile RAM. When the drive system is switched off, this data is lost.

The data has to be saved as follows in a non-volatile memory so that it is available the next time the drive is switched on.

- Save parameters – device and all drives

  p0977 = 1   Is 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   Is automatically reset to 0

- Reset parameters – All parameters drive object “Control Unit”

  p0009 = 30   Parameter reset

  p0976 = 1   Is automatically reset to 0

5.2 Data sets

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 (see Section 5.4).

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)

One command data set is available for servo mode and two for vector mode.

The following parameters are available for selecting command data sets and for displaying the currently selected command data set in vector mode:

Table 5-1 Command data set: selection and display

	Selection	**Display**	
	Bit 0	**Selected**	**Active**
CDS	**p0810**	**r0836**	**r0050**
0	0	0	0
1	1	1	1

If a command data set that does not exist is selected, the current data set remains active.

Example: Switching between command data set 0 and 1

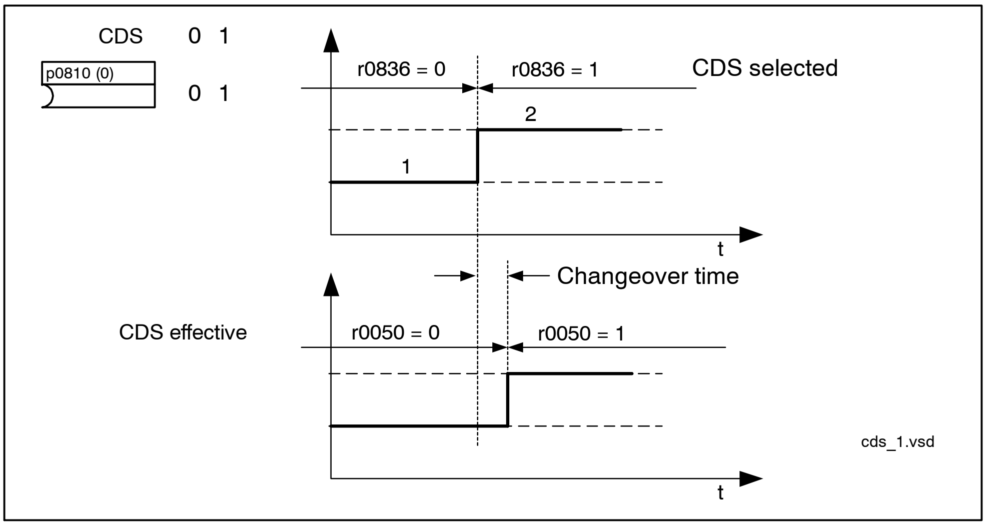


Fig. 5-3 Switching the command data set (example)

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 parameter list by “Data Set DDS” and are assigned an index [0..n].

More than one drive data set can be parameterized. You can switch easily between different drive configurations (control type, motor, encoder) by selecting the corresponding drive data set.

One drive object can manage up to 32 drive data sets. The number of drive data sets is configured with p0180.

Binector inputs p0820 to p0824 are used to select a drive data set. They represent the number of the drive data set (0 to 31) in binary format (where p0824 is the most significant bit).

- p0820 BI: Drive data set selection DDS bit 0
- p0821 BI: Drive data set selection DDS bit 1
- p0822 BI: Drive data set selection DDS bit 2
- p0823 BI: Drive data set selection DDS bit 3
- p0824 BI: Drive data set selection DDS bit 4

Supplementary conditions and recommendations

- Recommendation for the number of drive data sets for a drive

  The number of drive data sets for a drive should correspond to the options for switchover. The following must, therefore, apply:

  p0180 (DDS) $\geq$ max (p0120 (PDS), p0130 (MDS))
- Maximum number of DDS for one drive object = 32 DDS

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.

One drive object can manage up to 3 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.

Note

Only the same encoder data sets can be assigned to all the drive data sets for one drive object. You cannot switch between different encoder data sets.

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 visualization parameters with calculated data.

- Adjustable parameters, e.g.:
  - Motor component number (p0131)
  - Motor type selection (p0300)
  - Rated motor data (p0304 ff)
  - ...
- Visualization parameters, e.g.:
  - Calculated rated data (p0330 ff)
  - ...

The parameters that are grouped together in the motor data set are identified in the SINAMICS parameter list 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.

Motor data sets can only be switched when a DDS is switched.
The motor data set switchover is used in the following cases, for example:

- Switching over different motors
- Switching over different windings in a motor (e.g. star-delta switchover)
- Adapting the motor data

If several motors are operated alternately on a Motor Module, a matching number of drive data sets must be created. For more information on the motor switchover, see Section 4.9.

Notice

Only one motor on a Motor Module can have an encoder; all the other motors must run without encoders.

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 611U interface mode (p2038 = 1), the drive data sets are divided into groups of eight (1-8; 8-16;...). Within a group, the assignment to the
motor data set must be the same:
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 is not the case, 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.

Copying the command data set (vector only)

Set parameter p0809 as follows:

1. p0809[0] = number of the command data set to be copied (source)
2. p0809[1] = number of the command data to which the data is to be copied (target)
3. p0809[2] = 1

Start copying.

Copying is finished when p0809[2] = 0.

Note

In STARTER, you can copy the command data sets (Drive -> Configuration -> “Command data sets” tab page).
You can select the displayed command data set in the relevant STARTER screens.

Copying a drive data set

Set parameter p0819 as follows:

1. p0819[0] = Number of the drive data set to be copied (source)
2. p0819[1] = Number of the drive data set to which the data is to be copied (target)
3. p0819[2] = 1

Start copying.

Copying is finished when p0819[2] = 0.

Note

In STARTER, you can set the drive data sets via the drive configuration.

Function diagram overview (see List Manual)

- 8560 Command data set (CDS)
- 8565 Drive data set (DDS)
- 8570 Encoder data set (EDS)
- 8575 Motor data set (MDS)

Overview of key parameters (see List Manual)

- p0120 Power Module data set (PDS) number
- p0130 Motor data set (MDS) number
- p0140 Encoder data set (EDS) number
- p0170 Command data set (CDS) number
- p0180 Drive data sets (DDS) 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

5.3 Drive objects

A drive object is a self-contained software function with its own parameters and, if necessary, its own faults and alarms. Drive objects can be provided as standard (e.g. I/O evaluation), or you can add single (e.g. Option Board) or multiple objects (e.g. drive control).

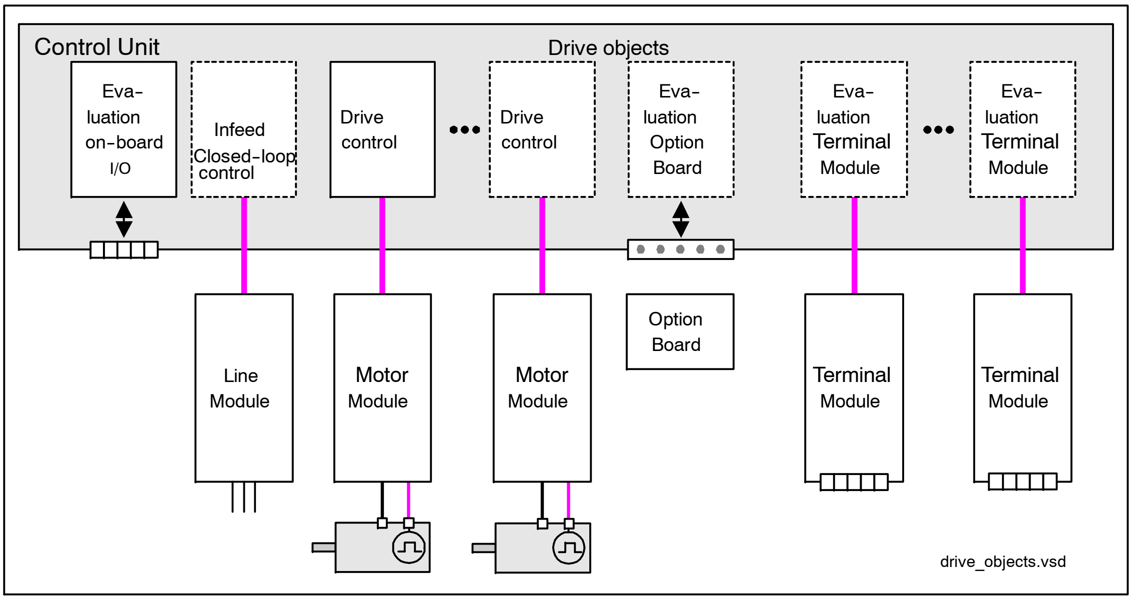


Fig. 5-4 Drive objects

Drive objects installed as standard

- Drive control

  The drive control handles closed-loop control of the motor. 1 Motor Module and at least 1 motor and up to 3 sensors are assigned to the drive control.

  Various types of drive control can be configured (e.g. servo control, vector control, etc.).

  Several drive controls can be configured, depending on the performance of the Control Unit and the demands made on the drive control system.

- Control Unit, inputs/outputs

  The I/Os on the Control Unit are evaluated within a drive object. High-speed inputs for probes are processed here in addition to bidirectional digital I/Os.

- Properties of a drive object
  - Separate parameter space
  - Separate window in STARTER
  - Separate fault/alarm system (for VECTOR, SERVO, INFEED)
  - Separate PROFIBUS telegram for process data (for VECTOR, SERVO, INFEED)

Optional drive objects

- Infeed: Line Module infeed control with DRIVE-CLiQ interface

  If a Line Module with a DRIVE-CLiQ interface is used for the infeed in a drive system, the infeed open-loop/closed-loop control is implemented on the Control Unit within a corresponding drive object.
- Infeed: Line Module infeed control without DRIVE-CLiQ interface

  If a Line Module without a DRIVE-CLiQ interface is used for the infeed in a drive system, the Control Unit must handle activation and evaluation of the corresponding signals (RESET, READY).
- Option Board evaluation

  A further drive object is responsible for evaluating an installed Option Board. The specific method of operation depends on the type of Option Board installed.
- Terminal Module evaluation

  A separate drive object handles evaluation of the respective optional Terminal Modules.

Configuring drive objects

During initial commissioning in STARTER, the drive objects processed by means of software in the Control Unit are created via configuration parameters. Various drive objects can be created within a Control Unit.

The drive objects are configurable function blocks and are used to execute specific drive functions.

If you need to configure additional drive objects or delete existing ones after initial commissioning, the drive system must be switched to configuration mode.

The parameters of a drive object cannot be accessed until the drive object has been configured and you have switched from configuration mode to parameterization mode.

Note

Each installed drive object is allocated a number between 0 and 63 during initial commissioning for unique identification.

Parameter overview (see List Manual)

Adjustable parameters

- p0101 Drive object numbers
- p0107 Drive object type
- p0108 Drive object configuration

Visualization parameters

- r0102 Number of drive objects

5.4 BICO technology: interconnecting signals

Description

Every drive contains a large number of interconnectable input and output variables and internal control variables.

BICO technology (Binector Connector Technology) allows the drive to be adapted to a wide variety of conditions.

Digital and analog signals, which can be interconnected as required by means of BICO parameters, are identified by the prefix BI, BO, CI, or CO in their parameter name. These parameters are identified accordingly in the parameter list or in the function diagrams.

Note

The STARTER parameterization and commissioning tool is recommended when you use BICO technology.

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 5-2 Binectors

Abbreviation and symbol	Name	Description
BI	Binector input Binector input (signal sink)	Can be interconnected to a binector output as source. The number of the binector output must be entered as a parameter value.
BO	Binector output Binector output (signal source)	Can be used as a source for a binector input.

Connectors, CI: connector input, CO: connector output

A connector is an analog signal. Connectors are subdivided into connector inputs (signal sink) and connector outputs (signal source).

The options for interconnecting connectors are restricted to ensure that performance is not adversely affected.

Table 5-3 Connectors

Abbreviation and symbol	Name	Description
CI	Connector input Connector input (signal sink)	Can be interconnected to a connector output as source. The number of the connector output must be entered as a parameter value.
CO	Connector output Connector output (signal source)	Can be used as a source for a connector input.

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

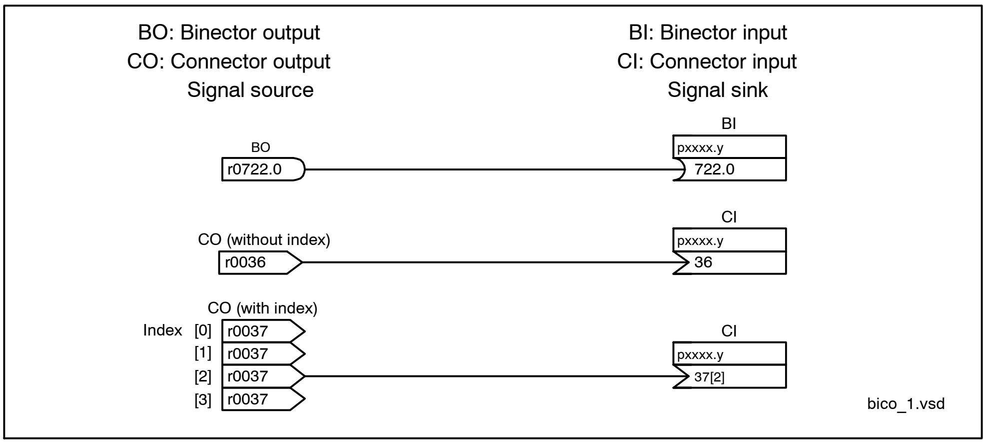


Fig. 5-5 Interconnecting signals using BICO technology

Note

A signal source (BO) can be connected to any number of signal sinks (BI).

A signal sink (BI) can only ever be connected to one signal source (BO).

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.

Internal encoding of the binector/connector output parameters

The internal codes are required for writing BICO input parameters via PROFIBUS, for example.

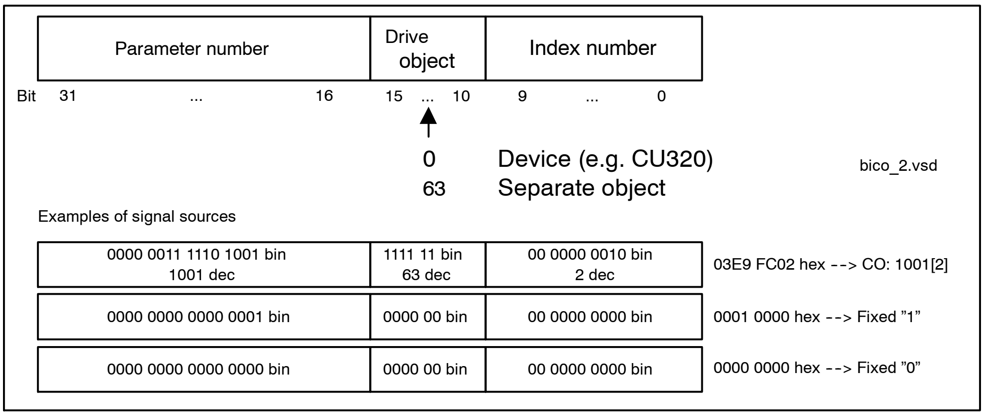


Fig. 5-6 Internal encoding of the binector/connector output parameters

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.

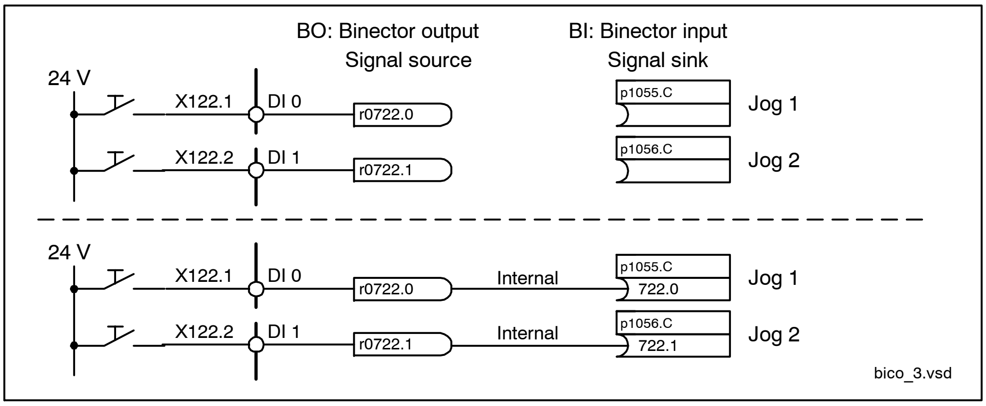


Fig. 5-7 Interconnection of digital signals (example)

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).

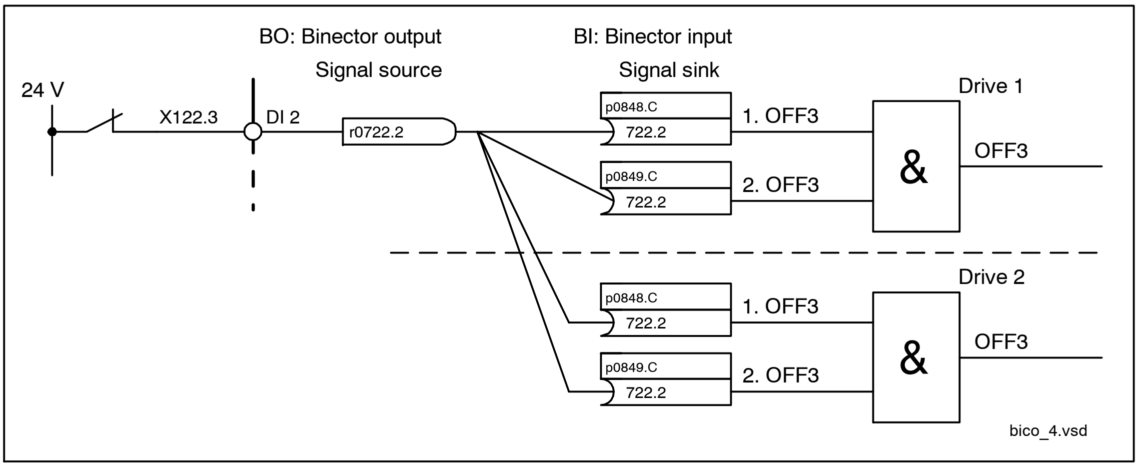


Fig. 5-8 Connection of OFF3 to several drives (example)

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: PROFIBUS 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: PROFIBUS 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.

Signals for the analog outputs

Table 5-4 List containing some of the signals for analog outputs

Signal	Parameters	Unit	Scaling (100% = ...)
Speed setpoint before the setpoint filter	r0060	1/min	p2000
Speed actual value motor encoder	r0061	1/min	p2000
Actual speed value	r0063	1/min	p2000
Drive output frequency	r0066	Hz	Reference frequency
Absolute current actual value	r0068	Arms	p2002
Actual DC link voltage value	r0070	V	p2001
Torque setpoint total	r0079	Nm	p2003
Actual active power	r0082	kW	r2004
Control deviation	r0064	1/min	p2000
Control factor	r0074	%	Reference control factor
Current setpoint, torque-generating	r0077	A	p2002
Current actual value, torque-generating	r0078	A	p2002
Flux setpoint	r0083	%	Reference flux
Actual flux	r0084	%	Reference flux
Speed controller PI torque output	r1480	Nm	p2003
Speed controller I torque output	r1482	Nm	p2003

Scaling for vector object

Table 5-5 Scaling for vector object

Size	Scaling parameter	Default for initial commissioning
Reference speed	100 % = p2000	p2000 = Maximum speed (p1082)
Reference voltage	100 % = p2001	p2001 = 1000 V
Reference current	100 % = p2002	p2002 = Current limit (p0640)
Reference torque	100 % = p2003	p2003 = 2 * rated motor torque (p0333)
Reference power	100 % = r2004	r2004 = p2003 * p2000 * 2π / 60
Reference frequency	100 % = p2000/60	–
Reference control factor	100 % = Maximum output voltage without overload	–
Reference flux	100 % = Rated motor flux	–
Reference temperature	100 % = 100°C	–
Reference electrical angle	100 % = 90°	–

Scaling for servo object

Table 5-6 Scaling for servo object

Size	Scaling parameter	Default for initial commissioning
Reference speed	100 % = p2000	Induction motor p2000 = maximum motor speed (p0322) Synchronous motor p2000 = rated motor speed (p0311)
Reference voltage	100 % = p2001	p2001 = 1000 V
Reference current	100 % = p2002	p2002 = Motor limit current (p0338); when p0338 = “0”, 2 * rated motor current (p0305)
Reference torque	100 % = p2003	p2003 = p0338 * p0334; when “0”, 2 * rated motor torque (p0333)
Reference power	100 % = r2004	r2004 = p2003 * p2000 * π / 30
Reference frequency	100 % = p2000/60	–
Reference control factor	100 % = Maximum output voltage without overload	–
Reference flux	100 % = Rated motor flux	–
Reference temperature	100 % = 100°C	–
Reference electrical angle	100 % = 90°	–

Scaling for object A_Inf

Table 5-7 Scaling for object A_Inf

Size	Scaling parameter	Default for initial commissioning
Reference frequency	100 % = p2000	p2000 = p0211
Reference voltage	100 % = p2001	p2001 = r0206/r0207
Reference current	100 % = p2002	p2002 = p0207
Reference power	100 % = r2004	r2004 = p0206
Reference control factor	100 % = Maximum output voltage without overload	–
Reference temperature	100 % = 100°C	–
Reference electrical angle	100 % = 90°	–

Scaling for object B_Inf

Table 5-8 Scaling for object B_Inf

Size	Scaling parameter	Default for initial commissioning
Reference frequency	100 % = p2000	p2000 = 50
Reference voltage	100 % = p2001	p2001 = r0206/r0207
Reference current	100 % = p2002	p2002 = p0207
Reference power	100 % = r2004	r2004 = p0206
Reference temperature	100 % = 100°C	–
Reference electrical angle	100 % = 90°	–

■

Notes

List of Abbreviations

Abbreviation	
A	
A ...	Alarm
AC	Alternating current
ADC	Analog Digital Converter
AI	Analog Input
ALM	Active Line Module
AO	Analog Output
AOP	Advanced Operator Panel
ASC	Armature Short-Circuit
ASCII	American Standard Code for Information Interchange
available soon	In preparation: this feature is currently not available
B	
BEROs	Tradename for a type of proximity switch
BI	Binector Input
BIA	German Institute for Occupational Safety
BICO	Binector Connector Technology
BLM	Basic Line Module
BOP	Basic Operator Panel
C	
C	Capacitance
C...	Safety message
CAN	Controller Area Network
CBC	Communication Board CAN
CD	Compact Disc
CDS	Command Data Set
CI	Connector Input
CNC	Computer Numerical Control
CO	Connector Output

Abbreviation

CO/BO:	Connector Output/Binector Output
COB-ID	CAN object identification
COM	Mid-position contact of a changeover contact
CP	Communications Processor
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CT	Constant Torque
CU	Control unit
D	
DAC	Digital Analog Converter
DC	Direct Current
DCN	Direct Current Negative
DCP	Direct Current Positive
DDS:	Drive Data Set
DI	Digital Input
DI/DO	Bidirectional Digital Input/Output
DMC	DRIVE-CLiQ Module Cabinet (Hub)
DO	Digital Output
DO	Drive Object
DPRAM	Dual-Port Random Access Memory
DRAM	Dynamic Random Access Memory
DRIVE CLiQ	Drive Component Link with IQ
DSC	Dynamic Servo Control
E	
EDS	Encoder Data Set
ESD	Electrostatic Sensitive Devices
EMF	Electromagnetic Force (EMF)
EMC	Electromagnetic Compatibility
EN	European Standard
EnDat	Encoder-Data-Interface
EP	Enable Pulses
ES	Engineering System
ESB	Equivalent circuit diagramm
ESR	Extended Stop and Retract
F	
F ...	Fault
FAQ	Frequently Asked Questions

Abbreviation

FCC	Function Control Chart
FCC	Flux Current Control
FEPROM	Flash-EPROM
FG	Function Generator
FI	Residual-Current Circuit-Breaker (RCCB)
FP	Function diagram
FW	Firmware
G	
GC	Global Control telegram (broadcast telegram)
GSD	Device master file: describes the features of a PROFIBUS slave
GSDML	Generic Station Description Markup Language
GPS	Gate Supply Voltage
H	
HF	High Frequency
HFD	High frequency reactor
RFG	Ramp-Function Generator
HMI	Human Machine Interface
HTL	High-Threshold Logic
HW	Hardware
I	
IBN	Commissioning
I/O	Input/Output
ID	Identifier
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
IL	Pulse suppression
IT	Three-phase supply network ungrounded
J	
JOG	Jogging
K	
KDV	Data cross-checking
KIP	Kinetic buffering

Abbreviation	
Kp	Proportional gain
KTY	Special temperature sensor
L	
L	Inductance
LED	Light Emitting Diode
LSB	Least Significant Bit
LSS	Line Side Switch
M	
M	Reference potential, zero potential
MB	Megabyte
MCC	Motion Control Chart
MDS	Motor Data Set
MLFB	Machine-readable product designation
MMC	Man Machine Communication
MSB	Most Significant Bit
MSCY_C1	Master Slave Cycle Class 1
MT	Measuring probe
N	
N. C.	Not Connected
N...	No Report
NAMUR	Standardization association for measurement and control in chemical industries
NC	Normally Closed contact
NC	Numerical Control
NEMA	National Electrical Manufacturers Association
NM	Zero mark
NO	Normally Open contact
O	
OC	Operating Condition
OEM	Original Equipment Manufacturer
OLP	Optical Link Plug
OMI	Option Module Interface
P	
p ...	Adjustable parameter
PcCtrl	Master Control
PDS	Power Module Data Set

Abbreviation	
PE	Protective Earth
PELV	Protective Extra Low Voltage
PG	Programming device
PI	Proportional Integral
PID	Proportional Integral Differential
PLC	Programmable Logic Controller
PLL	Phase Locked Loop
PNO	PROFIBUS user organisation
PRBS	Pseudo Random Binary Signal
PROFIBUS	Process Field Bus
PS	Power Supply
PSA	Power Stack Adapter
PTC	Positive Temperature Coefficient
PTP	Point To Point
PWM	Pulse Width Modulation
PZD	PROFIBUS process data
Q	
R	
r...	Display parameter (read only)
RAM	Random Access Memory
RCCB	Residual-Current Circuit-Breaker
RCD	Residual Current Device
RJ45	Standard Describes an 8-pole plug connector with twisted pair Ethernet.
RKA	Recooling system
RO	Read Only
RPDO	Receive Process Data Object
RS232	Serial interface
RS485	Standard Describes the physical characteristics of a digital serial interface.
S	
S1	Continuous operation
S3	Periodic duty
SBC	Safe Brake Control
SBH	Safe operating stop
SBR	Safe braking ramp
SGE	Safe input signal
SH	Safe standstill

Abbreviation

SI	Safety Integrated
SIL	Safety Integrity Level
SLM	Smart Line Module
SLVC	Sensorless Vector Control
SM	Sensor Module
SMC	Sensor Module Cabinet
SME	Sensor Module External
SPC	Setpoint Channel
(e.g. SIMATIC from Siemens)	Programmable Logic Controller (PLC)
STW	PROFIBUS controlword
Technical data for ANT D10	
TB	Terminal Board
TIA	Totally Integrated Automation
TM	Terminal Module
TN	Grounded three-phase supply network
Tn	Integral time
TPDO	Transmit Process Data Object
TT	Grounded three-phase supply network
TTL	Transistor-Transistor-Logic
U	
UL	Underwriters Laboratories Inc.
UPS	Uninteruptible power supply
V	
VC	Vector control
Vdc	DC link voltage
VDE	Association of German Electrical Engineers
VDI	Association of German Electrical Engineers
Vpp	Volt peak to peak
VSM	Voltage Sensing Module
VT	Variable Torque
W	
WZM	Machine tool
X	
XML	Extensible Markup Language

Abbreviation	
Y	
Z	
DC link	DC Link
ZSW	PROFIBUS statusword

■

Notes

References

SINAMICS Documentation

Catalogs

/D11.1/	**SINAMICS G110 Converter Chassis Units 0.12 kW to 3 kW**		
	Order no.:	E86060-K5511-A111-A2	Edition: 10.2005
/D11/	**SINAMICS G130 Drive Converter Chassis Units,** **SINAMICS G150 Drive Converter Cabinet Units**		
	Order no.:	E86060-K5511-A101-A2	Edition: 07.2004
/D21.1/	**SINAMICS S120 Vector Control Drive System**		
	Order number:	E86060-K5521-A111-A1	Edition: 04.2005
/D21.2/	**SINAMICS S120 Servo Control Drive System**		
	Order number:	E86060-K5521-A121-A1	Edition: 04.2004
/D21.3/	**SINAMICS S150 Converter Cabinet Units** 75 kW to 1200 kW		
	Order number:	E86060-K5521-A131-A1	Edition: 05.2004

Related catalogs

/ST70/	**SIMATIC Components for Totally Integrated Automation, Catalog ST70** Ordering information		
	Order number:	E86060-K4670-A111-A9	Edition: 10.2004
/PM10/	**SIMOTION Motion Control System, Catalog PM10** Ordering information		
	Order no.:	E86060-K4910-A101-A5	Edition: 07.2005

Interactive catalogs

/**CA01**/ **Automation and Drives' Offline Mall**
CD-ROM
Order number: E86060-D4001-A100-C3 Edition: 10.2004

/**Mall**/ **A&D Mall, Catalog and Online Ordering System**
http://www.siemens.com/automation/mall

Electronic documentation

/**CD2**/ **SINAMICS**
The SINAMICS System
Order no.: 6SL3097-2CA00-0YG2 Edition: 07.2005

User Documentation

/**BA1**/ **SINAMICS G150**
Operating Instructions
Order no.: On request Edition: 06.2005

/**BA2**/ **SINAMICS G130**
Operating Instructions
Order no.: On request Edition: 06.2005

/**BA3**/ **SINAMICS S150**
Operating Instructions
Order no.: On request Edition: 06.2005

/**GH1**/ **SINAMICS S120**
Equipment Manual for Control Units and Additional System Components
Order no.: 6SL3097-2AH00-0AP2 Edition: 06.2005

/**GH2**/ **SINAMICS S120**
Equipment Manual for Booksize Power Modules
Order no.: 6SL3097-2AC00-0AP2 Edition: 06.2005

/GH3/ **SINAMICS S120**
Equipment Manual for Chassis Power Modules
Order no.: 6SL3097-2AE00-0AP0 Edition: 12.2004

/GH4/ **SINAMICS S120**
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/LH1/ **SINAMICS S**
List Manual
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Further supplementary documentation

1 **Drive ES Basic V5.1**
Function Description
Engineering system for drives from the SIEMENS A&D product range
Order no.: 6SW1700-0JA00-0AA0 Edition: 08.2001

2 **SIMOTION Engineering System**
Handling
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/PFK7S/ **SIMODRIVE Synchronous Motors 1FK7**
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Order no.: 6SN1197-0AD02-0AP1 Edition: 07.2005

PROFIBUS documentation

/P1/ **PROFIBUS-DP/DPV1 IEC 61158**
Basic Information, Tips and Tricks for Users
Hüthig; Manfred Popp, 2nd Edition
ISBN 3-7785-2781-9

/P2/ **PROFIBUS-DP, Getting Started**
PROFIBUS User Organization e.V.; Manfred Popp
Order number: 4.071

/P3/ **Distributed Layouts using PROFIBUS-DP**
Architecture and Fundamentals, Configuration and Use of PROFIBUS-DP with SIMATIC S7
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Order no.: A19100-L531-B714
ISBN 3-89578-074-X

/P4/ **Manual for PROFIBUS Networks, SIEMENS**
Order number: 6GK1970-5CA20-0AA0

/P5/ **PROFIBUS Profile PROFIdrive Profile Drive Technology**
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Haid-und-Neu-Straße 7, 76131 Karlsruhe
Order number: 3.172 Version 3.1, November 2002

/IKPI/ **SIMATIC NET, Industrial Communication and Field Equipment**
Catalog
Order number: E86060-K6710-A101-B4 Edition: 2005

/PDP/ **PROFIBUS Installation Guidelines**
Installation Guideline for PROFIBUS-FMS/DP
Installation and wiring recommendation for RS 485 Transmission
Order no.: 2.111 (German)
2.112 (English) Version 1.0

Documentation for Safety Equipment

Note

For more information about technical documentation for Safety Integrated, visit the following address:

http://www.siemens.de/safety

The following list contains some of the safety-related documentation available.

/LVP/ **Low-Voltage Switchgear**
Catalog
Order number: E86060-K1002-P101-A5 Edition: 2005

/LV10/ **Industrial Switchgear**
Catalog
Order number: E86060-K1002-A101-A4 Edition: 2004

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/LV30/ **Products and Systems for Energy Distribution**
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Order number: E86060-K1801-A101-A4 Edition: 2004

/MRL/ **Directive 98/37/EEC of the European Parliament and Council**
Machine Directive
Bundesanzeiger-Verlags GmbH Edition: 06/22/1998

/SIAH/ **Safety Integrated**
Application Manual
Order no.: 6ZB5000-0AA01-0BA1 5th edition

/SICD/ **Safety Integrated**
CD-ROM
Order no.: E20001-D10-M103-X-7400 Edition: 09.2004

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General documentation / catalogs

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SINAMICS G130 G150
D11
Converter Chassis Units
Converter Cabinet Units

SINAMICS S120
- D21.1: Vector Control Drive System
- D21.2: Servo Control Drive System

SINAMICS S150
D21.3
Converter Cabinet Units
75 kW to 1200 kW

Manufacturer/service documentation

SINAMICS G110
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- Operating Instructions
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SINAMICS G130
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- Equipment Manual Control Units and Additional System Components
- Equipment Manual Booksize Power Sections
- Equipment Manual Booksize Power Sections Cold-Plate
- Equipment Manual Chassis Power Sections
- Commissioning Manual
- CANopen Commissioning Manual
- Function Manual
- List Manual

SINAMICS S150
- Operating Instructions
- List Manual

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