SINAMICS G120

CU230P-2 Control Units

Function Manual · Edition 03/2009 · FW 4.2

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SINAMICS G120

CU230P-2
CU230P-2 inverter functions

Function Manual

03/2009 Edition

03/2009, FW 4.2
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Legal information

Warning notice system

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

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

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

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

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

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

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

Qualified Personnel

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

Proper use of Siemens products

Note the following:

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

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Disclaimer of Liability

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

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Ⓟ 04/2009

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Introduction 1

Note

The term "speed" is used in this manual instead of and with the equivalent meaning to the term "frequency". The rare cases in which the term "speed" actually means "speed in rev/min" can be deduced from the context.

The actual speed depends on the number of pole pairs of the connected motor.

1.1 Customer documentation and product support on the Internet

Manual collection and online document support for standard drive units

Collection of manuals for standard drive units

The collection of manuals for standard drive units is an extensive compilation of all documentation for standard drive units which covers the entire range of standard drive products including inverters, motors and geared motors. It can be ordered as a DVD which runs on a special Java-controlled HTML interface.

The order number of the manual collection for standard drive units is:
6SL3298-0CA00-0MG0

Online documentation

You will find the documentation for all standard drive units on the Internet:
(http://support.automation.siemens.com/ww/view/en/4000024)

All documents, including operating instructions and parameter lists, are available for downloading.

Generic station description files (GSD)

Generic station description files (GSD) are used to integrate inverters into higher-order control units, e.g. SIMATIC S7 via **PROFIBUS DP**. You can download the GSD files from the Internet under: (http://support.automation.siemens.com/ww/view/en/23450835)

Electronic Data Sheets (EDS file)

The EDS files are used to integrate an inverter via CAN into the particular system configuration. You can download the EDS files from the Internet under:
(http://support.automation.siemens.com/WW/view/en/35209032)

Manuals for inverters with CU230P-2 Control Unit

The following manuals are available for inverters with CU230P-2 Control Units:

- For the CU230P-2
  - Getting Started
  - Operating Instructions
  - Function Manual
  - List Manual
- For the Power Module
  - Getting Started
  - Hardware Installation Manual

General product information

Comprehensive information and support tools are available at the following addresses for the frequency inverters: (http://www.siemens.com/sinamics-g120)

Application examples

You will find application examples and useful notes on the application of frequency inverters under the following link:
(http://support.automation.siemens.com/WW/view/en/20208582/136000)

Safety notes 2

Safety instructions

The warnings, safety information and remarks that follow are intended to be used as both safety measures for users and measures that can be put in place to avoid damage to the product or to components of the connected machines. The following section provides an overview of warnings, safety information and remarks that are generally applicable to any work involving the inverter. These are divided into general instructions and instructions for transportation and storage, commissioning, operation, repair, disassembly, and disposal.

Special warnings, information and notes relating to specific activities/work are listed at the beginning of the respective sections of this manual and are repeated or expanded at critical points in these sections.

Please read this information carefully, it has been included for your personal safety and to help you extend the service life of your inverter and other devices connected to it.

General information

WARNING

These devices carry hazardous voltages and control rotating mechanical parts which can be dangerous in some circumstances. Non-observance of the warnings or non-compliance with the instructions in this manual can lead to danger to life, serious injury or substantial damage to property.

Protection by means of SELV/PELV in case of direct touching is permitted only in areas with equipotential bonding and in dry interior spaces. If these conditions are not fulfilled, other protective measures against electric shock are to be taken, e.g., protective insulation.

Only suitably qualified personnel who have previously familiarized themselves with all the instructions regarding safety, installation, operating and maintenance as set out in this manual are permitted to work on these devices. Successful and safe operation of these devices depends on their proper handling, installation, operation and maintenance.

Since the residual current for this product is greater than 3.5 mA AC, a fixed ground connection is required and the minimum size of the protective conductor must comply with local safety regulations for equipment with a high leakage current.

The power supply, direct-current and motor terminals as well as the brake cables and thermistor cables can carry hazardous voltages even when the inverter is out of service. Once the power supply has been disconnected, wait at least 5 minutes until the device has discharged itself. Only then can you start the installation work.

It is strictly forbidden to isolate the device from the supply on the motor side; isolation from the supply must always be carried out on the supply side of the inverter.

Before the power supply for the inverter is connected, ensure that the terminal box of the motor is connected.

This device is designed to ensure internal motor overload protection in accordance with UL508C. See P0610 and P0335; i^2t has been set to ON as the standard setting.

If an LED or similar indicator does not light up or is not active when a function is switched from ON to OFF, this does not mean that the unit has been switched off or is current-free.

The inverter must always be properly grounded.

The device must be isolated from the power supply before any cables, plugs or wires are connected to the device or altered.

Make sure that the inverter has been configured for the correct supply voltage. It must be ensured that the inverter is not connected to a higher supply voltage.

Static discharge on surfaces or at interfaces which are not generally accessible (e.g. terminals or connector pins) can cause malfunctions or defects. The ESD protective measures should therefore be observed during work with inverters or inverter components.

The general and regional installation and safety regulations for working on equipment carrying hazardous voltages (e.g. EN 50178) as well as the relevant stipulations regarding the correct use of tools and personal protective equipment (PPE) are especially to be observed.

⚠ CAUTION
Children and other unauthorized persons must be forbidden access to the devices! It is only permissible to use these devices for the purpose indicated by the manufacturer. Unauthorized changes and the use of spare parts and accessories which are not sold or recommended by the manufacturer of the device can lead to fires, electric shock and injuries.

NOTICE
This manual is to be kept somewhere close to the devices and must be easily accessible for all users. If measurements or tests have to be carried out on the live device, the stipulations of safety regulation BGV A2 are to be complied with, especially § 8 "Permissible deviations during work on live parts". Suitable electronic tools are to be used. Before installation and commissioning, please read this safety information and the warnings carefully as well as the warning signs fitted to the devices. It must be ensured that the warning signs are always legible; any signs that are damaged or missing are to be replaced.

Transport and storage

⚠ WARNING
Appropriate transport and storage, as well as careful operation and maintenance are essential for the correct and safe operation of the devices.

⚠ CAUTION
During transport and storage, the device must be protected against mechanical shocks and vibrations. It is important to protect the unit against water (rain) and against excessively high/excessively low temperatures.

Commissioning

⚠ WARNING
Work performed on the devices by unqualified personnel or failure to observe warnings can cause serious bodily injury or considerable property damage. Work on the devices must only be carried out by qualified personnel who are familiar with the design, installation, commissioning and operation of the devices.

CAUTION

Cable connection

The control cables must be routed separately from the supply cables. If this is not possible, we recommend the use of shielded cables. The connection must be performed according to the instructions in the "Installation" section of this manual, in order to prevent inductive and capacitive interference from affecting smooth operation of the plant.

During operation

WARNING

SINAMICS G120 inverters operate with high voltages.

When operating electrical devices, hazardous voltages in certain parts of the devices cannot be avoided. Therefore, emergency off equipment in accordance with EN 60204, IEC 204 (VDE 0113) must be functional in all operating modes of the control equipment. Switching off an emergency off device must not lead to an uncontrolled or undefined restart of the plant.

Certain parameter settings (for example, the functions for automatic restart) can cause the SINAMICS G120 inverter to automatically restart following a power supply failure.

For the areas of the control equipment in which faults can cause considerable damage to property or even serious injury, additional external precautions must be taken, or devices installed to ensure safe operation even if a fault occurs (for example, independent limit switches, mechanical interlocks, etc.).

The motor parameters must be precisely configured so that the motor overload protection functions correctly.

The Control Unit can also have dangerous voltages even if the Power Module power supply is shut down. Therefore carefully ensure that the 230 V AC power supply voltage for the relay outputs on the Control Unit are also shut down before you start any work on the unit.

This device is designed to ensure internal motor overload protection in accordance with UL508C.

You must only use Control Units with fail-safe functions as an "emergency off device" (see EN 60204, Section 9.2.5.4).

The use of mobile radio equipment with a transmitter power of > 1 W close to the units (< 1.5 m) can have a negative impact on the function of the units.

Repairs

⚠ WARNING
Only Siemens customer service, repair centers that have been authorized by Siemens or authorized personnel may repair drive equipment. Al of the persons involved must have in-depth knowledge of all of the warnings and operating instructions as listed in this Manual. All damaged parts or components must be replaced only using parts and components that are listed in the relevant spare parts list. Before opening the device, disconnect the supply voltage in order to gain access to the interior components.

Disassembly and disposal

CAUTION
The packaging of the inverter is re-usable. Store the packaging carefully for re-use. The packaging can be easily dismantled into its individual parts using removable screw and snap catches. The parts can be recycled, disposed of in accordance with local regulations, or returned to the manufacturer.

Description 3

Inverter families

This manual describes the functions of SINAMICS G120 with CU230P Control Units:

The inverters have a modular structure. This means that Control Units and Power Modules within an inverter series can be combined depending on the application requirements.

3.1 CU230P function overview

This section contains an overview of the functions of the various types of frequency inverters.

General inverter functions

The inverters provide the following functions:

- Basic functions
  - Digital input functions
  - Digital output functions
  - Analog input functions
  - Analog output functions
  - Automatic restart
  - Flying restart
  - Technology controller as PID controller
  - Motor data identification
  - Efficiency optimization
  - Braking functions
  - Data sets
  - BICO technology
- Setpoint channel
  - Ramp-function generator
  - Setpoint modification
  - OFF functions
  - Motor-driven potentiometer
  - Fixed speed setpoints
  - Jog function
- Monitoring functions
  - General monitoring functions and messages
  - Load torque monitoring
  - Power Module protection
  - General overload monitoring
  - Power Module temperature monitoring
  - Thermal motor protection and overload behavior
  - Thermal motor model
  - Motor temperature identification after restart
  - Temperature sensor
- Control functions
  - V/f control with several variants
  - Vector control with several variants

Power Module-dependent functions

Table 3- 1 Power Module-related functions

	SINAMICS G120	
	PM240	PM250
VDC control	X	---
Electronic brakes	X	---
Regenerative brake with regenerative feedback	---	X

4 Inverter Functions

4.1 Automatic restart

Description

The "automatic restart" function is used to restart the drive automatically once the power has been restored following a power failure. In this case, all of the faults present are automatically acknowledged and the drive is powered up again. This function is not only restricted to line supply faults; it can also be used to automatically acknowledge faults and to restart the motor after any fault trips. In order to allow the drive to be powered-up while the motor shaft is still rotating, the "flying restart" function should be activated using p1200.

⚠ WARNING
If p1210 is set to values > 1, the motor can start automatically once the power supply has been restored. This is especially critical, if, after longer line supply failures, motors come to a standstill (zero speed) and it is incorrectly assumed that they have been powered down. For this reason, entering the area around the drive when it is in this condition can cause death, serious injury, or considerable material damage.

Automatic restart mode

- **P1210 = 0: Disable automatic restart**
  automatic restart inactive
- **P1210 = 1: Acknowledge all faults without automatic restart**
  When p1210 = 1, any faults that are present are acknowledged automatically once the cause has been rectified. If further faults occur after faults have been acknowledged, then these are also again automatically acknowledged. A minimum time of p1212 + 1s must expire between successful fault acknowledgement and a fault re-occurring if the signal ON/OFF1 (control word 1, bit 0) is at a HIGH signal level. If the ON/OFF1 signal is at a LOW signal level, the time between a successful fault acknowledgement and a new fault must be at least 1s.

  For p1210 = 1, fault F07320 is not generated if the acknowledge attempt failed (e.g. because the faults occurred too frequently).
- **P1210 = 4: Restart after power failure, no further starting attempts**
  Automatic restart only if F30003 (undervoltage in the DC link) has occurred on the Power Module in addition to the power failure.
  If further faults are present, then these are also acknowledged and the starting attempt is continued.
  If the 24 V power supply for the CU fails, this is interpreted as a power failure.

- **P1210 = 6: Restart after any fault with additional starting attempts**
  Automatic restart after any fault.
  If the faults occur one after the other, then the number of starting attempts is defined by p1211. Monitoring over time can be set using p1213.

> ⚠ **WARNING**
>
> In the case of communication via the field bus interface, the motor restarts with the setting p1210 = 6 even if the communication link is interrupted. This means that the motor cannot be stopped via the open-loop control. In this case, automatic restart must be inhibited.
>
> This can be parameterized with p1206[n] = communication error number (n = 0 … 9).
> PROFIBUS/USS: F1910
> CANOpen: F8700

- **P1210 = 14: Restart after power failure, no additional starting attempts**
  Same procedure as with p1210 = 4, but F30003 and any further errors must be acknowledged manually.
- **P1210 = 16: Restart after any fault with additional starting attempts**
  Same procedure as with p1210 = 6, but the faults must be acknowledged manually.

Note

Restart when p1210 = 6 or 16

The automatic restart with p1210 = 6 or 16 is not used for the fault numbers listed in p1206, index 0 ... 9.

Example: p1206[3] = 07331 -> no restart with error F07331.

Starting attempts (p1211) and delay time (p1212)

p1211 is used to specify the number of starting attempts. The number is decremented internally after each successful fault acknowledgement (the line voltage must be re-applied or the infeed signals that it is ready). The inverter shuts down with F07320 if the number of parameterized starting attempts is exceeded.

When p1211 = x, x + 1 starting attempts are made.

Note

The first starting attempt starts immediately after the fault has occurred.

Each fault is automatically acknowledged after half of the p1212 delay time.

After successful acknowledgment and return of the voltage, then the system is automatically powered up again.

The starting attempt has been successfully completed if the flying restart and the motor magnetization (induction motor) have been completed (r0056.4 = 1) and one additional second has expired. The starting counter is only reset back to the initial value p1211 after this time.

If additional faults occur between successful acknowledgement and the end of the starting attempt, then the starting counter is also decremented when it is acknowledged.

Monitoring time line supply return (p1213)

The monitoring time starts when the faults are detected. If the automatic acknowledgements are not successful, the monitoring time runs again. If the drive has not successfully started again after the monitoring time has expired (flying restart and motor magnetization must have been completed: r0056.4 = 1), fault F07320 is output. The monitoring is de-activated with p1213 = 0.

Monitoring time for restart (p1213[0])
If p1213 is set lower than the sum of p1212, the magnetizing time p0346 and the additional delay time due to flying restart, then fault F07320 is generated at each restart. If a fault is active after the timer in p1213 has run down (inspite of p1210 = 1), fault F07320 is generated. The monitoring time must be extended if the faults that occur cannot be immediately and successfully acknowledged (e.g. if other machine components are not yet ready for operation).

Reset the monitoring time for the starting counter (p1213[1])
The error counter (see r1214) is only reset to starting value p1211 once the time in p1213[1] has expired after a successful restart. The delay time is not effective in the case of an error acknowledgment without an automatic restart (p1210 = 1). If the power supply fails (blackout), the delay time only starts once the power has been restored and the Control Unit is ramped up. The error counter is set to p1211 if F07320 occurs (automatic restart aborted), the switch-on command is canceled and the error is acknowledged.

If starting value p1211 or mode p1210 is changed, the fault counter is immediately updated.

Commissioning

1. Activate the "automatic restart" function via p1210 and, if necessary, the "flying restart" function via p1200.
2. Set the number of starting attempts via p1211
3. Set the delay times via p1212 and p1213
4. Check function.

Important parameters, for details refer to the List Manual

- Set p1206[0...9] fault number without automatic restart
- p1210 Automatic restart, mode
- p1211 Automatic restart, attempts to start
- p1212 Automatic restart, delay time start attempts
- p1213 Automatic restart, waiting time increment
- r1214 automatic restart status

4.2 Flying restart

Description

After power ON, the "flying restart" function automatically connects a Power Module to a motor which may already be turning.

The "Flying restart" function should be activated via p1200 for loads which may coast after power interruption. This prevents sudden loads in the entire mechanics.

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

First, a search is carried out for the current speed. The search starts at the maximum speed plus 25 %. The motor is magnetized immediately (p0346) after the speed has been determined.

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

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

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

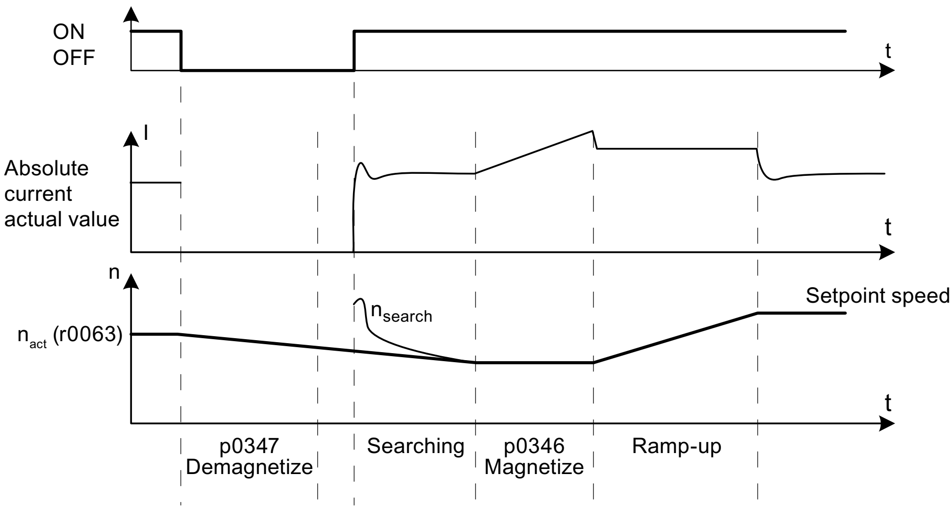


Figure 4-1 Flying restart example

⚠ 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

Before the flying restart is activated, the de-magnetizing time is elapsed, enabling the voltage at the motor terminals to be decreased, otherwise high equalizing currents can occur when the pulses are enabled due to a phase short-circuit.

Important parameters, for details refer to the 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).
  - 4: Flying restart is always active Start in setpoint direction **only**.
- p1202 Flying restart search current
- p1203 Flying restart search rate factor
- r1204 CO/BO: Flying restart, V/f control status
- r1205 CO/BO: Flying restart, vector control status

4.3 Direct-current brake for induction motors

Description

With the "DC brake" function, a DC current is applied that slows down the motor or maintains it at standstill. It is configured via P1231.

The DC brake can be used to quickly brake the motor in the case of a fault or as operating mode that is directly selected using BiCo parameter p1230. The errors with which the DC brake should be activated can be assigned via p2100 and p2101.

If the motor type (p0300) is changed, the responses to errors and alarms that are changed using p2100 and p2101 are reset.

The level, duration and operational frequency of the braking current and therefore the braking torque can be set during parameterization. DC injection braking can support a braking process from around < 10 Hz. In addition, it prevents or minimizes the rise in DC-link voltage in the regenerative braking process by directly absorbing energy in the motor.

NOTICE
When activating the DC brake, the motor may continue to turn after the DC brake has been applied, although orientation has been lost. In this case, the inverter goes into the fault state and switches off with OFF2.

Special features of the DC brake

- Significantly shorter response time than a mechanical brake
- A holding torque can be generated at standstill so that undesired movements can be suppressed, e.g. after positioning actions.

Main areas of application:

- Centrifuges
- Saws
- Grinding machines
- Conveyor belts

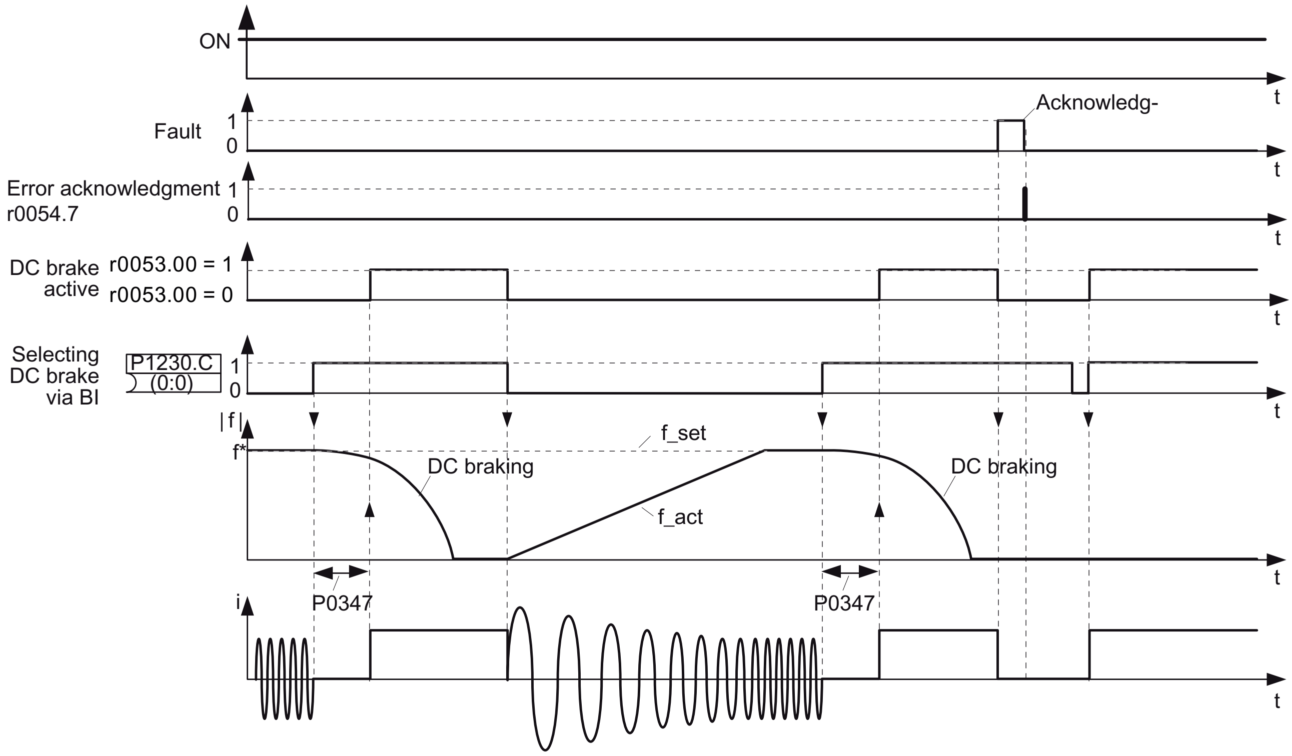
Activation of the DC brake via a binector input (BI)

If the DC brake is activated by the digital input signal, the first step is that the pulses are inhibited for the demagnetizing time p0347 of the motor in order to demagnetize the motor - the parameter p1234 "Speed at the start of DC braking" is ignored.

Then the DC brake, braking current p1232 is applied as long as the input is initiated in order to brake the motor or hold it at standstill.

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

For details on using the DC brake as an operational function, please refer to the following diagram.



For function diagrams, see the List Manual

- 7017 DC brake (p0300 = 1xx, induction motors)

Important parameters, for details refer to the List Manual

- r0046 Missing enable signals
- r0053 Status word 1
- p0347 De-magnetizing time
- p1226 Standstill detection, velocity threshold
- p1230[0...n] BI: Armature short-circuit/DC brake activation
- p1231[0...n] Armature short-circuit/DC brake configuration
- p1232[0...n] DC brake, braking current
- p1233[0...n] DC braking time
- p1234[0...n] DC brake starting speed
- 1239.0..10 CO/BO: Armature short-circuit/DC brake status word

4.4 Hibernation

Data

Parameter range:	2390 … 2399
Alarms:	7324 and 7325
Faults:	--
Function diagram number:	--

Description - operation

The "Hibernation" function is mainly used for pumps and fans. Typical applications include pressure and temperature controls.

With hibernation mode, the inverter stops and starts the motor depending on the system conditions. It can be operated both via the technology controller (without external commands via terminals or bus interface) and external setpoint input.

Hibernation mode offers the advantages of energy saving, lowering mechanical wear and reduced noise.

Note

Restrictions in entering a setpoint in the hibernation mode

In the hibernation mode state, the impulses are inhibited and it is not possible to enter a setpoint via the MOP as the MOP signal cannot withdrawn the pulse inhibit.

This is the reason that the "hibernation" function is therefore not suitable for setpoint input via the MOP.

Operating principle

Hibernation mode starts as soon as the absolute motor speed drops below the hibernation start frequency. However, the motor is only switched off after an adjustable time has expired. If, during this time, the frequency setpoint rises above the hibernation start frequency due to pressure or temperature changes, hibernation mode is exited and the inverter functions in normal operation. Otherwise the inverter switches off the motor, but continues to monitor the frequency or technology setpoint. As soon as this rises above an adjustable threshold, the inverter starts the motor and exits hibernation mode.

In order to prevent frequent startups and shutdowns, the speed may be boosted for a short time before shutdown (hibernation boost). This function can be disabled by setting the time for the hibernation boost to 0.

To avoid tank deposits, particularly where liquids are present, it is possible to exit hibernation mode after an adjustable time has expired and to switch to normal operation.

The parameter settings required for the respective variant can be found in the following tables.

Hibernation with setpoint input using the internal technology controller

In this operating mode, the technology controller must be activated as the setpoint source and used as the main setpoint. The function can be operated both with and without the hibernation boost.

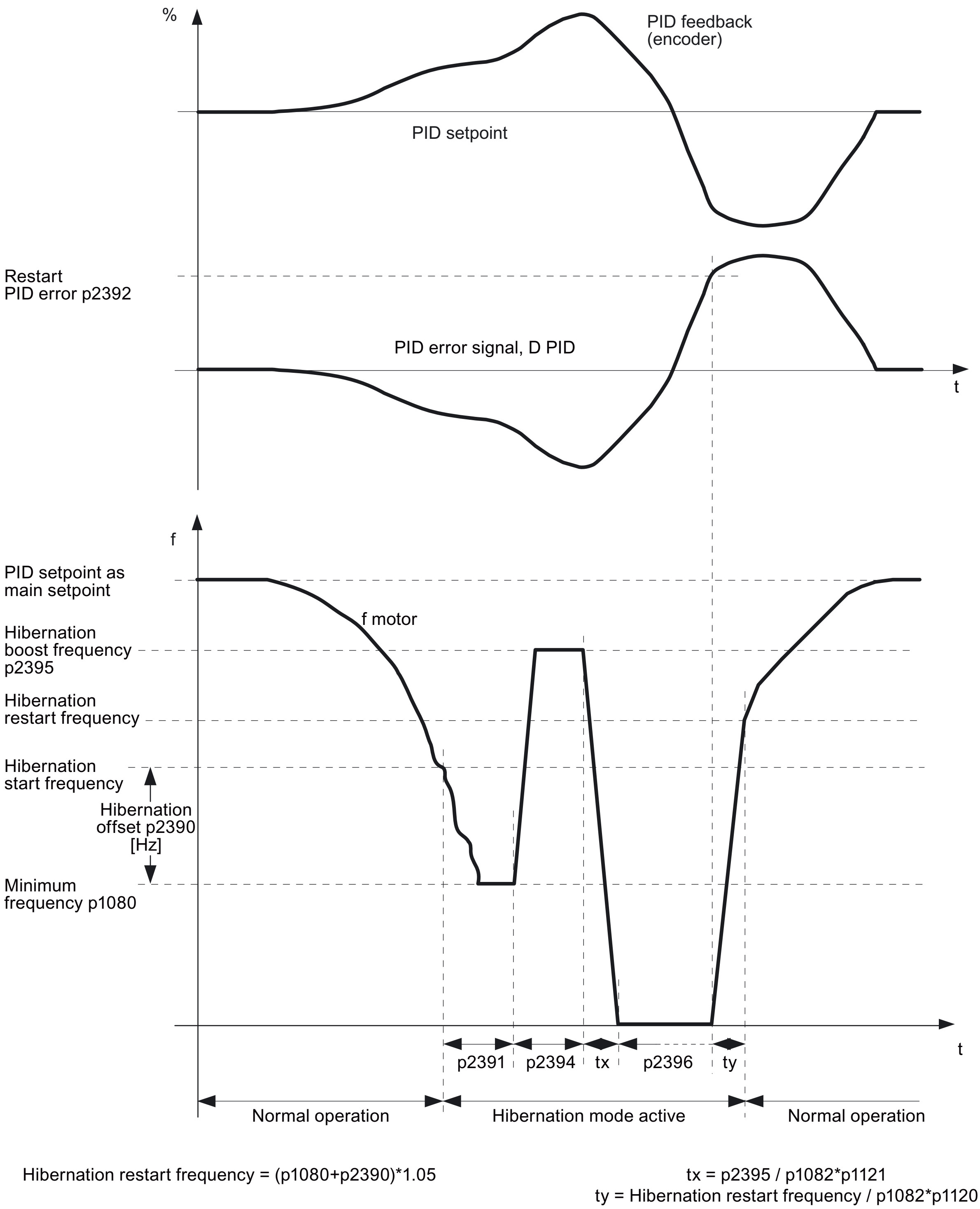


Figure 4-2 Hibernation using the technology setpoint as the main setpoint with the hibernation boost

Hibernation with external setpoint input

In this operating mode, the setpoint is specified by an external source (e.g. a temperature sensor); the technology setpoint can be used here as a supplementary setpoint.

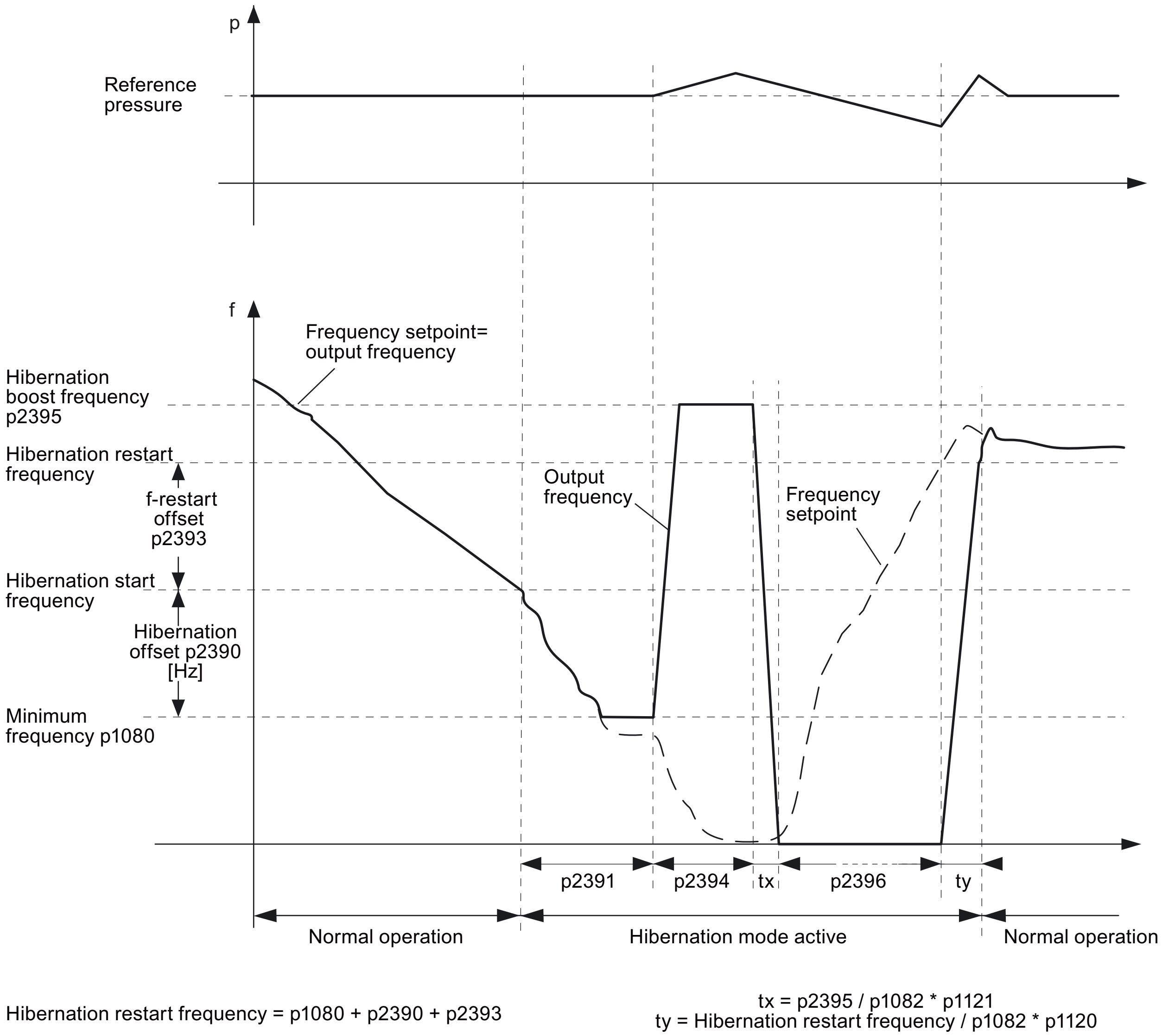


Figure 4-3 Hibernation using an external setpoint with hibernation boost

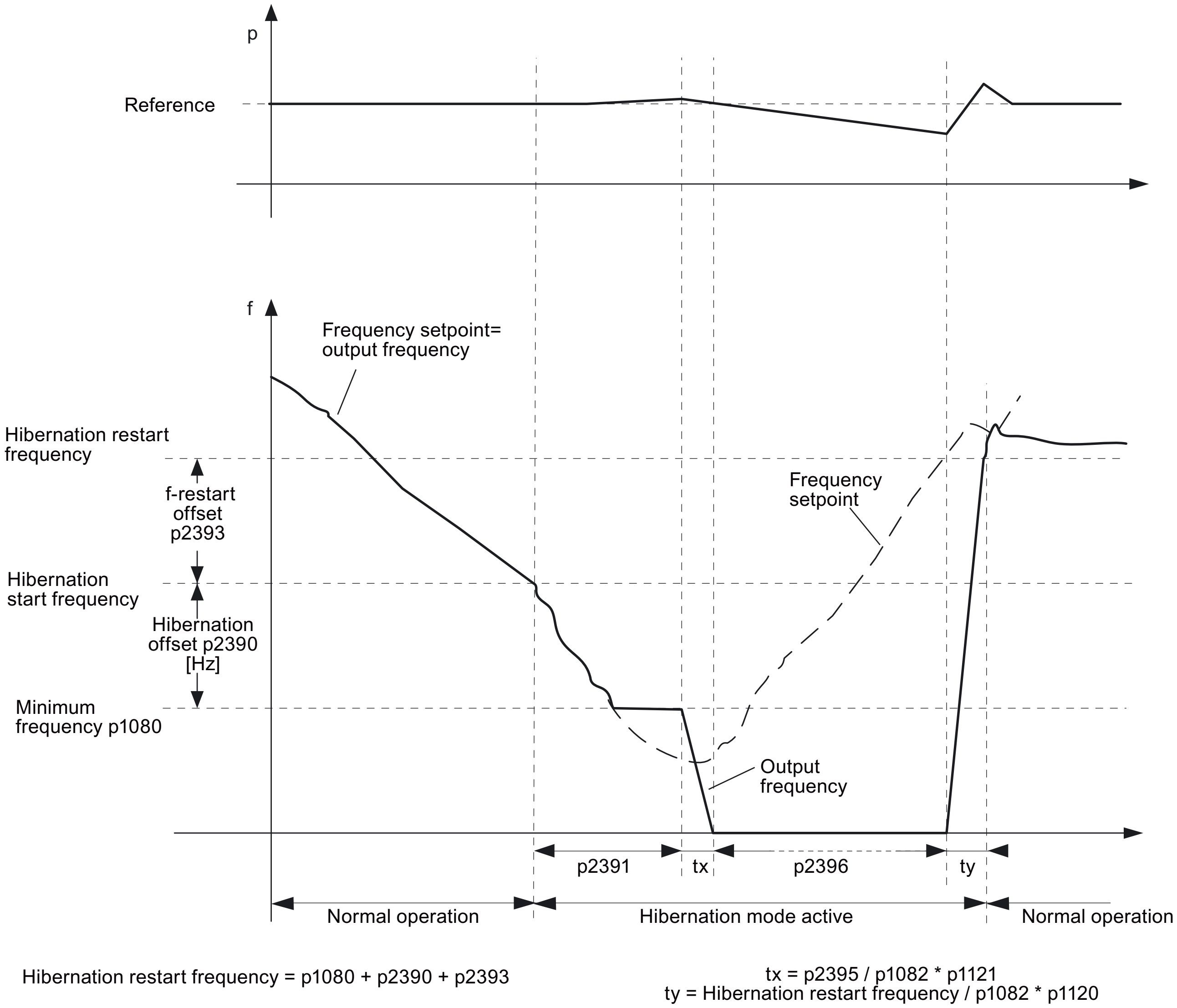


Figure 4-4 Hibernation using an external setpoint without hibernation boost

Adjustable parameters for the hibernation mode function

Table 4- 1 Main function parameters

Parameters	Description
P2200 = …	**Enable technology controller** (only necessary if the technology setpoint is used as the main or supplementary setpoint) 0: Technology controller deactivated (factory setting), 1: Technology controller activated
P2251 = …	**Technology controller mode** (only necessary if the technology setpoint is used as the main or supplementary setpoint) 0: Technology controller as main setpoint (factory setting), 1: Technology controller as supplementary setpoint
P2398 = …	**Hibernation mode** 0: Hibernation disabled (factory setting) 1: Hibernation enabled
P2390 = …	**Hibernation start speed** 0 (factory setting) ... 650 Hz. Once this frequency is exceeded, the hibernation delay time starts and shuts down the motor once the time set there has elapsed. The hibernation start frequency is entered as an offset to the minimum frequency P1080.
P2391 = …	**Hibernation delay time** 0 ... 3599 s (factory setting 120). The hibernation delay time starts as soon as the output frequency of the inverter drops below the hibernation start frequency p2930. If the output frequency increases above this threshold during the delay time, the hibernation delay time is aborted. Otherwise, the motor is switched off after the delay time has expired (if necessary, after a short boost).
P2392 = …	**Hibernation restart value,** required if the technology setpoint is used as the main setpoint. The restart value p2392 must be specified as a percentage. As soon as the technology setpoint exceeds the hibernation restart value, the inverter switches to normal operation and the motor starts up with a setpoint of 1.05 * (p1080 + p2390).
P2393 = …	**Hibernation restart speed (Hz),** required in the case that a setpoint is externally entered. The motor starts as soon as the setpoint exceeds the restart frequency. The restart frequency is calculated as follows: Absolute restart frequency = P1080 + p2390 + p2393 P1080 = minimum frequency p2390 = hibernation start frequency p2393 = hibernation restart frequency
P2394 = …	**Hibernation boost duration** 0 (factory setting) … 3599 s. Before the inverter switches over to hibernation mode, the motor is accelerated for the time set in p2394 according to the acceleration ramp, but not to more than the speed set in P2395.
P2395 = …	**Hibernation boost speed** 0 (factory setting) ... 650 Hz. Before the inverter switches over to hibernation mode, the motor is accelerated for the time set in p2394 according to the acceleration ramp, but not to more than the speed set in P2395. **Caution:** Make sure that the hibernation boost does not cause any overpressure or overflows.
P2396 = …	**Maximum hibernation shutdown time** 0 (factory setting) … 863999 s. At the expiration of this time at the latest, the inverter switches to normal operation and is accelerated up to the start speed. (P1080 + P2390). If the inverter is switched to normal operation in advance, the shutdown time is reset to the value set in this parameter.

Table 4- 2 Additional commissioning parameters

Parameters	Description
P1080 = …	**Minimum frequency** 0 (factory setting) ... 650 Hz. Lower limit of the motor speed, independent of the frequency setpoint.

Display parameters

Parameters	Description
r2397	**Current boost or start speed** Current boost speed before the pulses are inhibited or the current start speed after the restart.
r2399	**Hibernation status word** 00 Hibernation enabled (P2398 <> 0) 01 Hibernation active 02 Hibernation delay time active 03 Hibernation boost active 04 Hibernation motor switched off 05 Hibernation motor switched off, cyclical restart active 06 Hibernation motor restarted 07 Hibernation supplies the total setpoint of the ramp-function generator 08 Hibernation bridges the ramp-function generator in the setpoint channel

4.5 Operating hours counter and other important inverter data

Total system runtime

The total system runtime is displayed in r2114.

- Index 0: Milliseconds
- Index 1: Days

When r2114.0 = 86,400,000 (24 hours) is reached, it is reset to 0 and r2114.1 is incremented by 1.

The value is saved when the system is switched off and the count continues once it is switched back on.

Relative system runtime

The relative system runtime, the time since the last ON command, is displayed in p0969 in milliseconds. The counter runs over after 49 days.

Operating hours counter for the fan

The operating hours of the fan in the Power Module are displayed in p0251. The parameter can be set to 0, for example, after a fan change.

Other important data

CU SW version	r0018
Current pulse frequency	p1800
Output reactor	p0230
Connected motor	p0300:
Gating unit operating mode	p1810

For details about individual parameters, please refer to the List Manual.

4.6 Changing the phase in the case of incorrect direction of rotation without reconnection

Features

- No change to the speed/torque setpoint and actual value.
- Only possible when the pulses are inhibited

Description

The output direction of rotation of the inverter can be reversed via p1820. This means that the rotating field can be changed without having to interchange the power connections.

Important parameters, for details refer to the List Manual

- r0069 Phase current, actual value
- r0089 Actual phase voltage
- p1820 Direction of rotation reversal of the output phases (vector)

4.7 Motor data identification and rotating measurement

Description

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

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

Both types can be selected via p1900 as follows:

- p1900 = 0: => No motor data identification
- p1900 = 1: => Standstill measurement (p1910 = 1) and rotating measurement (p1960 = 1)
- p1900 = 2: => Standstill measurement (p1910 = 1)

If a permanent-magnet synchronous motor is used (p0300 = 2), the pole position identification is activated with p1900 > 1, using the p1980 setting.

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

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

Note

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

The status of the motor data identification can be read out from parameter r3925.

Identifications refer only to the active drive data set (DDS).

⚠ DANGER

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

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

Motor data identification (p1910)

Motor data identification with p1910 is used for determining motor parameters at standstill:

- Equivalent circuit diagram data p1910 = 1

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

Table 4- 3 Data determined using p1910

	Induction motor	Permanent-magnet synchronous motor
p1910 = 1	• Stator resistance (p0350) • Rotor resistance (p0354) • Stator leakage inductance (p0356) • Rotor leakage inductance (p0358) • Magnetizing inductance (p0360) • Drive converter valve threshold voltage (p1825) • Drive converter valve interlocking times (p1828 ... p1830)	• Stator resistance (p0350) • Stator resistance q axis (p0356) • Stator inductance d axis (p0357) • Drive converter valve threshold voltage (p1825) • Converter valve interlocking times (p1828 ... p1830)

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

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

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

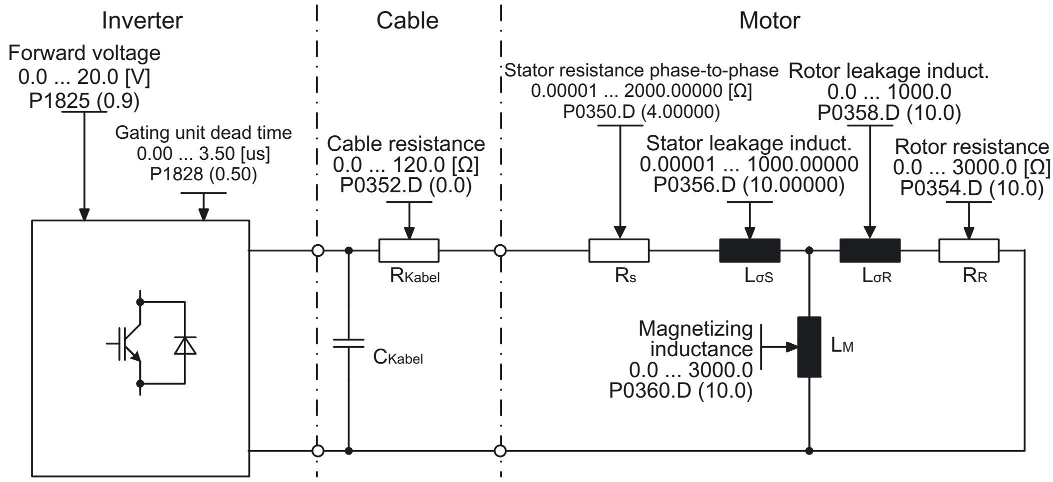


Figure 4-5 Equivalent circuit diagram for induction motor and cable

If an output filter (see p0230) is available, the data for this must also be entered before the standstill measurement.

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

Note

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

Note

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

Note

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

Motor data identification sequence

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

Rotating measurement (p1960)

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

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

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

The same applies to the speed in p1961, with which the saturation characteristic is determined.

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

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

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

- Before connecting the load, a complete "rotating measurement" (p1960 = 1) should be executed. 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 performed by selecting parameter p1960 (p1960 = 3). During the speed optimization, the saturation characteristic recording is automatically deactivated in parameter p1959.

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 for induction motors:
  - Measurement of the saturation characteristic (p0362 to p0369)
  - Measurement of the magnetization current (p0320) and determination of the offset voltage of the inverter for offset compensation
- Speed controller optimization
  - p1470 and p1472, if p1960 = 1
  - Kp adaptation switch-off
- Acceleration pre-control setting (p1496)
- Setting for ratio between the total moment of inertia and that of the motor (p0342)

Note

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

DANGER

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

Important parameters, for details refer to the List Manual

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

Rotating measurement

- 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
- p1980 Pole position identification technique

Motor data identification at standstill

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

4.8 Efficiency optimization

Description

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

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

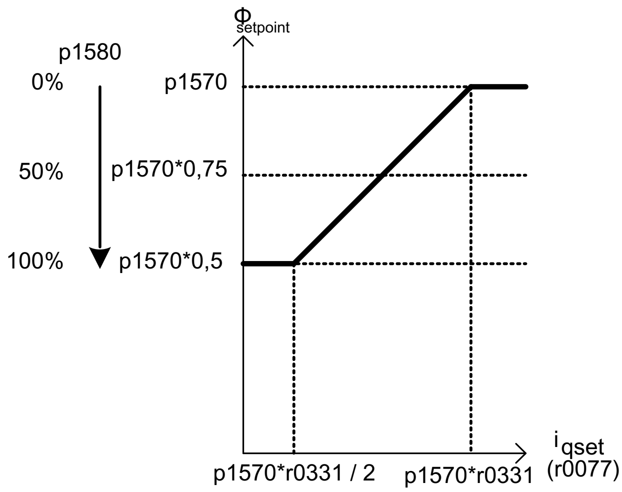


Figure 4-6 Efficiency optimization

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

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

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

For function diagrams, see the List Manual

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

Important parameters, for details refer to the List Manual

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

4.9 Technology controller

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 fed in via an analog input. A PT1000 or NI1000 temperature sensor can be used as sensors for the closed-loop temperature control. See also Sensors for temperature control (Page 42) .

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.

4.9.1 Features

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

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

The technology controller features:

- Two scalable setpoints
- Scalable output signal
- Separate fixed values
- Integrated motorized potentiometer
- The output limits can be activated and deactivated via the ramp-function generator.

- The D component can be switched to the control deviation or actual value channel.
- The motorized potentiometer of the technology controller is only active when the drive pulses are enabled.

4.9.2 Examples

Level control

The objective here is to maintain a constant level in the container.

This is carried out by means of a variable-speed pump in conjunction with a sensor for measuring the level.

The level is determined via an analog input 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.

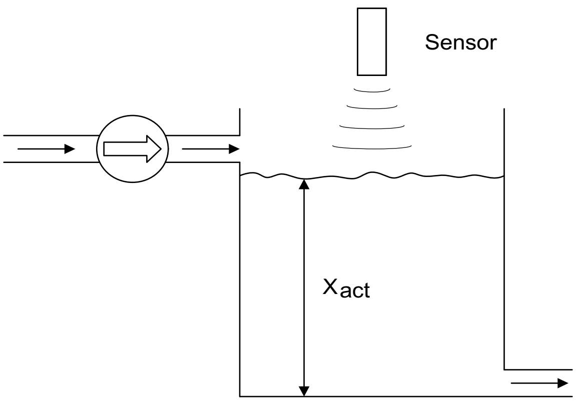


Figure 4-7 Level control application

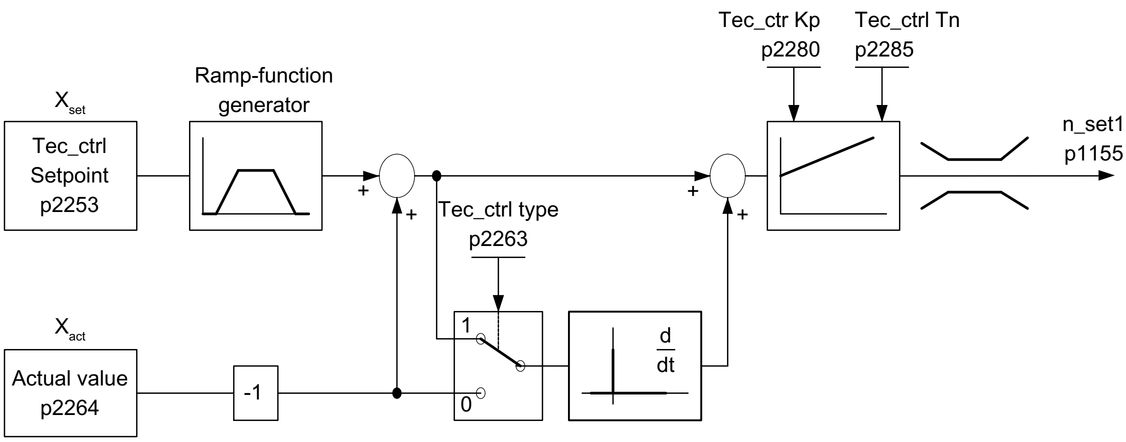


Figure 4-8 Level control: Controller structure

Table 4- 4 Important parameter settings for the level control

Parameter	Meaning	Example
p1155	n_setp1 downstream of RFG	p1155 = r2294 Tec_ctrl output_sig [FP 3080]
p2200	BI: Technology controller enable	p2200 = 1 Technology controller enabled
p2253	CI: Technology controller setpoint 1	p2253 = r2224 Fixed setpoint active [FP 7950]
p2263	Technology controller type	p2263 = 1 D component in fault signal [FP 7958]
p2264	CI: Technology controller actual value (X_{ACTUAL})	p2264 = r0755[1] analog input AI1
p2280	Technology controller p-gain	p2280 Determine by optimization
p2285	Technology controller integral action time	p2285 Determine by optimization

4.9.3 Integration

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

For function diagrams, see the List Manual

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

Important parameters, for details refer to the 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, starting value
- r2245 CO: Technology controller motorized potentiometer, setpoint before RFG
- p2247[0...n] Technology controller motorized potentiometer, ramp-up time
- p2248[0...n] Technology controller motorized potentiometer, ramp-down time
- r2250 CO: Technology controller motorized potentiometer, setpoint after RFG

Closed-loop control

- p2200 BI: Technology controller enable
- p2253[0...n] CI: Technology controller setpoint 1
- p2254 [0...n] CI: Technology controller setpoint 2
- p2255 Technology controller setpoint 1 scaling
- p2256 Technology controller setpoint 2 scaling
- p2257 Technology controller ramp-up time
- p2258 Technology controller ramp-down time
- p2261 Technology controller setpoint filter time constant
- p2263 Technology controller type
- p2264[0...n] CI: Technology controller actual value
- p2265 Technology controller actual value filter time constant
- p2280 Technology controller proportional gain
- p2285 Technology controller integral action time
- p2289[0...n] CI: Technology controller pre-control signal
- p2295 Technology controller output scaling

4.9.4 Sensors for temperature control

Temperature measurement via PT1000/NI1000

The temperature-dependent PT1000 or NI1000 resistors can be used as sensors for the technology controller. The values of these sensors are entered as actual values for the controller via analog input 2 (p2264 = 0756).

The connection is established at AI2 (terminals 50, 51) or AI3 (terminals 52, 53). The sensor type is set in p0756.

- NI1000 measuring range: - 88 °C … 165 °C (p0756 = 6)
- Pt1000 measuring range: - 88 °C … 240 °C (p0756 = 7)

For temperatures outside this range, alarm A03520 "Temperature sensor error" is output.

More detailed information is provided in r2124. The following is applicable:

- r2124 = 21 (hex) => sensed via AI2, wire breakage or sensor not connected
- r2124 = 22 (hex) => sensed via AI2, short circuit
- r2124 = 31 (hex) => sensed via AI3, wire breakage or sensor not connected
- r2124 = 32 (hex) => sensed via AI3, short circuit

Additional information is provided in the parameter list.

5 Closed-loop and open-loop control functions

5.1 V/f control

5.1.1 Introduction

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

- Pumps and fans
- Belt drives

and other similar processes.

V/f control aims to maintain a constant flux Φ in the motor. whereby the flux is proportional to the magnetization current (Iμ) or the ratio of voltage (U) to frequency (f).

Φ ~ Iμ ~ V/f

The torque (M) generated by the induction motors is, in turn, proportional to the product (or, more precisely, the vector product (Φ x I)) of the flux and current.

M ~ Φ x I

To generate as much torque as possible with a given current, the motor must function using the greatest possible constant flux. To maintain a constant flux (Φ), therefore, the voltage (V) must be changed in proportion to the frequency (f) to ensure a constant magnetization current (Iμ). V/f characteristic control is derived from these basic premises.

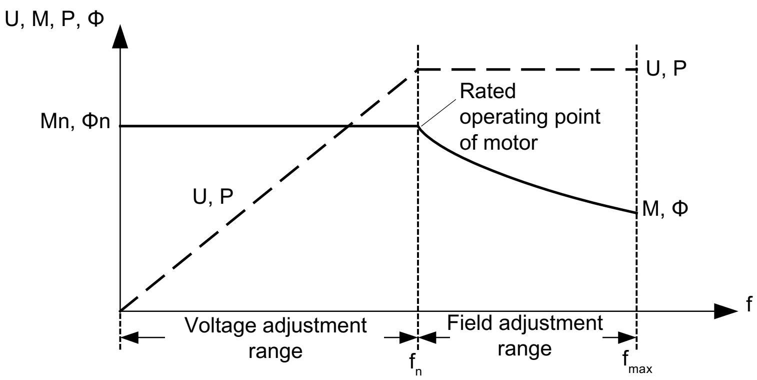
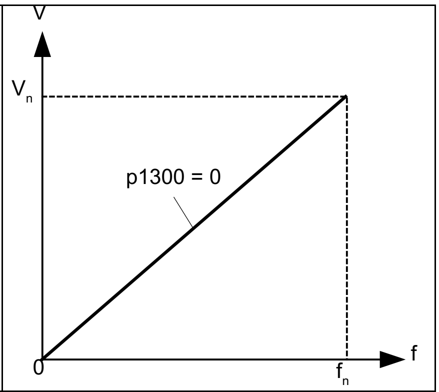
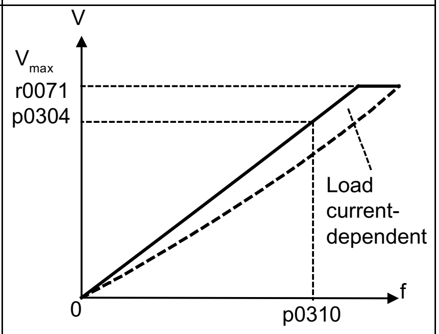
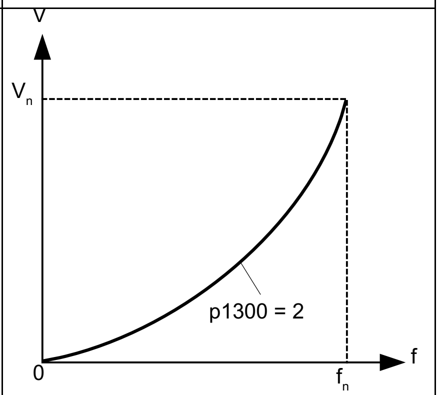
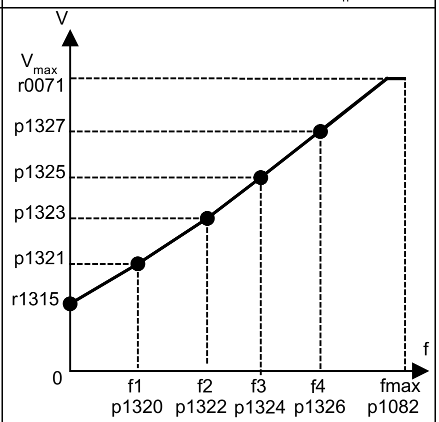
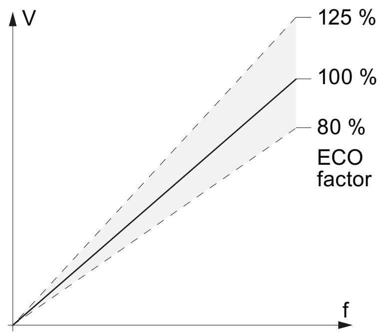


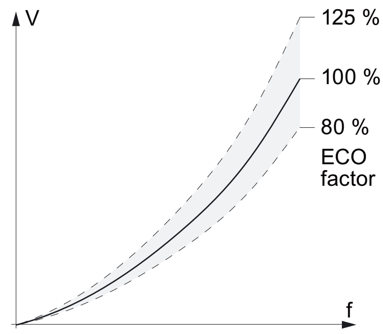
Figure 5-1 Operating areas and characteristic curves for the induction motor with inverter supply

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

Table 5- 1 V/f characteristic (p1300)

P1300 = 0 linear characteristic Standard (w/o voltage boost)	
P1300 = 1 linear characteristic with flux current control (FCC) Characteristic that compensates for voltage losses in the stator resistance for static / dynamic loads (flux current control FCC). This is particularly useful for small motors, since they have a relatively high stator resistance.	
P1300 = 2 parabolic characteristic Characteristic that takes into account the motor torque curve (e.g. fan/pump). a) Quadratic characteristic (f^2 characteristic) b) Energy saving because the low voltage also results in small currents and drops.	
P1300 = 3 programmable characteristic Characteristic that takes into account motor/machine torque curve (e.g. synchronous motor).	

<table>
<tr><td>P1300 = 4 ECO mode with linear characteristic
P1300 = 7 ECO mode with parabolic characteristic
The ECO mode is suitable for applications with a low dynamic response and allows energy savings of up to 40 %.
It uses an algorithm that approaches the optimum operating point of the motor (essentially dependent on the load and the speed) in the range of 80 ... 125% of the setpoint voltage. The algorithm is activated if the setpoint is reached and remains unchanged for 5 s. It is deactivated when the setpoint changes or if the Vdc_max or Vdc_min controller is active. In such cases the inverter accelerates to 100% of the voltage setpoint.
Dependencies to be observed in ECO mode:
For ECO mode, the slip compensation should be set to 100 % in order to maintain a stable actual value. To ensure error-free functioning in ECO mode, the ramp-function generator tolerance (p1148) should be reduced.
To allow ECO mode to also be used with (minor) setpoint fluctuations, the ramp-function generator tolerance can be increased via p1148.
Note: The current ECO factor is output in r1348.
Important: Sudden load variations can cause the motor to stall.</td><td>

ECO, linear


ECO, parabolic</td></tr>
<tr><td colspan="2">P1300 = 5 precise frequency drives
Characteristic that takes into account the technological particularity of an application (e.g. textile applications):
a) whereby the current limitation (Imax controller) only affects the output voltage and not the output frequency, or
b) by disabling slip compensation</td></tr>
<tr><td colspan="2">P1300 = 6 precise frequency drive with flux current control (FCC)
Characteristic that takes into account the technological particularity of an application (e.g. textile applications):
a) whereby the current limitation (Imax controller) only affects the output voltage and not the output frequency, or
b) by disabling slip compensation
Voltage losses in the stator resistance for static / dynamic loads are also compensated (flux current control FCC). This is particularly useful for small motors, since they have a relatively high stator resistance.</td></tr>
<tr><td colspan="2">P1300 = 19 independent voltage setpoint
The output voltage of the inverter can be input independently of the speed via the BICO parameter p1330 either via the fieldbus interface or an analog input.</td></tr>
</table>

5.1.2 Voltage boost

With low output frequencies, the V/f characteristics yield only a low output voltage. Along with the influence of the ohmic resistance at low frequencies, this can lead to too low an output voltage. To avoid this, a voltage boost can be set via parameters p1310 to p1312 in order 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.

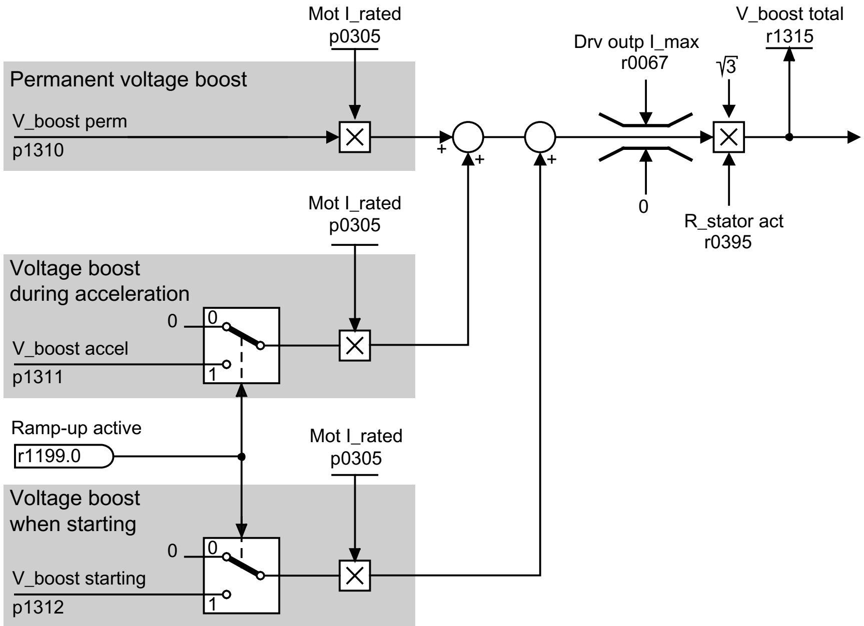


Figure 5-2 Voltage boost total

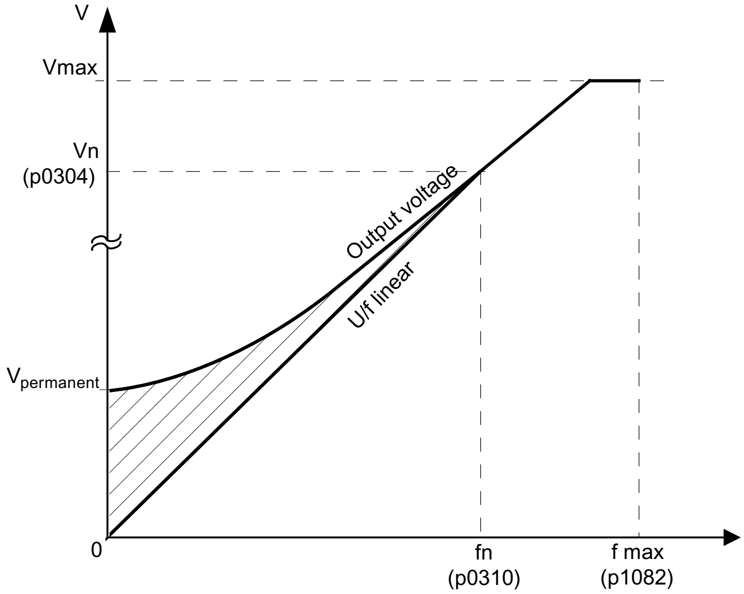
Note

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

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

Permanent voltage boost (p1310)

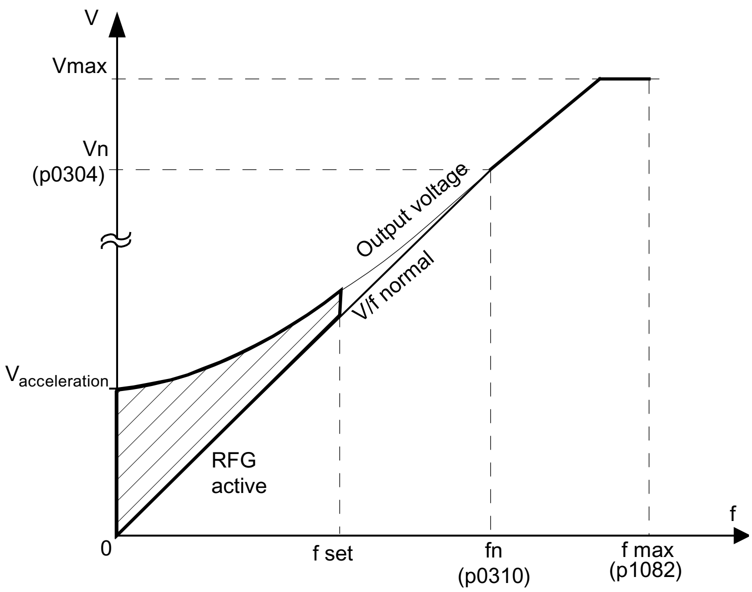
The voltage boost takes effect across the entire frequency range, whereby the value at high frequencies continuously decreases.



$V_{permanent}$ = p0305 (rated motor current) x
r0395 (actual stator resistance) x
p1310 (permanent voltage boost)

Voltage boost at acceleration (p1311)

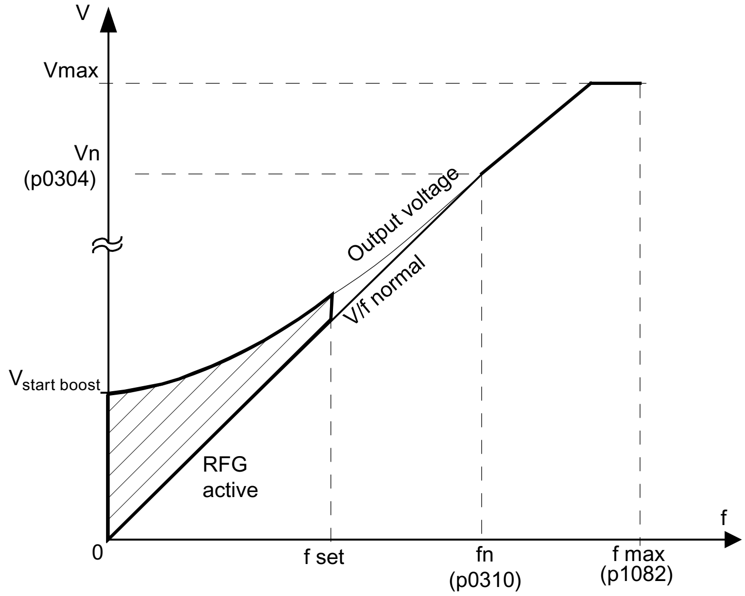
Voltage boost at acceleration is effective if the ramp-function generator provides the feedback signal "ramp-up active" (r1199.0 = 1).



$V_{acceleration}$ = p0305 (rated motor current) x
r0395 (actual stator resistance) x
p1311 (voltage when accelerating)

Voltage boost during ramp-up (p1312)

The voltage boost only takes effect when accelerating from standstill.



$V_{start\ boost}$ = p0305 (rated motor current) x
r0395 (actual stator resistance) x
p1312 (voltage boost when starting)

For function diagrams, see the List Manual

- 6300 V/f characteristic and voltage boost

Important parameters, for details refer to the List Manual

- p0304[0...n] Rated motor voltage
- p0305[0...n] Rated motor current
- r0395[0...n] Stator resistance current
- p1310[0...n] Voltage boost permanent
- p1311[0...n] Voltage boost at acceleration
- p1312[0...n] Voltage boost on starting
- r1315 Voltage boost total

5.1.3 Slip compensation

Description

Slip compensation is an additional V/f control function. It ensures that the setpoint speed n_{set} of induction motors is maintained at a constant level irrespective of the load (torque M_1 or M_2).

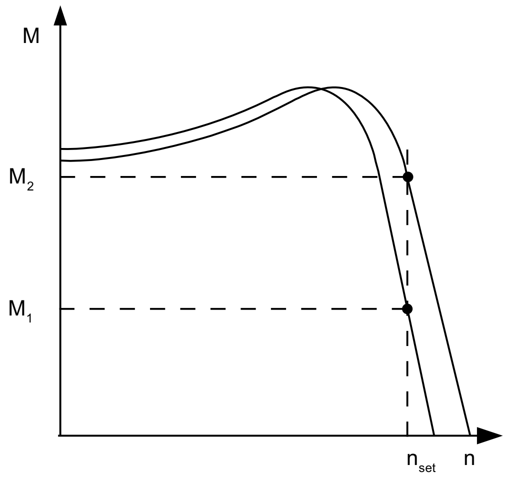


Figure 5-3 Slip compensation

Important parameters, for details refer to the List Manual

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

5.1.4 Vdc control with V/f control

Function dependent on the Power Module

This function only applies in conjunction with PM240 Power Modules. With PM250 or PM260 Power Modules, the VDC control cannot be used.

Description

The Vdc control 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 the regenerative mode and is supplying too much energy to the DC link.
  - Remedy: Reduce the regenerative torque to maintain the DC link voltage within permissible limits. With the Vdc controller activated, the inverter may automatically extend the ramp down time of a drive if the shutdown supplies too much energy to the DC link. This process is called Vdc_max control.
- 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. This procedure is called Vdc_min control or kinetic buffering.

Properties

Vdc control is composed of the Vdc_max control and the Vdc_min control (kinetic buffering). It uses a technology controller via which the dynamic factor is set higher or lower for the Vdc_min and Vdc_max control independently.

- Vdc_max control

  This function can be used to control momentary regenerative load without shutdown using "overvoltage in the DC link".

- 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 decelerating the drive.

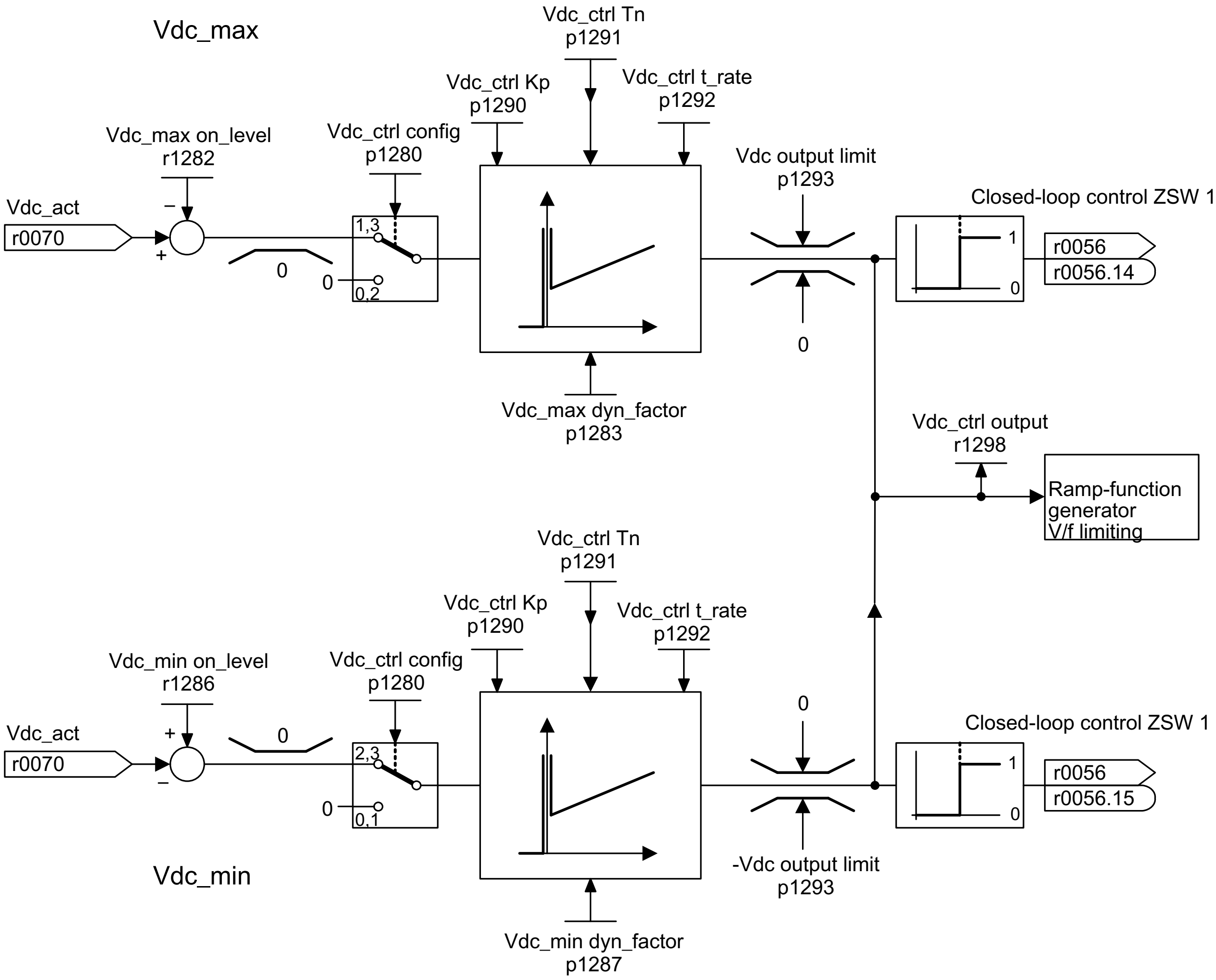


Figure 5-4 Vdc control V/f

Vdc_max control

Note

The Vdc_max control must be deactivated to operate the inverter with a braking resistor.

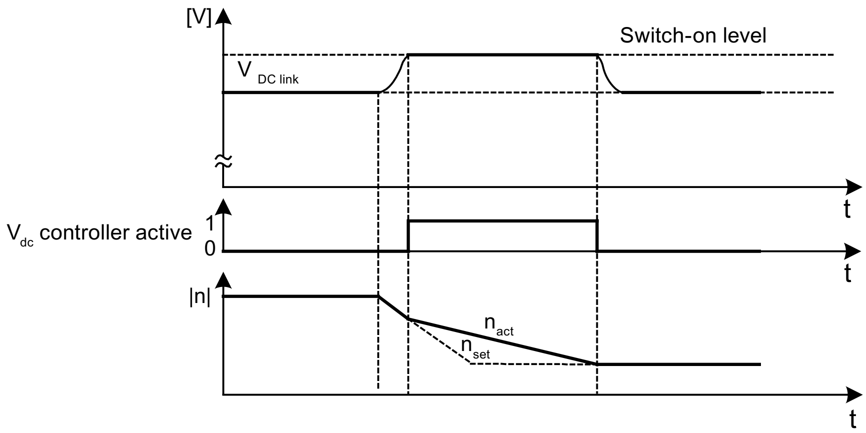


Figure 5-5 Switching Vdc_max control on/off

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

- When the function for automatically detecting the switch-on level is switched off (p1294 = 0)
  r1282 = 1.15 * sqrt(2) *p0210 (device supply voltage).
- When the function for automatically detecting the switch-on level is switched on (p1294 = 1)
  r1282 = Vdc_max - 50 V (Vdc_max: overvoltage threshold of the Power Module)

Vdc_min control

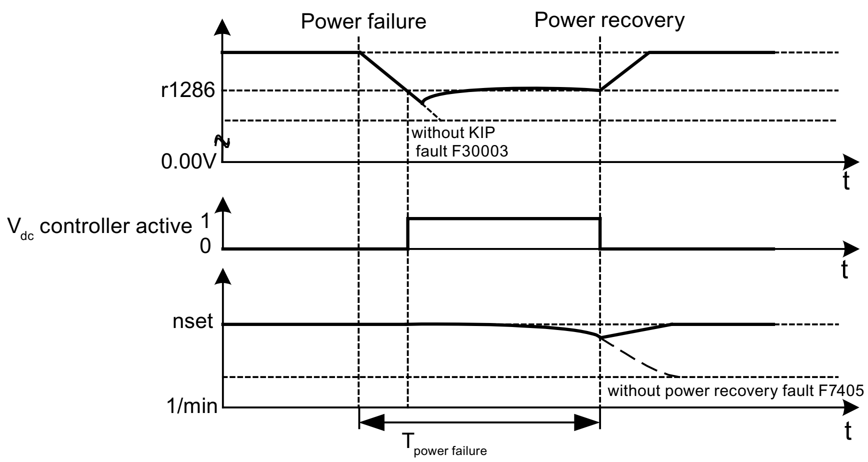


Figure 5-6 Switching Vdc_min control on/off (kinetic buffering)

In the event of a power failure, Vdc_min control is activated when the Vdc_min switch-on 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 the Vdc_min control is deactivated again at 5 % above the Vdc_min switch-on level. The motor continues operating normally.

If the power supply is not restored, the motor speed continues to drop. When the threshold in p1297 is reached, fault message F07405 is output (minimum speed of the kinetic buffering fallen below). If p1296 is also set to 1, after the time set in p1295 has expired (maximum kinetic buffering duration exceeded) then fault message F07406 is output with the selected response (factory setting: OFF3).

Note

The full functionality of the Vdc_min control can only be used if, when the line supply fails, the inverter is not disconnected from the line supply - e.g. by a contactor that drops out.

For this particular case, the contactor must be supplied with a power source that is independent of the inverter power supply.

For function diagrams, see the List Manual

- 6320 Vdc_max controller and Vdc_min controller

Important parameters, for details refer to the List Manual

- p1280[0...n] Vdc controller configuration (V/f)
- r1282 Vdc_max controller switch-on level (V/f)
- p1283[0...n] Vdc_max controller dynamic factor (V/f)
- p1285[0...n] Vdc_min controller switch-on level (kinetic buffering) (V/f)
- r1286 Vdc_min controller switch-on 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[0...n] Vdc controller output limiting (V/f)
- p1294 Vdc_max controller automatic detection ON signal level (V/f)
- p1295[0...n] 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 CO: Vdc controller output (V/f)

5.2 Vector control

Advantages of vector control

Sensorless vector control (SLVC) has the following advantages compared with vector V/f control:

- 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 torque
- Motor protection via variable torque limitation in both motor and regenerative mode
- Drive and braking torque controlled independently of the speed
- Maximum breakaway torque possible at speed 0

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

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

Description

The CU230P-2 uses sensorless vector control (SLVC). With this control type, 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 frequencies of around 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.

⚠ CAUTION
Orientation loss, e.g. due to a motor overload If the inverter loses orientation, it is not possible to switch off via an OFF1 or OFF3 command. In this case, it is necessary to trigger an OFF2 command or to inhibit the pulses via r0054.3.

The changeover from closed-loop to open-loop operation is carried out in accordance with the following figure. If both the setpoint at the input of the ramp-function generator and the actual value lie below $f_{\text{open-loop controlled}}$, there is an immediate switchover to open-loop operation.

$$f_{\text{open loop}} = \text{p1755 [Hz]} * \frac{\text{p1756 [\%]}}{\text{100 [\%]}}$$

Example of fset < 0.5 x fopen loop and fact > fopen loop

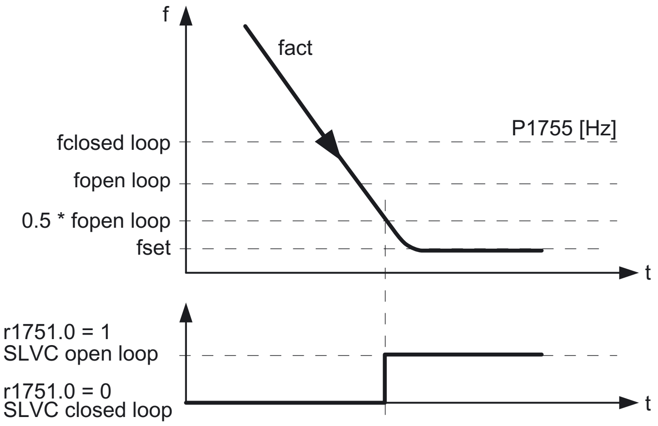


Figure 5-7 Changeover condition during the startup phase for SLVC

The changeover from open-loop to closed-loop operation is carried out in accordance with the following figure. If the actual value exceeds the value of p1755, there is an immediate changeover to closed-loop operation - without waiting for the time set in p1759.

Example of fset >fclosed loop and fact > fopen loop

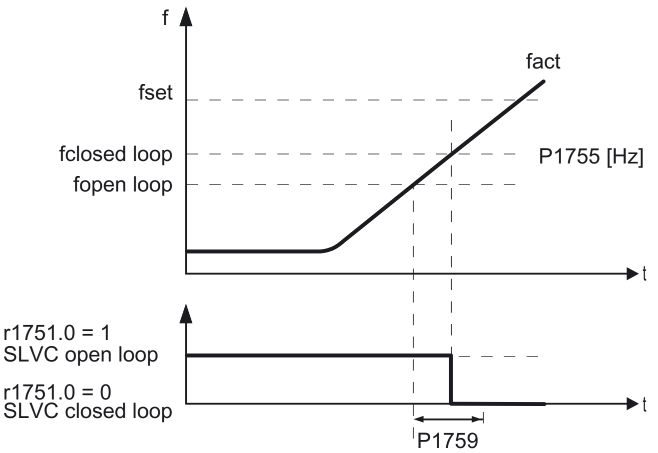


Figure 5-8 Changeover condition during the run-down phase up to a negative setpoint for SLVC

Example of changeover condition during the startup phase up to a negative setpoint: |fset| > 0.5 x fopen loop

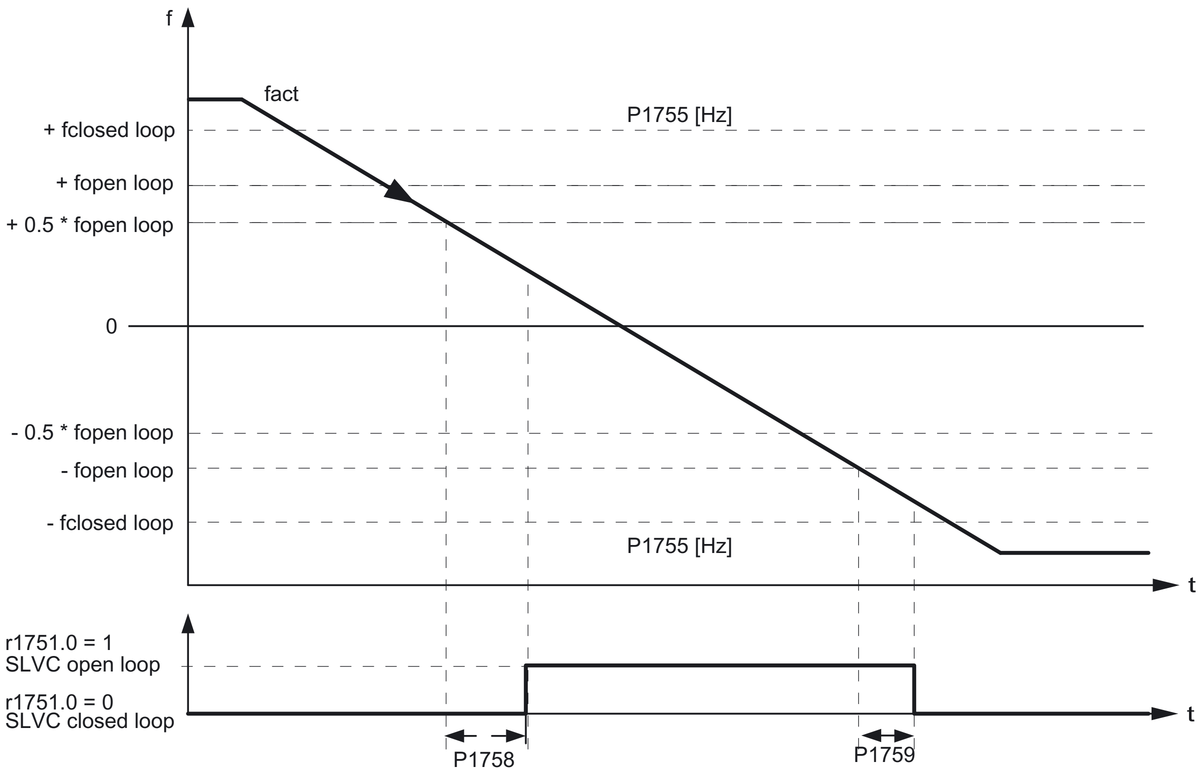


Figure 5-9 Changeover condition during the run-down phase up to a negative setpoint for SLVC

Note

A permanent torque increase can be parameterized with p1610 and a torque increase for acceleration with p1611 for the open-loop control range (i.e. for low speeds). This can prevent the motor from stalling at speeds in this range. Factory setting is 50 % for p1610 and 0 % for p1611.

Long ramp up and ramp down times in particular may require a torque increase to be programmed with p1610 and p1611.

For vector control without an actual speed value encoder, the inverter has the following prominent features in the lower frequency range compared to other AC inverters:

- Closed-loop operation down to ≈ 1 Hz
- Can be started in closed-loop operation (directly after switching on the motor)
- Passes through the low-frequency range (0 Hz) in closed-loop operation

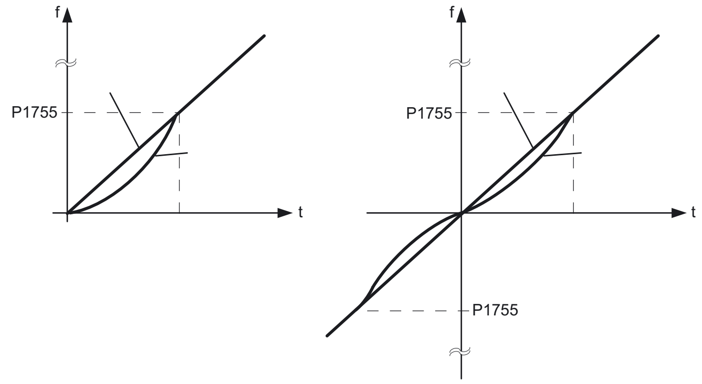


Figure 5-10 Starts up and passes through 0 Hz in closed-loop operation

Closed-loop operation up to a value of around 1 Hz (selection via parameter P1755) offers the following advantages, as well as the option for closed-loop controlled immediate start at 0 Hz or closed-loop controlled direction reversal (set via parameter 1750):

- No changeover required within closed-loop control (smooth operation - no dips in frequency)
- Continuous speed-torque control possible up to around 1 Hz.

Note

During closed-loop controlled direction reversal or the closed-loop controlled start from 0 Hz, it is important to take into account that a changeover is made from closed-loop to open-loop operation automatically if the system remains in the 0 Hz range for too long (> 2 s or > P1758).

For function diagrams, see the List Manual

- 6730 Interface to the Power Module for induction motor (p0300 = 1)

Important parameters, for details refer to the List Manual

Adjustable parameters

- p1400 Speed control configuration
- p1452 Filter time for act. speed (SLVC)
- p1470 Gain speed controller (SLVC)
- p1472 Integral time n-ctrl. (SLVC)
- p1477 Set integrator of n-ctrl.
- p1478 Set integrator value n-ctrl.
- p1488 Droop source
- p1489 Droop scaling
- p1492 Enable droop
- p1496 Scaling speed pre-control
- p1499 Scaling accel. torque control

- p1500 Selection of torque setpoint
- p1501 Change to torque control
- p1503 Speed setpoint
- p1511 Supplementary torque setpoint
- p1520 Upper torque limit
- p1521 Lower torque limit
- p1522 Upper torque limit
- p1523 Lower torque limit
- p1525 Scaling lower torque limit
- p1530 Motoring power limitation
- p1531 Regenerative power limitation
- p1570 Fixed value flux setpoint
- p1574 Dynamic voltage reserve
- p1580 Efficiency optimization
- p1582 Smooth time for flux setpoint
- p1596 Int. time field weak. controller
- p1610 Cont. torque boost (SLVC)
- p1611 Acc. torque boost (SLVC)
- p1654 Smooth time for Isq setpoint
- p1715 Gain current controller
- p1717 Integral time current controller
- p1740 Gain for oscillation damping
- p1745 Flux variance limit in stall
- p1750 Control word of motor model
- p1755 Start-freq. motor model (SLVC)
- p1756 Hyst.-freq motor model (SLVC)
- p1758 T (delay) transit to pre-ctrl mode
- p1759 T (delay) transit to cl.-lp operation
- p1764 Kp of n-adaptation (SLVC)
- p1767 Tn of n-adaptation (SLVC)
- p1780 Control word of Rs/Rr adaptation

Display parameters

- r1407 Status 2 of motor control
- r1438 Freq. setpoint to controller
- r1445 Act. filtered frequency
- r1482 Integral output of n-ctrl.
- r1490 Droop frequency
- r1508 Torque setpoint
- r1515 Additional torque setpoint
- r1518 Acceleration torque
- r1526 Upper torque limitation
- r1527 Lower torque limitation
- r1536 Max. trq. motoring current
- r1537Max. trq. regenerative current
- r1538 Upper torque limit (total)
- r1539 Lower torque limit (total)
- r1583 Flux setpoint (smoothed)
- r1597 Outp. field weak. controller
- r1598 Flux setpoint (total)
- r1718 Output of Isq controller
- r1719 Integral output of Isq ctrl.
- r1723 Output of Isq controller
- r1724 Integral output of Isq ctrl.
- r1725 Integral limit of Isd ctrl
- r1728 Decoupling voltage
- r1746 Current flux variance
- r1751 Status word of motor model
- r1770 Prop. output of Xm adaptation
- r1771 Int. output of n-adaptation
- r1778 Flux angle difference

5.2.1 Vdc control with vector control

Function dependent on the Power Module

This function only applies in conjunction with PM240 Power Modules. With PM250 or PM260 Power Modules, the VDC control cannot be used.

Description

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

- Overvoltage in the DC link
  - Typical cause: The drive is operating in regenerative mode and is supplying too much energy to the DC link.
  - Remedy: Reduce the regenerative torque to maintain the DC link voltage within permissible limits. With the Vdc controller activated, the inverter may automatically extend the ramp down time of a drive if the shutdown supplies too much energy to the DC link. This process is called Vdc_max control.
- 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. This procedure is called Vdc_min control or kinetic buffering.

Properties

The Vdc control comprises the components of the Vdc_max control and the Vdc_min control (kinetic buffering), which are independent of one another.

It uses a PID controller that can be set to be either softer or harder using a dynamic factor that can be separately set for the Vdc_min and Vdc_max controls.

- Vdc_max control

  This function can be used to control momentary regenerative load without shutdown using "overvoltage in the DC link".
- 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 decelerating the drive.

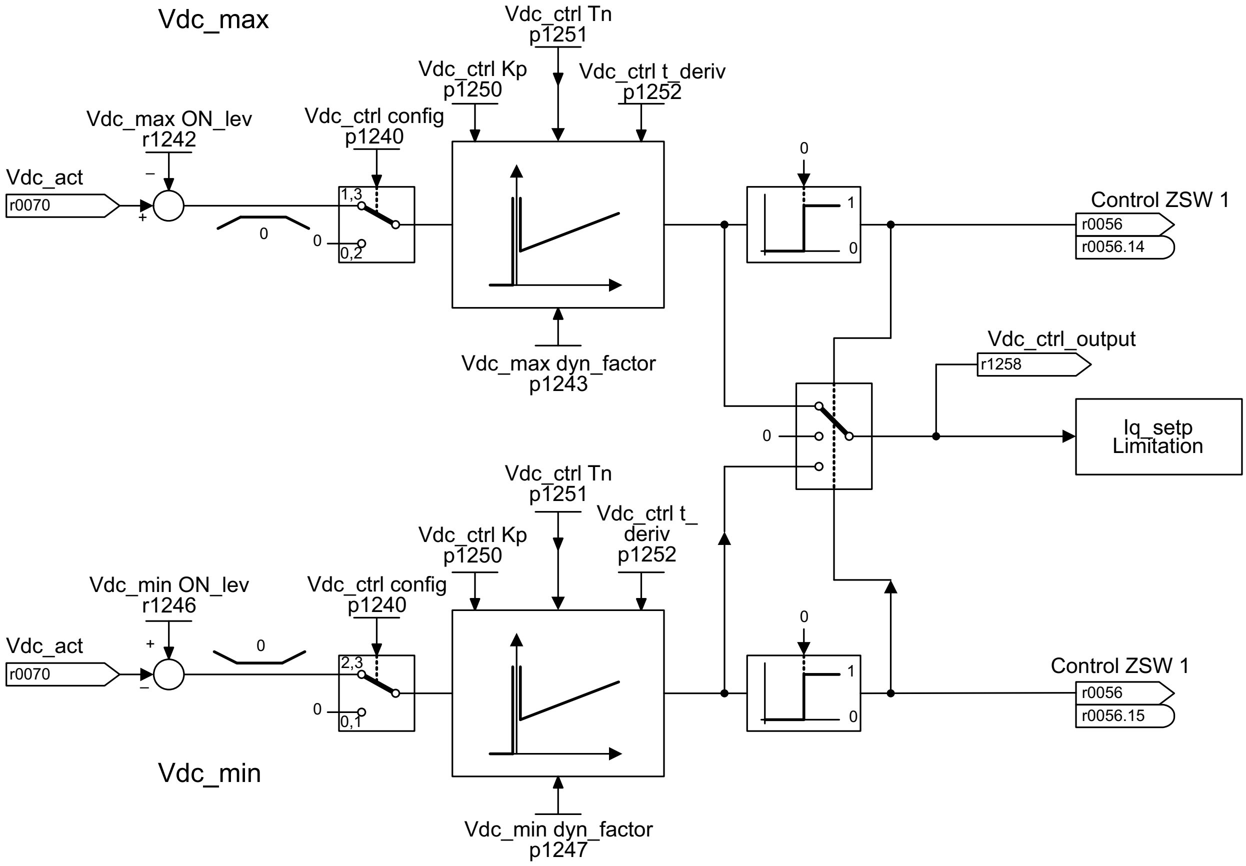


Figure 5-11 Vdc control vector

Vdc_max control

Note

The Vdc_max control must be deactivated to operate the inverter with a braking resistor.

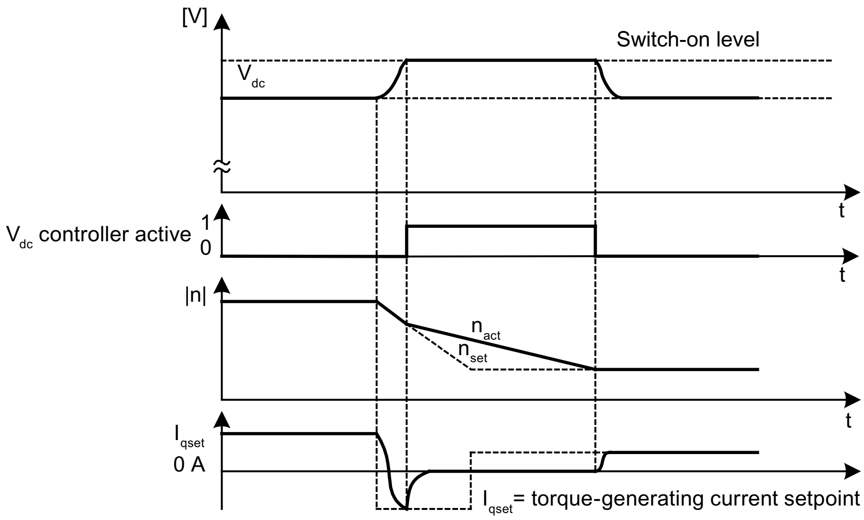


Figure 5-12 Switching Vdc_max control on/off

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

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

Vdc_min control

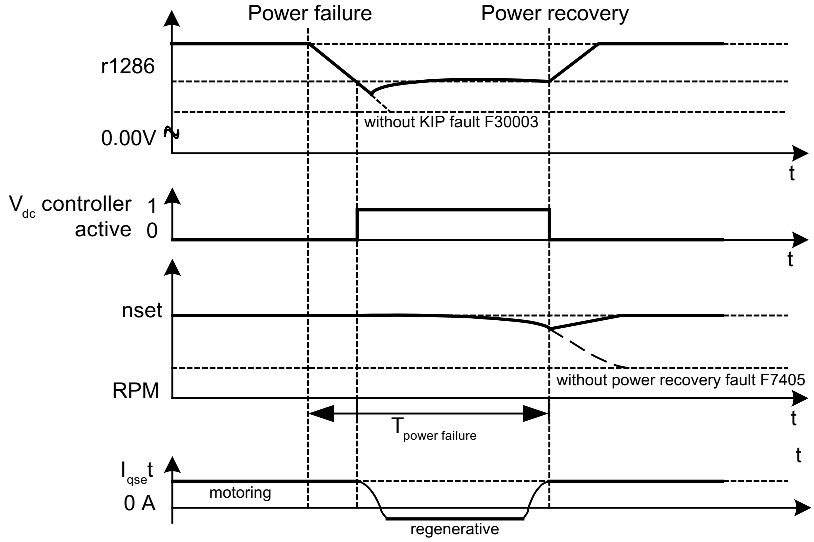


Figure 5-13 Switching Vdc_min control on/off (kinetic buffering)

In the event of a power failure, Vdc_min control is activated when the Vdc_min switch-on 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 the Vdc_min control is deactivated again at 5 % above the Vdc_min switch-on level. The motor continues operating normally.

If the power supply is not restored, the motor speed continues to drop. When the threshold in p1257 is reached, fault message F07405 is output (minimum speed of the kinetic buffering fallen below). If p1256 is also set to 1, after the time set in p1255 has expired (maximum kinetic buffering duration exceeded) then fault message F07406 is output with the selected response (factory setting: OFF3).

Note

The full functionality of the Vdc_min control can only be used if, when the line supply fails, the inverter is not disconnected from the line supply - e.g. by a contactor that drops out.

For this particular case, the contactor must be supplied with a power source that is independent of the inverter power supply.

For function diagrams, see the List Manual

- 6220 Vdc_max controller and Vdc_min controller

Important parameters, for details refer to the List Manual

- p1240[0...n] Vdc controller or Vdc monitoring configuration
- r1242 Vdc_max controller switch-on level
- p1243[0...n] Vdc_max controller dynamic factor (control)
- p1245[0...n] Vdc_min controller switch-on level (kinetic buffering) (control)
- r1246 Vdc_min controller switch-on level (kinetic buffering) (control)
- p1247[0...n] Vdc_min controller dynamic factor (kinetic buffering) (control)
- p1250[0...n] Vdc controller proportional gain (control)
- p1251[0...n] Vdc controller integral time (control)
- p1252[0...n] Vdc controller derivative-action time (control)
- p1254 Vdc_max controller automatic detection ON level (control)
- p1256[0...n] Vdc_min controller response (kinetic buffering) (control)
- p1257[0...n] Vdc_min controller speed threshold (controller)
- r1258 CO: Vdc controller output (control)

5.2.2 Speed controller

The CU230P uses sensorless closed-loop speed control (SLVC); it contains the following components:

- PI controller
- Speed controller pre-control
- Droop

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

Description

The speed controller receives its setpoint (r0062) from the setpoint channel and its actual value (r0063) indirectly via the motor model. The system deviation is increased by the PI controller and, in conjunction with the pre-control, results in the torque setpoint.

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

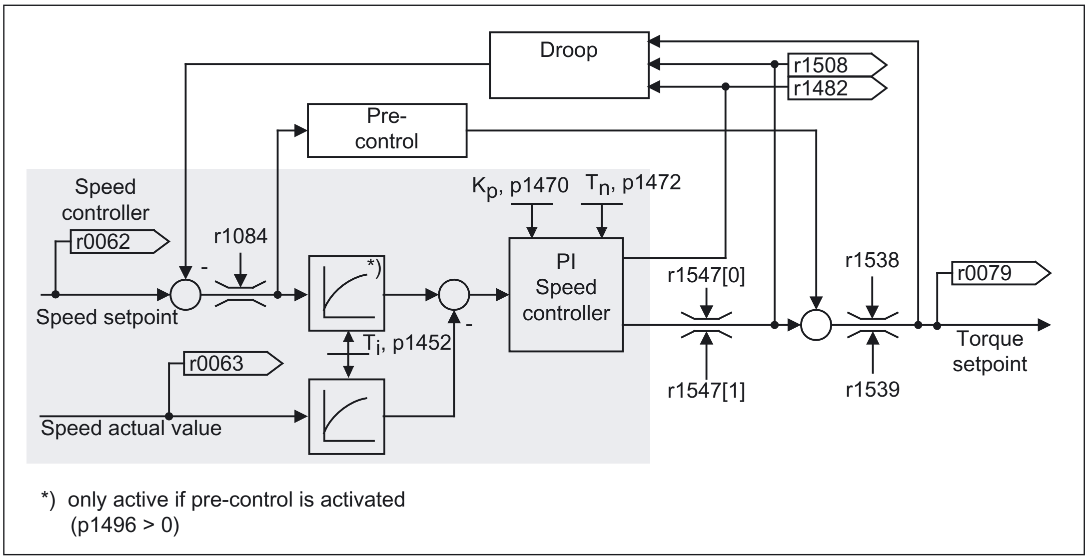


Figure 5-14 Speed control - Overview

The optimum speed controller setting can be determined via the automatic speed controller optimization function (p1960 = 1, rotating measurement).

If the inertia load has been specified, the speed controller (Kp, Tn) can be calculated by means of automatic parameterization (p0340 = 4).

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 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).

For function diagrams, see the List Manual

- 6040 Speed controller

Important parameters, for details refer to the List Manual

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

5.2.2.1 Speed controller adaptation

Description

The speed controller adjustment is carried out via the free Kp_n adaptation

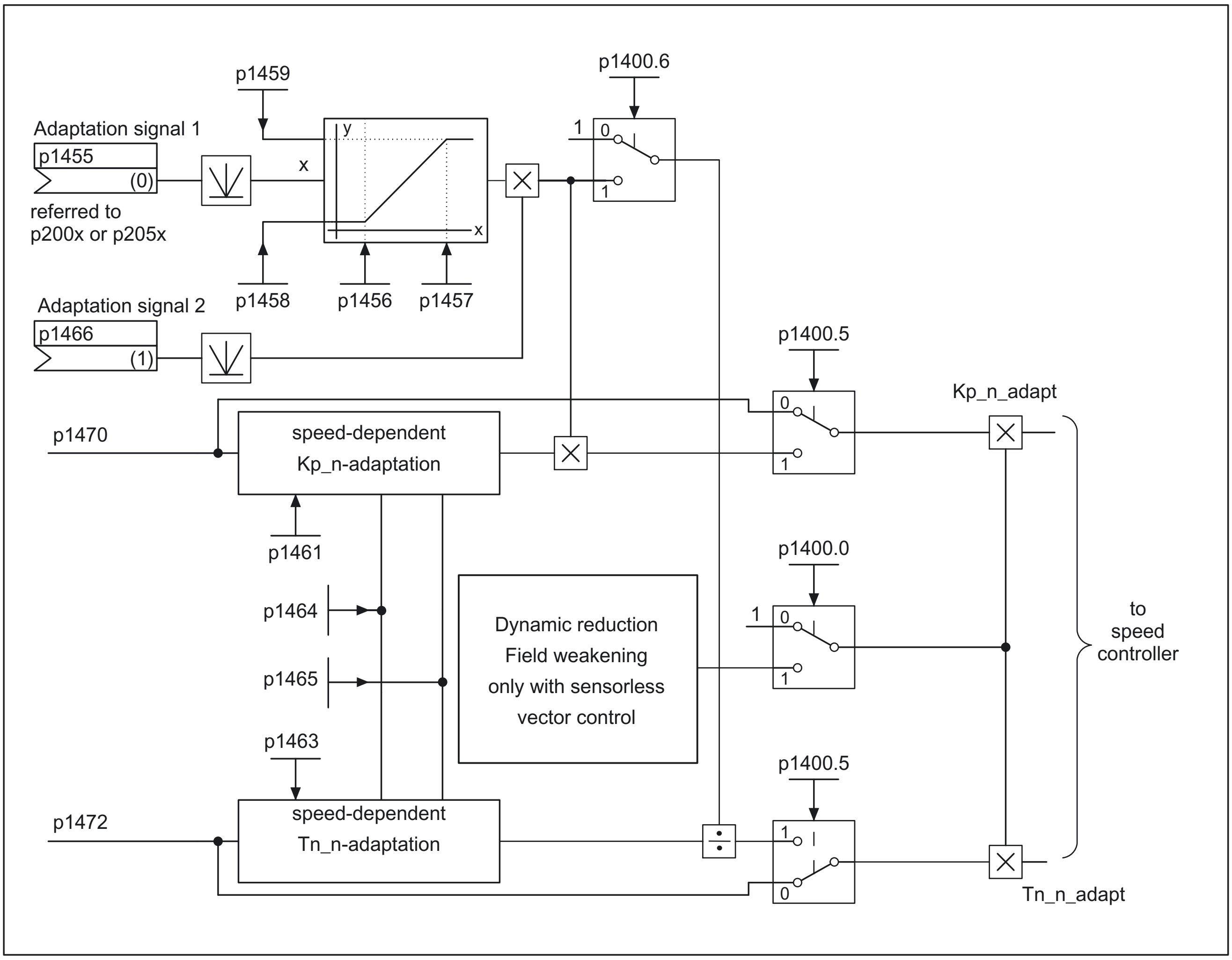


Figure 5-15 Kp_n-/Tn_n adaptation

In the field-weakening range, a dynamic response reduction can be activated via p1400.0. This is activated when the speed controller is optimized in order to achieve a greater dynamic response in the basic speed range.

Parameterization

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

For function diagrams, see the List Manual

- 6050 Kp_n and Tn_n adaptation

Important parameters, for details refer to the List Manual

- p1400 Speed control configuration
- p1470 Speed controller encoderless operation P-gain
- p1472 Speed controller encoderless operation integral-action time

Free Kp_n adaptation

- p1455 CI: Speed controller P gain adaptation signal
- p1456 Speed controller P gain adaptation lower starting point
- p1457 Speed amplifier, P gain adaptation upper starting point
- p1458 Adaptation factor lower
- p1459 Adaptation factor upper
- p1461 Speed controller P gain adaptation speed, upper
- p1463 Speed controller integral action time adaptation speed, upper
- p1464 Speed controller adaptation speed, lower
- p1465 Speed controller adaptation speed, upper
- p1466 CI: Speed controller P gain scaling

5.2.2.2 Speed controller pre-control

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

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

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

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

Note

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

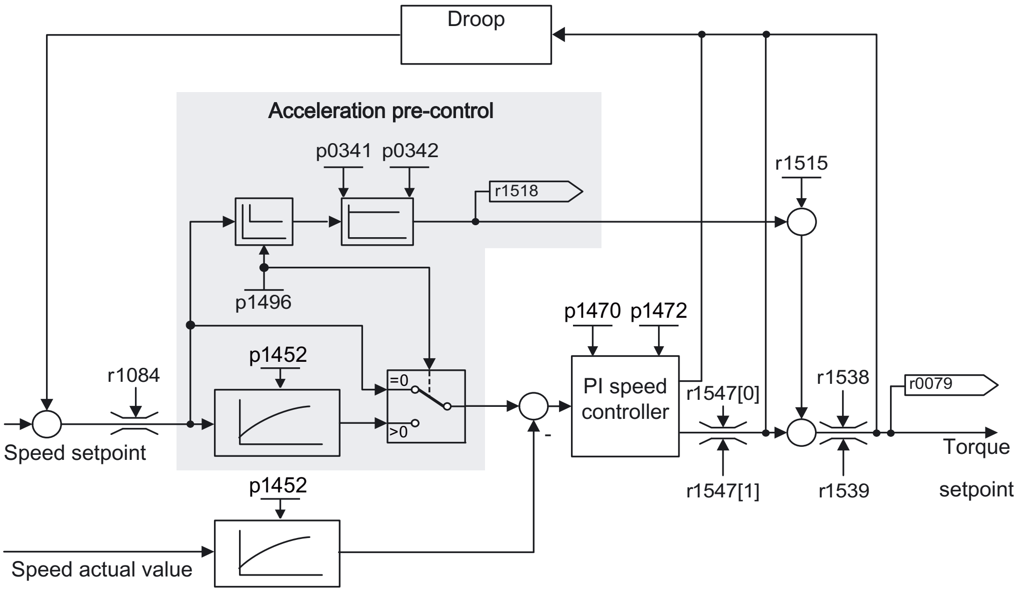


Figure 5-16 Speed controller with pre-control

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 (p1452) as the actual value (r1445). This ensures that no target/actual difference (r0064) occurs at the controller input during acceleration, which would be attributable solely to the signal propagation time.

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

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

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

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

Note

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

For function diagrams, see the List Manual

- 6031 Pre-control balancing, acceleration model
- 6040 Speed controller

Important parameters, for details refer to the List Manual

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

5.2.2.3 Droop

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

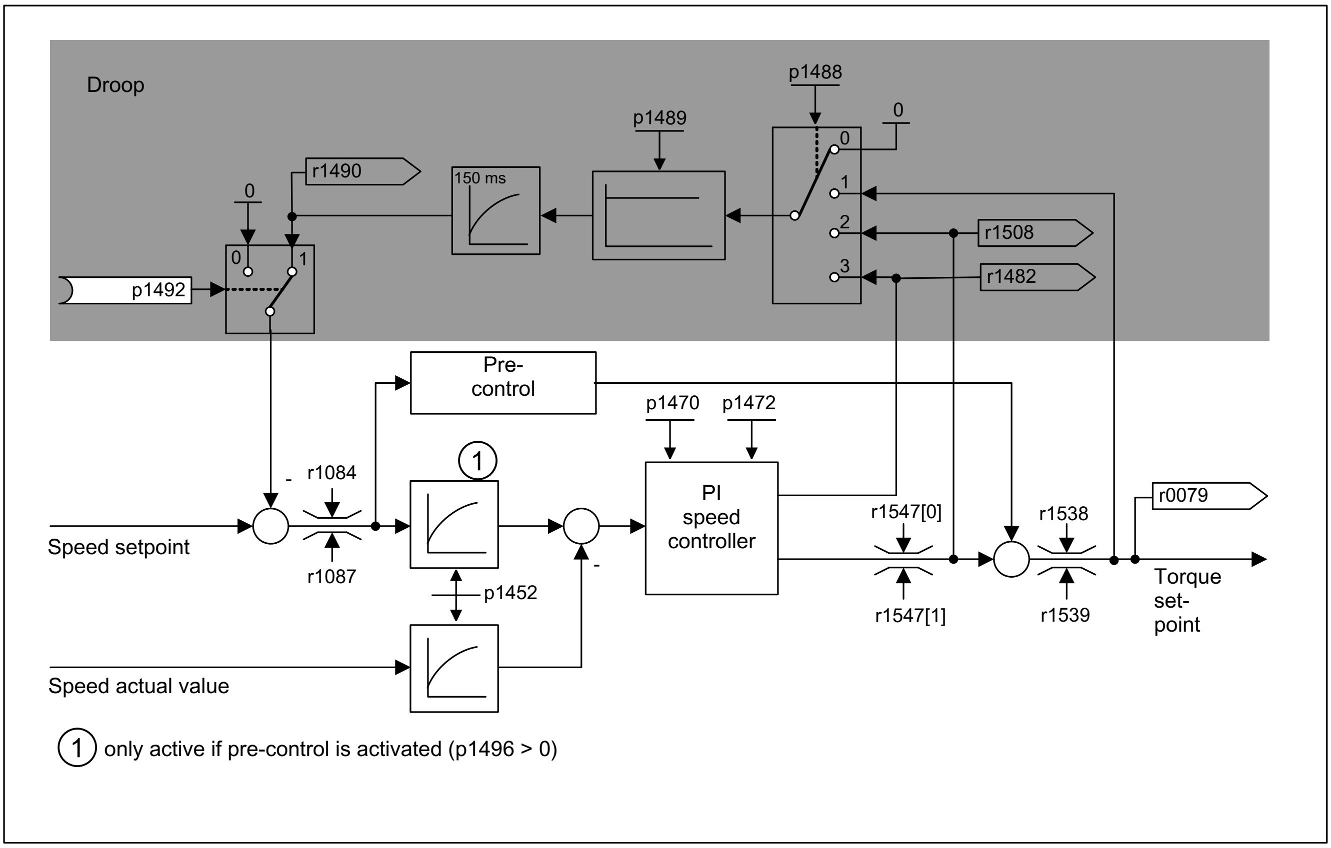


Figure 5-17 Speed controller with droop

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

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

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

Prerequisites

- All connected drives must be operated with speed control.
- Only a single common ramp-function generator may be used for mechanically coupled drives.

For function diagrams, see the List Manual

- 6030 Speed setpoint, droop, acceleration model

Important parameters, for details refer to the 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

5.2.3 Torque control

In the case of speed control, p1300 = 20, it is possible to switch to torque control (slave drive) via BICO parameter p1501. This changeover is not possible if torque control is selected directly via p1300 = 22 or 23. The torque setpoint and/or additional setpoint can be entered via BICO parameter p1503 (CI: torque setpoint) or p1511 (CI: supplementary torque setpoint). The supplementary torque is active both with torque and speed control. This particular feature with the supplementary torque setpoint allows a pre-control torque to be applied for speed control.

Note

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

Any accumulated regenerative energy must be either fed back into the supply system or converted into heat via a braking resistor.

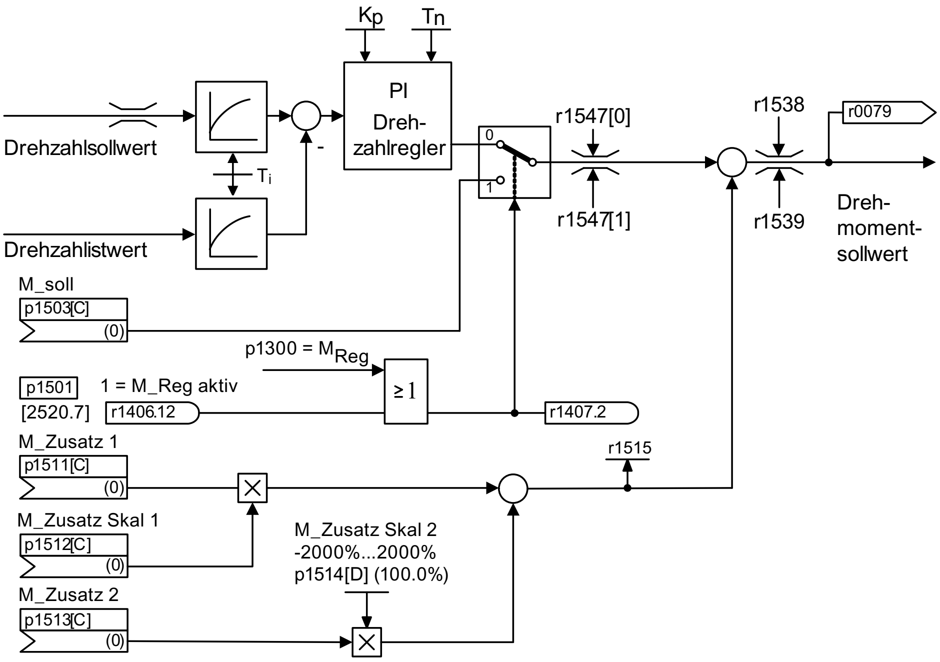


Figure 5-18 Closed-loop speed/torque control

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

A "real" closed-loop torque control (with a speed that automatically sets itself) is only possible in the closed-loop control range but not in the open-loop control range of the sensorless closed-loop vector control. In open-loop control, the torque setpoint adjusts the setpoint speed via a ramp-function generator (integration time ~ p1499 x p0341 x p0342). For this reason, encoderless torque control at standstill is only suitable for applications that require an accelerating torque but no load torque (e.g. traction drives).

OFF responses

- OFF1 and p1300 = 22
  - Reaction as for OFF2
- OFF2
  - Immediate pulse suppression, the drive coasts to standstill.
  - The motor brake (if parameterized) is closed immediately.
  - Switching on inhibited is activated.
- OFF3
  - Switch to speed-controlled operation
  - n_set = 0 is input immediately to brake the drive along the OFF3 deceleration ramp (p1135).
  - The pulses are suppressed.
  - Standstill is detected when the actual speed value is less than the speed threshold (p1226) or when the monitoring time (p1227) that started when speed setpoint ≤ speed threshold (p1226) has expired.
  - Switching on inhibited is activated.

For function diagrams, see the List Manual

- 6060 Torque setpoint

Important parameters, for details refer to the List Manual

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

5.2.3.1 Torque limiting

Description

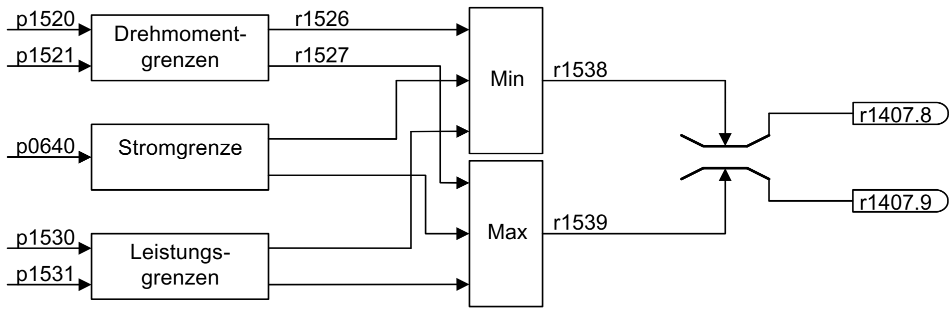


Figure 5-19 Torque limiting

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

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

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

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

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

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

These cyclical values therefore limit the torque setpoint at the speed controller output/torque input or indicate the instantaneous max. possible torque.

A torque limit that is active in the Power Module due to the values specified in 1538 and 1539 is displayed in:

- r1407.8 CO/BO: Upper torque limit active
- r1407.9 CO/BO: Lower torque limit active

For function diagrams, see the List Manual

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

5.2.4 Induction motors

5.2.4.1 Quick magnetization for induction motors

Description

This function can be used in conjunction with vector control.

With many crane applications, for example, multiple motors are operated alternately on one single inverter. Every time the data set for a different motor is selected, an undesirable delay occurs while the new motor becomes magnetized.

A significant reduction in these delays can be achieved with the quick magnetizing function.

Features

- Application for induction motors in closed-loop vector control.
- Fast flux build-up through injection of a field-generating current at the current limit, resulting in a significant reduction in magnetizing time.
- The "flying restart" function continues in parameter p0346.

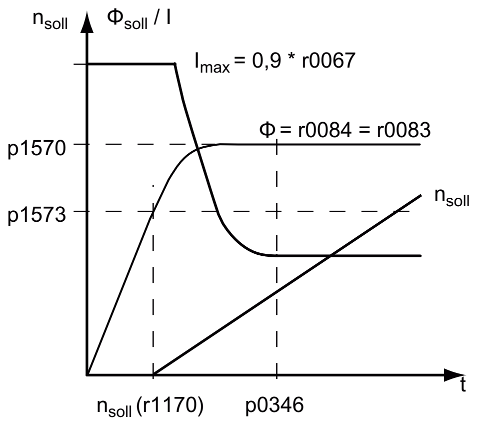


Figure 5-20 Quick magnetizing characteristics

Commissioning

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

This setting initiates the following sequence during motor starting:

- The field-producing current setpoint jumps to its limit value: 0.9*r0067 (I_{max}).
- The flux increases as fast as physically possible with the specified current.
- The flux setpoint r0083 is made to follow accordingly.

- As soon as the flux threshold value programmed in p1573 is reached (default 100 %, min.: 10 % and max. 200 %), excitation ceases and the speed setpoint is enabled. The flux threshold value must not be set too low for a large load because the torque-producing current is limited during magnetization.

Note

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

- The flux is increased further until the flux setpoint in p1570 has been reached.

Note

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

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

The stator resistance identification function is operative only in vector control mode; the setting in p0621 is ignored in V/f control mode.

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

Explanations of alarms and fault messages

A07416 Drive: Flux controller configuration

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

As these are data set-dependent parameters - p1401 and p0621 are DDS-dependent - the number of the data set is also specified in the fault value.

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

Remedy:
For fault code 1:

- Deactivate smooth starting: p1401 bit 0 = 0
- Deactivate quick magnetizing: p1401 bit 6 = 0

For fault code 2:

- Deactivate flux build-up control: p1401 bit 2 = 0
- Deactivate quick magnetizing: p1401 bit 6 = 0

For fault code 3:

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

In the STARTER, a consistency check is not necessary.

F07411 Drive: Flux controller output limited

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

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

Possible causes if the specified flux setpoint is not reached with configured quick magnetizing (p1401 Bit6 = 1), although 90 % of the maximum current has been specified.

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

Remedy:

- Correct the motor data.
- Check the motor connection type.
- Correct the current limits (p0640).
- Reduce the load on the induction motor.
- Possibly use a larger Power Module.
- Check the motor supply cable.

For function diagrams, see the List Manual

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

Important parameters, for details refer to the List Manual

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

5.2.4.2 Instructions for commissioning induction motors (ASM)

Equivalent circuit diagram for vector induction motor and cable

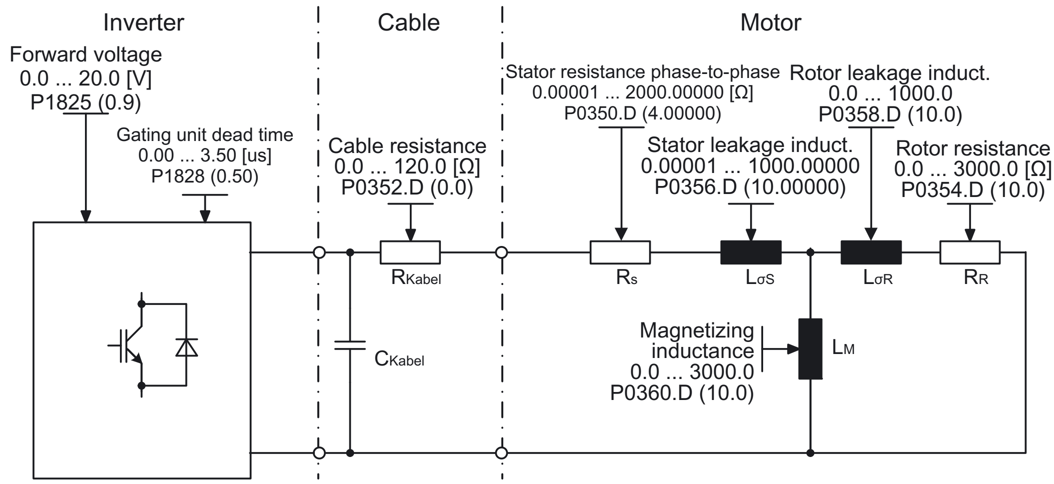


Figure 5-21 Equivalent circuit diagram for induction motor and cable

Induction motors, rotating

For commissioning with STARTER or IOP the following values should be available:

Table 5- 2 Motor data rating plate

Parameter	Description	Remark
p0304	Rated motor voltage	-
p0305	Rated motor current	-
p0307	Rated motor power	-
p0308	Rated motor power factor	-
p0310	Rated motor frequency	-
p0311	Motor rated speed	-
p0335	Motor cooling type	-

The following parameters should be entered provided they are known:

Table 5- 3 Optional motor data

Parameter	Description	Remark
p0320	Motor rated magnetization current/short-circuit current	If this value is not known, "0" can also be entered. Using this value, the stator leakage inductance can be more precisely calculated (p0356, p0357).
p0322	Maximum motor speed	-
p0341	Motor moment of inertia	-
p0342	Ratio between the total and motor moment of inertia	-
p0344	Motor weight	-
p0352	Cable resistance (component of the stator resistance)	-

Table 5- 4 Equivalent circuit diagram for motor data

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

Possible settings

- Field weakening up to approx. 1.2 * rated speed (this depends on the drive inverter supply voltage and the motor data, see also supplementary conditions)
- Flying restart (only possible with additional VSM)
- Vector closed-loop speed and torque control
- Vector V/f control for diagnostics
- Type of motor identification
- Speed controller optimization (rotating measurement)
- Thermal protection via temperature sensor (PTC/KTY)

Supplementary conditions

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

Commissioning procedure

Commissioning can be carried out via the STARTER or the IOP. Both tools provide user guidance.

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

5.3 Sinusoidal filter

Description

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

CAUTION
If a sine-wave filter is connected to the converter, the inverter must be activated during commissioning to prevent the filter from being destroyed.

Usage restrictions for sine-wave filters

The following restrictions must be taken into account when a sine-wave filter is used:

- The output frequency is limited to a maximum of 150 Hz, the pulse frequency must be set to 4 kHz.
- The modulation type (p1802) must be set to 3 or 4. This reduces the maximum output voltage to approx. 85 % of the rated output voltage.
- Maximum permissible motor cable lengths:
  - Unshielded cables: max. 150 m
  - Shielded cables: max. 100 m
- Other restrictions: see the Equipment Manual.

Note

If a filter cannot be parameterized (p0230 < 3), this means that a filter has not been provided for the component. In this case, the drive inverter must not be operated with a sine-wave filter.

Table 5- 5 Parameter settings for sine-wave filters

Order no.	Name	Setting
p0233	Power unit motor reactor	Filter inductance
p0234	Power unit sine-wave filter capacitance	Filter capacitance
p0290	Power unit overload response	Disable pulse frequency reduction
p1082	Maximum rotational speed	Fmax filter/pole pair number
p1800	Pulse frequency	Nominal pulse frequency of the filter
p1802	Modulator modes	Space vector modulation without overmodulation

Inputs and outputs 6

Overview

On the CU230P-2, there are the following digital or analog inputs/outputs

Three digital outputs	DO0 … DO2
Six digital inputs	DI0 ... DI5
Two analog inputs	AI0 … AI1
One analog output	AO0

6.1 Digital outputs

Properties

- Separate power supply
- Source can be adjusted via parameters
- Signal can be inverted via parameters
- Status as a binector or connector output signal

Note

Before the digital outputs can function, their own electronics power supply must be connected.

For function diagrams, see the List Manual

- 2230 Isolated digital outputs (DO 0 to DO 2)

6.2 Digital inputs

Properties

The digital inputs can be used both high-active and low-active, as well as isolated and non-isolated.

For the individual versions, the following interconnections are required:

High-active, non-isolated
(reference potential of the digital inputs is the ground of the Control Unit)

- Bridge terminal 28 with terminal 69
- Connect the inputs of the switches for the digital inputs to terminal 9 (+24 V OUT).

High-active, isolated

- External 24 V supply between terminal 69 and the inputs of the switches for the digital inputs (+24 V on terminal 69)

Low-active, non-isolated
(reference potential of the digital inputs is the ground of the Control Unit)

- Bridge terminal 9 with terminal 69
- Connect the inputs of the switches for the digital inputs to terminal 28 (GND).

Low-active, isolated

- External 24 V supply between terminal 69 and the inputs of the switches for the digital inputs (+0 V on terminal 69)

Additional properties:

- Fixed debouncing setting

  Delay time = 1 to 2 current controller cycles (p0115[0])
- Availability of the input signal for further interconnection
  – inverted and not inverted as a binector output
  – as a connector output
- Simulation mode settable and parameterizable.
- Sampling time for digital inputs/outputs adjustable on CU320 (p0799)

For function diagrams, see the List Manual

- 2220 Digital inputs, isolated (DI 0 ... DI 5)
- 2221 Analog inputs as digital inputs, (DI 11 ... DI 12)

6.3 Analog inputs

Properties

- Hardware input filter set permanently
- Simulation mode parameterizable
- Adjustable offset
- Inversion via binector input
- Adjustable absolute-value generation
- Noise suppression (p4068)
- Enabling of inputs via binector input
- Output signal as connector
- Scaling
- Smoothing
- Can be used as additional digital inputs

NOTICE
Scaling parameters p0757 to p0760 do not limit the voltage/current values.

For function diagrams, see the List Manual

- 9566 Analog inputs 0 and 1 (AI 0 and AI 1)
- 9568 Analog input 2 (AI 2)

6.4 Analog output

Properties

- Adjustable absolute-value generation
- Inversion via binector input
- Adjustable smoothing
- Adjustable transfer characteristic
- Output signal can be indicated via display parameter

NOTICE
Scaling parameters p0777 to p0780 do not limit the voltage/current values.

For function diagrams, see the List Manual

- 9572 Analog outputs (AO 0)

Setpoint channel 7

7.1 Description

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

The extended setpoint channel forms the connecting element between the setpoint source and the motor control. The inverter has a feature that enables the simultaneous input of setpoints from two independent setpoint sources. The generation and subsequent modification of the total setpoint (influencing the direction, skip frequency, up/down ramp) takes place in the extended setpoint channel.

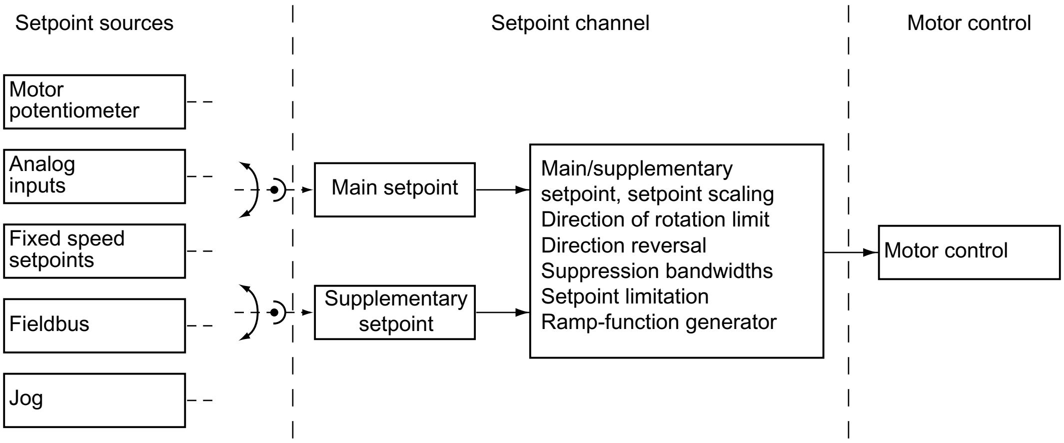


Figure 7-1 Overview of the extended setpoint channel

Control variables of the extended setpoint channel

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

Setpoint sources

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

There are various options for setpoint input:

- Fixed speed setpoints
- Motorized potentiometer
- Jog
- Fieldbus (e.g. setpoint via PROFIBUS)
- Via analog inputs (terminals)

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

7.2 Ramp function generator

Description

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

The maximum speed p1082[DDS] is used as a reference value for calculating the ramps of the ramp-function generator. A special adjustable ramp can be set via p1135 for quick stop (OFF3) (e.g. for rapid controlled deceleration after an EMERGENCY OFF).

- Functions of the ramp-function generator:
  - Acceleration and deceleration ramps
  - Ramp for quick stop (OFF3)
  - Setting values for the ramp-function generator

Properties of the ramp-function generator

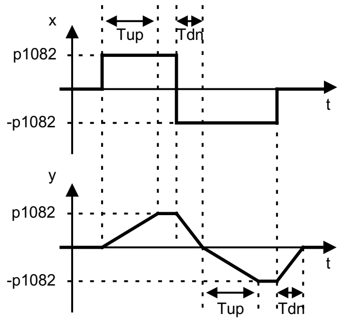


Figure 7-2 Acceleration and deceleration

Ramp-up time, Tup		p1120[DDS]
Ramp-down time, Tdn		p1121[DDS]
OFF 3 deceleration ramp OFF3 ramp-down time		p1135[DDS]
• Set ramp-function generator	Setting value of the ramp-function generator Set the ramp-function generator signal	P1144[CDS] p1143[CDS]
• Freezing the ramp-function generator (not in Jog mode r0046.31 = 0)		p1141

For function diagrams, see the List Manual

- 1550 Setpoint channel
- 3060 Ramp-function generator

Parameterization with STARTER

In the STARTER commissioning tool, the "Ramp-function generator" parameter screen is selected in the toolbar with the  icon:

Important parameters, for details refer to the List Manual

Adjustable parameters

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

Display parameters

- r1119 CO: Ramp-function generator setpoint at the input
- r1149 Ramp-function generator acceleration
- r1150 CO: Ramp-function generator speed setpoint at the output

7.3 Main/supplementary setpoint and setpoint modification

Description

Fine tuning (correction variable) often needs to be carried out on site for applications in which the control variables are generated by central control systems. This can be carried out conveniently with the help of the supplementarysetpoint, which is added to the main setpoint in the summation point.

Both variables are imported simultaneously via two separate or one setpoint source and added in the setpoint channel. Depending on the external conditions, the addition can be switched on or off dynamically.

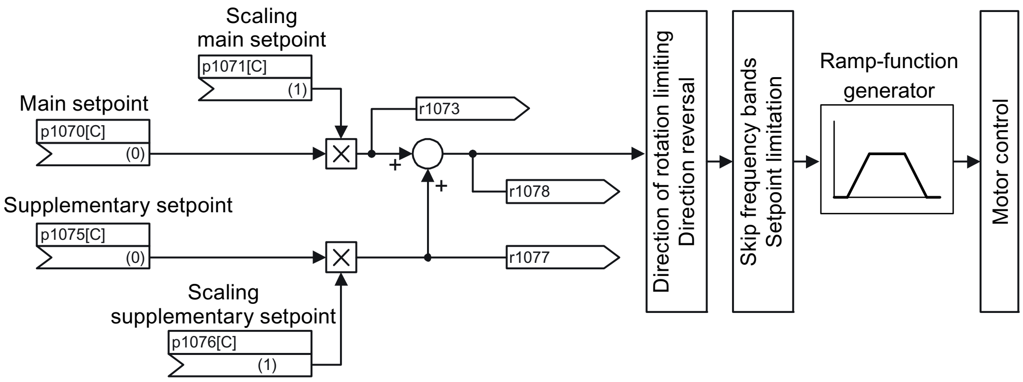


Figure 7-3 Setpoint addition, setpoint scaling

For function diagrams, see the List Manual

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

Important parameters, for details refer to the List Manual

Adjustable parameters

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

Display parameters

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

Parameterization with STARTER

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

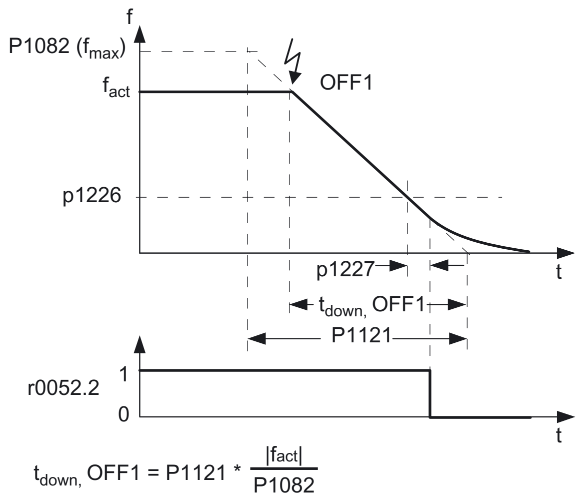
7.4 OFF functions

Description

Both the inverter itself and the user must respond to numerous different situations and if necessary shut down the inverter. For this reason, not just operational profiles, but also inverter protective functions (e.g. electrical or thermal overload) or man-machine protective functions must be observed. Thanks to the various shutdown functions (OFF1, OFF2, OFF3) the inverter can respond flexibly to the above mentioned requirements.

OFF1

The command OFF1 is directly connected to the ON command. This means that canceling the ON command activates OFF1 and the motor is decelerated with the ramp-down time p1121 (factory setting 10 s). If the output frequency falls below the value of parameter p1226 and the time in p1227 has expired, the inverter pulses are then inhibited.



Note

Using the BICO parameter p0840 (BI: ON/OFF1) and P0842 (BI: ON/OFF1 with direction reversal), the OFF1 command can be linked with different command sources.

In the factory setting, P0840 is preassigned either via the terminals (CU230H / CU240S) or via the fieldbus interface.

The ON and associated OFF1 commands must originate from the same command source.

If the ON/OFF1 command is assigned to more than one digital input, only the last assigned command is active (e.g. DI3).

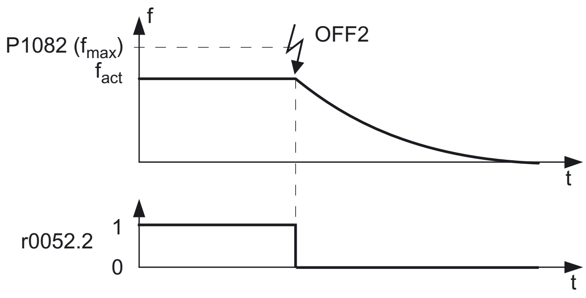
OFF1 is active in the "Low" state.

When simultaneously selecting various OFF commands the following priority applies:

1. OFF2 (highest priority)
2. OFF3
3. OFF1

OFF2

The OFF2 command immediately inhibits the inverter pulses. This means that the motor runs down and is not decelerated under closed-loop control.



Note

For the OFF2 command, two sources can be simultaneously parameterized using the BICO parameters P0844.1 and P0845.1.

In the factory setting, the OFF2 command is assigned to the BOP. This command source also remains active if, for example, another source is defined via the terminals.

OFF2 is active in the "Low" state.

When simultaneously selecting various OFF commands the following priority applies:

1. OFF2 (highest priority)
2. OFF3
3. OFF1

OFF3

The OFF3 command is identical to OFF1, with the exception of the ramp-down time, which can be independently adjusted using P1135 (factory setting 5 s).

Note

For the OFF3 command, two sources can be simultaneously parameterized using the BICO parameters P0848.1 and P0849.1.

Input values

Table 7- 1 Main function parameters

Parameter	Description	Setting
P0840 = …	ON/OFF1 possible sources: 722.x (digital input) / 2032.0 (option port) / 2090.0 (serial interface)	
P0842 = …	ON reverse direction/OFF1 possible source: 722.x (digital input)	
P0844 = …	1. OFF2 possible source: 722.x (digital input) / 2032.1 (option port) / 2090.1 (serial interface)	
P0845 = …	2. OFF2 possible source: 722.x (digital input) / 2032.1 (option port) / 2090.1 (serial interface)	
P0848 = …	1. OFF3 possible source: 722.x (digital input) / 2032.2 (option port) / 2090.2 (serial interface)	
P0849 = …	2. OFF3 possible source: 722.x (digital input) / 2032.2 (option port) / 2090.2 (serial interface)	
P1121 = …	Ramp-down time 0 ... 650 s, default 10 s	
P1135 = …	OFF3 ramp-down time 0 ... 650 s, default 5 s	
P1226 = …	Switch-off frequency f_off 0 ... 10 Hz, default 1 Hz: Defines the threshold value of the monitoring function |f_act| > P1226	
P1227 = …	Delay time T_off 0 ... 10000 s, default 10 s: Defines the time during which the inverter operates below the switch-off frequency (P1226) before switching off.	

Output value

Parameter	Description
r0052.2	Drive running

7.5 Jog

Description

The jog function enables, e.g. :

- The motor and inverter to be tested after commissioning to ensure that they function properly (first traverse movement, direction of rotation, etc.)
- A motor or a motor load to be positioned
- A motor to be moved, for example, after a program interruption

The function can be selected via digital inputs or a fieldbus (e.g. PROFIBUS). The setpoint is predefined using p1058[D] and p1059[D].

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

CAUTION
The jog function is not PROFIdrive compatible!

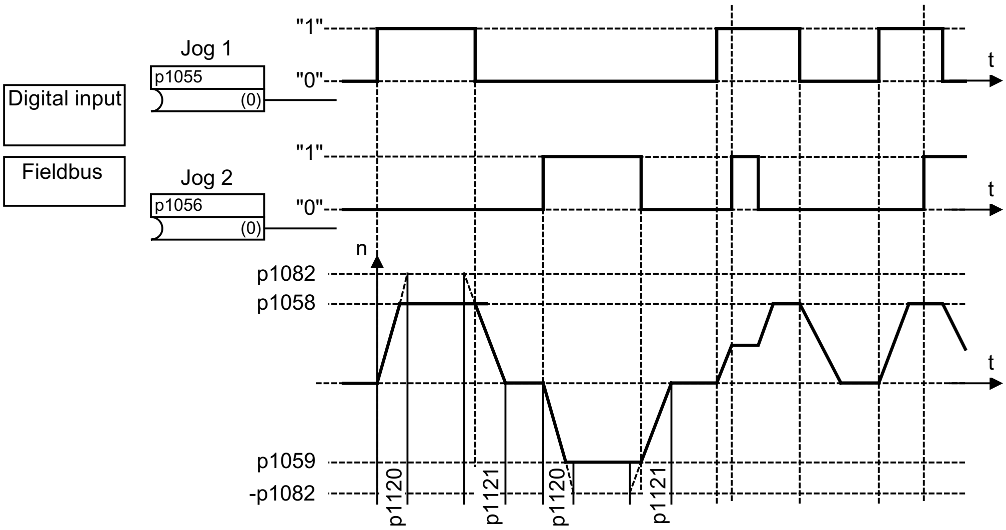


Figure 7-4 Function chart: jog and OFF1

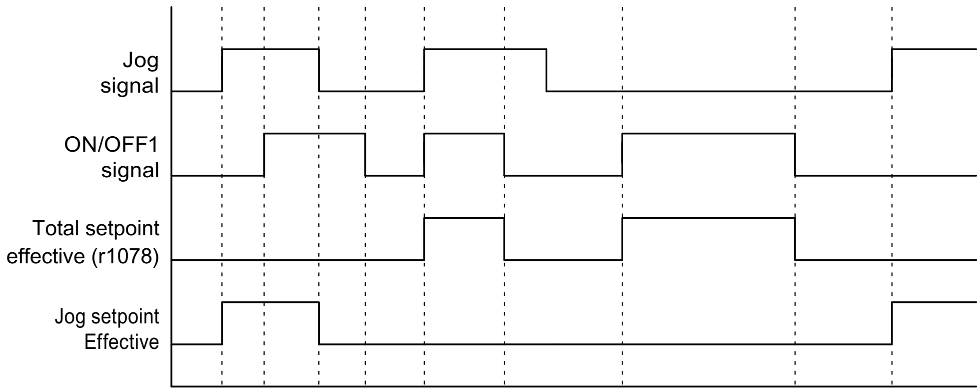


Figure 7-5 Flow diagram jog 1 and jog 2

Jog properties

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

Control and status messages

Table 7- 2 Jog control

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

Table 7- 3 Jog status message

Signal name	Internal status word	Parameter	PROFIdrive/Siemens telegram 1 ... 116
Ready for operation	ZSWA.0	r0899.0	ZSW1.0
Ready to run	ZSWA.1	r0899.1	ZSW1.1
Operation enabled	ZSWA.2	r0899.2	ZSW1.2
Switching on inhibited	ZSWA.6	r0899.6	ZSW1.6
Pulses enabled	ZSWA.11	r0899.11	ZSW1.11

For function diagrams, see the List Manual

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

Important parameters, for details refer to the List Manual

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

Parameterization with STARTER

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

7.6 Fixed speed setpoints

Description

This function can be used to specify speed setpoints. The individual fixed speed setpoints are defined via parameters and selected via binector inputs. These are added by activating several fixed speed setpoints.

16 combinations can be formed from the four fixed setpoints via the binary selection and connected via a connector output (e.g. to connector input p1070, main setpoint, or p1075, supplementary setpoint).

In the case of direct selection, the four individual fixed setpoints and the effective fixed setpoint (addition of the fixed setpoints p1001 … 1004) can be connected via a connector output (e.g. to connector input p1070, main setpoint, or p1075, supplementary setpoint).

Properties

- Number of fixed setpoints: 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

For function diagrams, see the List Manual

- 1550 Overviews - setpoint channel
- 3010 Fixed speed setpoints (binary selection)
- 3011 Fixed speed setpoints (direct selection)

Important parameters, for details refer to the List Manual

Adjustable parameters

- p1001[D] CO: Fixed speed setpoint 1
- ...
- p1015[D] CO: Fixed speed setpoint 15
- p1016: Fixed frequency mode
- p1020[C] BI: Fixed speed setpoint selection Bit 0
- p1021[C] BI: Fixed speed setpoint selection Bit 1
- p1022[C] BI: Fixed speed setpoint selection Bit 2
- p1023[C] BI: Fixed speed setpoint selection Bit 3

Display parameters

- r1024 CO: Fixed speed setpoint effective
- r1025 CO: Status, fixed speed setpoint
- 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.

7.7 Motorized potentiometer

Description

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

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

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

Properties for manual mode (p1041 = 0)

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

Properties for automatic mode (p1041 = 1)

- The input setpoint is specified via a connector input (p1042).x
- The motorized potentiometer acts like a "normal" ramp-function generator.
- Configurable ramp-function generator, e.g.:
  - Switch on/off (p1030.1)
  - Ramp-up/ramp-down time (p1047/p1048)
  - Setting value (p1043/p1044)
  - Initial rounding-off active/not active (p1030.2)
- Non-volatile storage of the setpoints via p1030.3
- Configurable setpoint for Power On (p1030.0)
  - Starting value is the value in p1040 (p1030.0 = 0)
  - Starting value is the stored value (p1030.0 = 1)

For function diagrams, see the List Manual

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

Important parameters, for details refer to the List Manual

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

Parameterization with STARTER

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

7.8 Direction of rotation reversal, inhibit direction of rotation reversal

Description

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

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

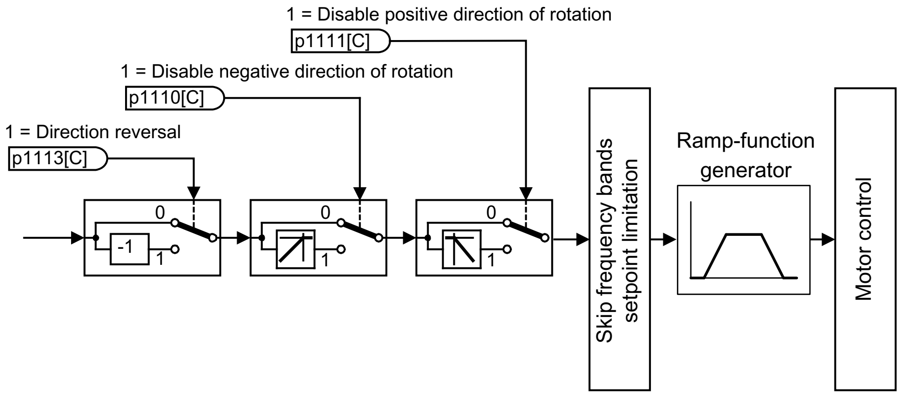


Figure 7-6 Direction of rotation limiting and direction of rotation changeover

For function diagrams, see the List Manual

- 1550 Setpoint channel
- 3040 Direction limitation and direction reversal

Important parameters, for details refer to the List Manual

Adjustable parameters

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

Parameterization with STARTER

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

7.9 Suppression bandwidths and setpoint limits

Description

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

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

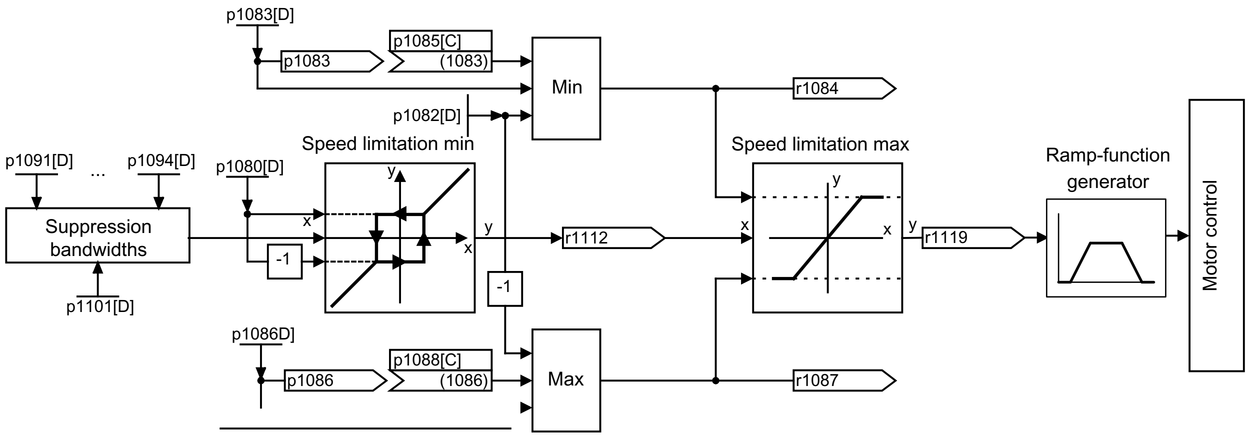


Figure 7-7 Suppression bandwidths, setpoint limitation

For function diagrams, see the List Manual

- 1550 Setpoint channel
- 3050 Suppression bandwidth and speed limiting

Important parameters, for details refer to the 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 via  in the toolbar of the STARTER commissioning tool:

Protection and monitoring functions 8

8.1 Power Module protection

Description

SINAMICS Power Modules provide comprehensive protection for individual components.

Table 8- 1 General protection of the Power Module

Protection against:	Precautions	Responses
Overcurrent[1)]	Monitoring with two thresholds	
	• First threshold exceeded	A30031, A30032, A30033 Current limiting of a phase has responded. The pulsing in the phase involved is inhibited. If it is too frequently exceeded F30017 –> OFF2
	• Second threshold exceeded	F30001 "Overcurrent" –> OFF2
Overvoltage[1)]	Comparison of DC link voltage with hardware shutdown threshold	F30002 "Overvoltage" –> OFF2
Undervoltage[1)]	Comparison of DC link voltage with hardware shutdown threshold	F30003 "Undervoltage" –> OFF2
Short-circuit[1)]	Second monitoring threshold checked for overcurrent	F30001 "Overcurrent" –> OFF2
Ground fault	Monitoring the sum of all phase currents	After threshold in p0287 is exceeded: F30021 "Power unit: ground fault" --> OFF2 **Note**: The sum of all phase currents is displayed in r0069[6]. For operation, the value in p0287[1] must be greater than the sum of the phase currents when the insulation is intact.
1) The monitoring thresholds are permanently defined in the inverter and cannot be changed.		

8.2 Thermal monitoring and overload responses

Description

The priority of thermal monitoring for power unit is to identify critical situations. If alarm thresholds are exceeded, the user can set parameterizable response options that enable continued operation (e.g. with reduced power) and prevent immediate shutdown.

The following thermal monitoring options are available:

- I^2t monitoring - A07805 - F30005
  The I^2t monitoring is used to protect components that have a high thermal time constant compared with semiconductors. An overload with regard to I^2t is present when the inverter load r0036 is greater than 100% (load in % in relation to rated operation).
- Heat-sink temperature - A05000 - F30004
  Monitoring of the heat-sink temperature (r0037) of power semiconductors (IGBT).
- Power unit: Overtemperature, thermal model. A05006 - F30024
- Chip temperature - A05001 - F30025
  Significant temperature differences can occur between the barrier layer of the IGBT and the heat sink. These differences are taken into account and monitored by the chip temperature (r0037).

If an overload occurs with respect to any of these three monitoring functions, an alarm is first output. The alarm threshold p0294 (I^2t monitoring) can be parameterized relative to the shutdown (trip) values.

Example

The factory setting for the alarm threshold for chip temperature monitoring is 15 Kelvin (K). Temperature monitoring for the heat sink and inlet air is set to 5 K, that is, the "Overtemperature, overload" alarm is triggered at 15 K or 5 K below the shutdown threshold.

The parameterized responses are induced via p0290 simultaneously when the alarm is output. Possible responses include:

- Reduction in pulse frequency (p0290 = 2, 3)
  This is a highly effective method of reducing losses in the power unit, since switching losses account for a high proportion of overall losses. In many applications, a temporary reduction in pulse frequency is tolerable in order to maintain the process.

  Disadvantage:
  Reducing the pulse frequency increases the current ripple which, in turn, can increase the torque ripple on the motor shaft (with low inertia load), thereby increasing the noise level. Reducing the pulse frequency does not affect the dynamic response of the current control circuit, since the sampling time for the current control circuit remains constant.
- Reduction in output frequency (p0290 = 0.2)
  This variant is recommended when you do not need to reduce the pulse frequency or the pulse frequency has already been set to the lowest level. Further, the load should also have a characteristic similar to the fan, that is, a quadratic torque characteristic with falling speed. Reducing the output frequency has the effect of significantly reducing the inverter output current which, in turn, reduces losses in the power unit.

- No reduction (p0290 = 1)
  You should choose this option if it is neither possible to reduce the pulse frequency nor reduce the output current. The inverter does not change its operating point once an alarm threshold has been overshot, which means that the drive can be operated until it reaches its shutdown values. Once it reaches its shutdown threshold, the inverter switches itself off and the "Overtemperature, overload" fault is output. The time until shutdown, however, is not defined and depends on the degree of overload.

  To ensure that an alarm can be output earlier or that the user can intervene, if necessary, in the drive process (e.g. reduce load/ambient temperature), only the alarm threshold can be changed.

For function diagrams, see the List Manual

- 8014 Thermal monitoring, power unit

Important parameters, for details refer to the List Manual

- r0036 Power unit overload
- r0037 Power unit temperatures
- p0290 Power unit overload response
- p0294 Alarm threshold I^2t overload power unit

8.3 Block protection

Description

The error message "Motor blocked" is only triggered if the speed of the drive is below the variable speed threshold set in p2175. With vector control, it must also be ensured that the speed controller is at the limit. With V/f control, the current limit must already have been reached.

Once the ON delay (p2177) has elapsed, the message "Motor blocked" and fault F7900 are generated.

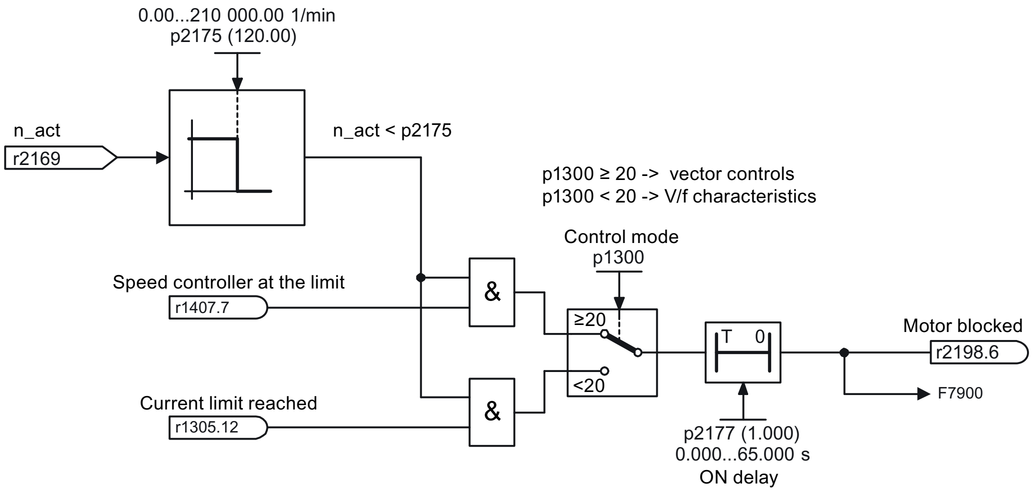


Figure 8-1 Block protection

For function diagrams, see the List Manual

- 8012 Torque messages, motor blocked/stalled

Important parameters, for details refer to the List Manual

- p2175 Motor blocked speed threshold
- p2177 Motor blocked delay time

8.4 Stall protection (only for vector control)

Description

If, in the low speed range (less than p1755 * p1756), the fault threshold value, set in p1745 is exceeded, then r1408.12 is set (motor stalled).

After the delay time has expired in p2178, fault F7902 (motor stalled) is output.

For function diagrams, see the List Manual

- 6730 Current control
- 8012 Torque messages, motor blocked/stalled

Important parameters, for details refer to the List Manual

- r1408 CO/BO: Control status word 3
- p1745 Motor model fault threshold value stall detection
- p1755 Motor model without encoder, changeover speed
- p1756 Motor model changeover speed hysteresis
- p2178 Motor stalled delay time

8.5 Thermal motor monitoring

Overview

For the thermal motor monitoring, depending on the motor type, the measured motor current and a possibly existing motor temperature sensor, the motor temperature is calculated using a motor model.

The thermal motor monitoring can be used for induction motors and for synchronous motors.

Note

p0610 can be used to parameterize different responses when the alarm thresholds are exceeded for the thermal motor monitoring; e.g. reducing the power, in order to avoid immediate shutdown.

Induction motors

The thermal motor model (p0612) can be used to calculate the motor temperature for induction motors. See also function diagram 8016 "Thermal motor monitoring".

For induction motors, with **inverter operation with vector control**, temperature monitoring without motor temperature sensor is possible using the thermal motor model if the function "Identify stator resistance after restart" (p0621) is activated.

For **inverter operation with V/f control,** the motor can be protected against overload by using temperature sensors. The reason for this is that in this particular case, the temperature is determined directly at the motor and is also always available when switching-on in the warm state (e.g. after a power failure).

Synchronous motors

A KTY, a PTC sensor or a bimetal NC contact can be used for temperature monitoring using a motor temperature sensor.

8.5.1 Thermally monitoring induction motors

Description

The thermal motor model (3-mass model) is activated using p0612.1 = 1.

Operation without temperature sensor

The motor temperature is calculated using the thermal motor model.

For operation with vector control, the motor temperature at switch-on can be determined using p0621 "Identify stator resistance after restart". This therefore improves the motor overload protection. The value of p0625 is used as basis value for the ambient temperature. The motor temperature is displayed in r0035.

Operation with temperature sensor

If a KTY motor temperature sensor is being used (p0601 = 2), at switch-on, the actual motor temperature is available and the motor is reliably protected against thermal overload. The motor temperature is displayed in r0035.

If a PTC sensor is being used (p0601 = 1), the shutdown threshold is measured and the motor is reliably protected against thermal overload. -200 °C is displayed in r0035 as motor temperature.

If a bimetal NC contact is being used (p0601 = 4), the shutdown threshold is monitored and the motor is reliably protected against thermal overload. -200 °C is displayed in r0035 as motor temperature.

For function diagrams, see the List Manual

- 8016 Thermal motor monitoring

Important parameters, for details refer to the List Manual

- r0035 Motor temperature
- p0601[0...n] Motor temperature sensor type
- p0604[0...n] Motor overtemperature alarm threshold
- p0605[0...n] Motor overtemperature fault threshold
- p0610[0...n] Motor overtemperature reaction to upper temperature limit
- p0612[0...n] Thermal motor model configuration

8.5.2 Thermally monitoring synchronous motors

Description

Operation with temperature sensor

A KTY, a PTC sensor or a bimetal NC contact can be used for temperature monitoring using a motor temperature sensor. The setting parameters are listed below.

For function diagrams, see the List Manual

- 8016 Thermal motor monitoring

Important parameters, for details refer to the List Manual

- p0601[0...n] Motor temperature sensor type
- p0604[0...n] Motor overtemperature alarm threshold
- p0605[0...n] Motor overtemperature fault threshold
- p0610[0...n] Motor overtemperature reaction to upper temperature limit
- p0611[0...n] Winding time constant
- p0615 Trip limit motor overtemperature thermal model

8.5.3 Sensors for the motor temperature monitoring

Overview

A KTY sensor, a PTC element or a bimetal contact is available to monitor the motor temperature or the shutdown threshold.

Temperature measurement via KTY

The device is connected to terminals 14 (anode) and 15 (cathode) in the forward direction of the diode. The measured temperature is limited to between -48 °C and +248°C and is made available for further evaluation.

- Set the KTY temperature sensor type: p0601 = 2
- When the alarm threshold is reached (set via p0604; factory setting: 130 °C), alarm A7910 is triggered.

  Parameter p0610 can be used to set how the drive responds to the alarm triggered:

  – 0: No response, alarm only, no reduction of I_max

  – 1: Alarm and reduction of I_max and fault (F07011)

  – 2: Alarm and fault (F07011), no reduction of I_max

- Fault F07011 is output (depending on the setting in p0610) if
  - the fault threshold temperature (settable in p0605) is reached
  - the alarm threshold temperature (settable in p0604) is reached and is still present after the delay time as expired.

Wire break and short-circuit monitoring:

- Wire break: Resistance value > 2120 Ω
- Short circuit: Resistance value < 50 Ω

As soon as a resistance outside this range is measured, A07015 "Alarm temperature sensor fault" is activated and after the delay time expires, F07016 "Motor temperature sensor fault" is initiated.

Temperature measurement via PTC

The device is connected to terminals 14 and 15.

Setting of the PTC temperature sensor type: p0601 = 1.

- Overtemperature: The threshold value to switch over to an alarm or fault is 1650 Ω. After the PTC responds, Alarm A07910 is initiated with the response corresponding to the setting in p0610.
- Short-circuit monitoring: Resistance values < 20 Ω indicate a temperature sensor short-circuit

Temperature sensing using the bimetal NC contact

The device is connected to terminals 14 and 15.

Setting the PTC temperature sensor type: p0601 = 4.

The bimetal NC contact responds at values ≥100 Ω. After the device responds, Alarm A07910 is initiated with a response corresponding to the setting in p0610.

8.6 Speed and load torque monitoring

8.6.1 General monitoring functions

Description

The CU230 has a comprehensive range of monitoring functions and messages that can be used for process control. The control can be implemented either in the inverter itself, or with the aid of an external controller (e.g. PLC). The logic functions in the inverter and the output signals for the external controller are both implemented via the BICO interconnection.

The states of the individual monitoring functions and the messages are emulated in the following CO/BO parameters:

r0050	CO/BO: Active command data set
r0052	CO/BO: Status word 1
r0053	CO/BO: Status word 2
r0054	CO/BO: Control word 1
r0055	CO/BO: Additional control word
r0056	CO/BO: Status word - motor control
r0722	CO/BO: Status, digital inputs
r0747	CO/BO: Status, digital outputs
r1407	CO/BO: Status 2 - motor control
r2197	CO/BO: Messages 1
r2198	CO/BO: Messages 2

Frequently used monitoring functions/messages including the parameter number and the bit number are listed in the table below.

Table 8- 2 Excerpt of the monitoring functions and messages

Functions / statuses	Parameter / bit number
Inverter ready	52.0
Inverter ready for operation	52.1
Drive in operation	52.2
An inverter fault is present	52.3
Coasting down active (OFF2)	52.4
Quick stop active (OFF3)	52.5
Switching on inhibited active	52.6
An inverter warning is present	52.7
Deviation between setpoint - actual value	52.8
Process data control	52.9
Maximum speed (p1082) reached	52.10 / 2197.6
Warning: Motor current/torque limit reached	52.11

Functions / statuses	Parameter / bit number
Motor overload	52.13
Motor CW rotation	52.14
Inverter overload	52.15
DC brake active	53.0
Actual speed > stationary state detection (p1226)	53.1
Actual speed > minimum speed (p1080)	53.2
Current threshold for alarm reached (p2170)	53.3 / 2197.8
Actual speed > speed threshold value 2 (p2155)	53.4 / 2197.2
Actual speed (absolute value) ≦ speed threshold value 2 (p2155)	53.5 / 2197.1
Actual speed >= setpoint (f_set)	53.6 / 2197.4
DC link voltage < VDC threshold (P2172)	53.7 / 2197.9
DC link voltage > VDC threshold (P2172)	53.8 / 2197.10
Ramp end	53.9
PID output R2294 == P2292 (PID_min)	53.10
PID output R2294 == P2291 (PID_max)	53.11
Actual speed (absolute value) <= P1080 (f_min)	2197.0
Actual speed > zero	2197.3
Actual speed (absolute value) <= standstill detection (p1226)	2197.5
f_act == setpoint (f_set)	2197.7
No-load operation	2197.11
Actual speed (absolute value) ≦ speed threshold value 5 (p2157)	2198.0
Actual speed (absolute value) > speed threshold value 5 (p2157)	2198.1
Actual speed (absolute value) ≦ speed threshold value 6 (p2159)	2198.2
Actual speed (absolute value) > speed threshold value 6 (p2159)	2198.3
Speed setpoint (absolute value) < P2161 (f_min_set)	2198.4
Speed setpoint > 0	2198.5
Motor blocked	2198.6
Motor stalled	2198.7
Actual current value (r0068) (absolute value) < current threshold (p2170)	2198.8
Actual torque value (absolute value) > P2174 and setpoint reached	2198.9
Torque setpoint (absolute value) < torque threshold value 1 (p2174)	2198.10
Load torque monitoring: Alarm	2198.11
Load torque monitoring: Fault	2198.12

For function diagrams, see the List Manual

- 8010 - Speed messages
- 8012 - Torque messages
- 8020 - Monitoring functions 1
- 8021 - Monitoring functions 2

8.6.2 Load monitoring functions

Overview

One of the following functions can be selected using p2193 for load monitoring:

- Torque and load failure monitoring
- Speed and load failure monitoring
- Load failure monitoring

Description

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 messages caused by brief transitional states.

Parameter p2181 offers the following setting options:

- p2181 = 0: => Load monitoring disabled
- p2181 = 1: => A07920 for torque/speed too low
- p2181 = 2: => A07921 for torque/speed too high
- p2181 = 3: => A07922 for torque/speed outside tolerance
- p2181 = 4: => F07923 for torque/speed too low
- p2181 = 5: => F07924 for torque/speed too high
- p2181 = 6: => F07925 for torque/speed out of tolerance

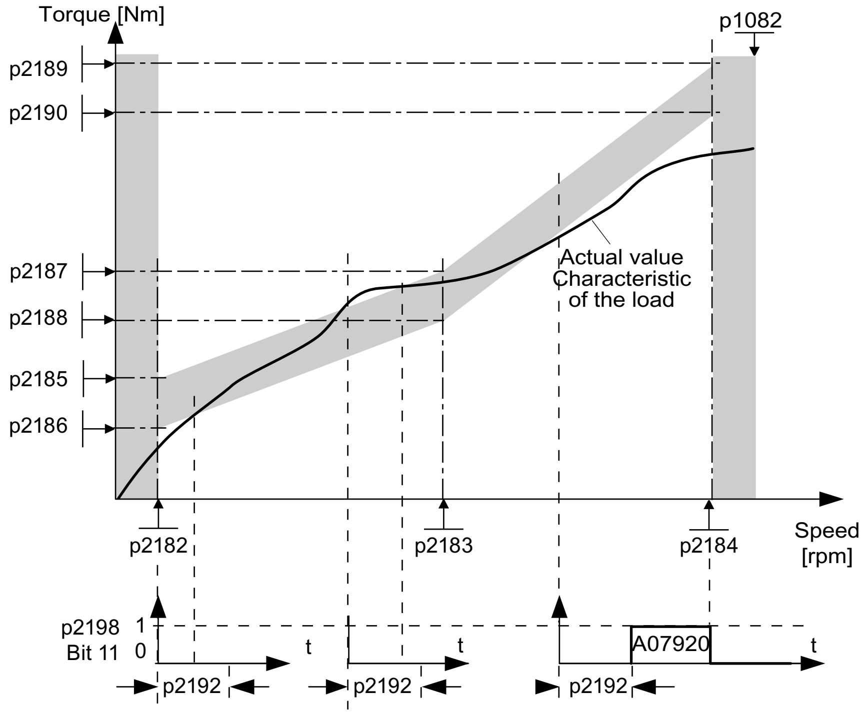


Figure 8-2 Example of load torque monitoring with p2193 = 1

For function diagrams, see the List Manual

- 8013 Load monitoring

Important parameters, for details refer to the List Manual

- p2181[D] Load monitoring response and type
- p2182[D] Load monitoring speed threshold 1
- p2183[D] Load monitoring speed threshold 2
- p2184[D] Load monitoring speed threshold 3
- p2185[D] Load torque monitoring torque threshold 1 upper
- ...
- p2190[D] Load torque monitoring torque threshold 3 lower
- p2192[D] Load monitoring delay time

Basic information about the drive system 9

9.1 Parameters

Parameter types

The following adjustable and display parameters are available:

- Adjustable parameters (write/read)

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

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

- Display parameters (read only)

  These parameters are used to display internal variables.

  Example: Current motor current

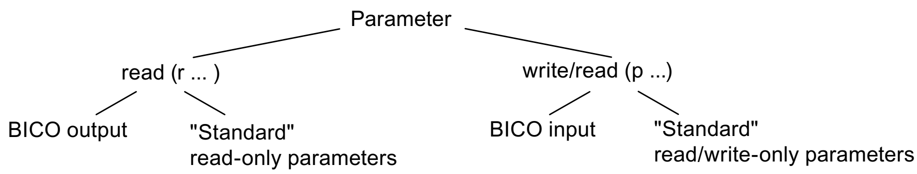


Figure 9-1 Parameter types

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

Parameter categories

The parameters of the inverter are categorized according to data sets as follows:

- CDS: Command data set
  By parameterizing several command data sets and switching between them, the drive can be operated with different pre-configured signal sources. In p0170, the number of CDSs can be defined (2 ... 4).
- DDS: Drive data set
  The parameters for the parameterization of the drive are summarized in the drive data set. In p1080, the number of DDSs can be defined (1 ... 4).

The data sets can be switched during operation.

9.1.1 Reference parameters/normalizations

Description

The quantities listed in the table below require reference variables corresponding to 100% to be programmed in the inverter. These reference variables are determined and preset during quick commissioning (when ended with p3900 ≠ 0), or when the motor and closed-loop control data are computed with p0340 = 1 or as part of the drive configuring process with STARTER.

After the calculation, these parameters are automatically protected via p0573 = 1 from being overwritten by a new calculation (p0340). This eliminates the need to adjust the references values in a PROFIdrive controller whenever a new calculation of the reference parameters via p0340 takes place.

Table 9- 1 Reference variables and reference parameters

Quantity	Reference parameter	Default at initial commissioning
Reference frequency	100 % = p2000	Value of p1082 (maximum frequency)
Reference voltage	100 % = p2001	p2001 = 1000 V
Reference current	100 % = p2002	Value of p0640 (current limit)
Reference torque	100 % = p2003	p2003 = 2 * value of r0333 (rated motor torque)
Reference power	100 % = r2004	r2004 = p2003 * p2000 * 2π
Reference angle	100% = p2005	90°
Reference acceleration	100% = p2007	0.01 $1/s^2$
Reference speed	100 % = p2000 * 60	
Reference modulation depth	100 % = Maximum output voltage without overload	
Reference flux	100 % = Rated motor flux	
Reference temperature	100 % = 100 °C	

CAUTION

Changing the reference parameters p2000 to p2007

If you change the value of a reference parameter, the physical value displayed in the connector parameter does not change, but the percent value in the BiCo interconnection is adjusted.

Example:

p2000 = 50 Hz, speed setpoint = 40 Hz => 80 %.

Value in p2000 is changed

p2000 = 100 Hz, actual speed = 40 Hz => 40 %.

Note

Using STARTER offline

When the reference variables are changed offline in STARTER, inadmissible values might be entered for the relevant inverter. As a result, faults might occur when the parameters are downloaded to the inverter.

If the reference variables (p2000 to p2007) are changed offline in STARTER, the parameter value limits might be violated, causing fault messages when the parameters are downloaded to the inverter.

Important parameters, for details refer to the List Manual

- p0340 Automatic calculation of motor/control parameters
- p0573 Disable automatic calculation of reference values
- p2000 Reference speed reference frequency
- p2001 Reference voltage
- p2002 Reference current
- p2003 Reference torque
- r2004 Reference power
- p2005 Reference angle
- p2007 Reference acceleration

9.2 Data sets

Overview of the data sets

In the inverter, the parameters in which the sources for commands and setpoints are defined are combined in the **Command Data Set** (CDS), the parameters for the open and closed-loop control of the motor in the **Drive Data Set** (DDS).

In the factory, two command data sets (CDS0, CDS1) and one drive data set (DDS0) are set-up.

Each data set can be individually assigned values independently of one another.

The drive can be operated from different signal sources by switching over the command data sets.

When switching over the drive data sets, it is possible to switch between different drive configurations (control type, motor).

The other characteristics of the command and drive data sets are described in the following sections.

9.2.1 CDS: Command Data Set

In the factory, two command data sets (CDS0 pxxxx[0], CDS1 pxxxx[1]) are set-up.

Two additional command data sets pxxxx[2], pxxxx[3] can be set-up using parameter p0170 (2 … 4). In this case, CDS0 is always copied with its actual settings.
(CDS0 → CDS2, CDS0 → CDS3). p0010 = 15 must be set to set-up new data sets. p0010 must be set to 0 once the required data sets have been set-up. The settings for the parameters of the individual data sets can then be made.

The individual command data sets are selected using binector inputs p0810 to p0811. The values of these two parameters form the number of the command data set (0 … 3) in the binary notation with p0811 as the most significant bit.

Selecting the command data set		Displays the selected command data set
p0810 = 0	p0811 = 0	r0050 = 0
p0810 = 1	p0811 = 0	r0050 = 1
p0810 = 0	p0811 = 1	r0050 = 2
p0810 = 1	p0811 = 1	r0050 = 3

If a command data set that does not exist is selected, the actual data set remains active. The selected data set is displayed r0836.

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)

Example: Changeover between command data set 0 and 1

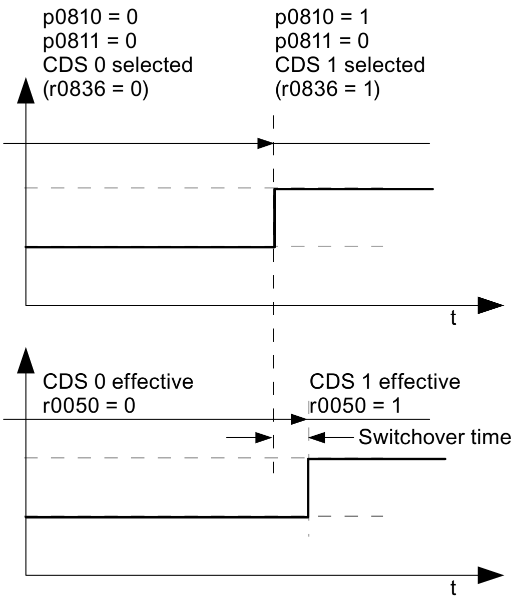


Figure 9-2 Switch command data set (CDS)

9.2.2 DDS: Drive Data Set

Note

The parameters identified as MDS or PDS in the List Manual belong to the drive data set DDS in the case of SINAMICS G120 frequency inverters.

In the factory, drive data set (DDS0) is set-up.

Three additional drive data sets can be set-up using parameter p0180 (1 … 4). In this case, the highest DDS is always copied with its actual settings. (DDS0 → DDS1 → DDS2 → DDS3). p0010 = 15 must be set to set-up new data sets. p0010 must be set to 0 once the required data sets have been set-up. The settings for the parameters of the individual data sets can then be made.

Note

The motor data (p0340/p3900) should be calculated for each drive data set after the data has been entered.

It should be observed that the reference frequency (p2000) is only calculated for the first drive data set and then applies to the other drive data sets. p0573 must be set to 0 if the reference frequency is to be calculated for another data set. The value calculated is then valid for all drive data sets.

The individual drive data sets are selected using binector inputs p0820 and p0821. The values of these two parameters form the number of the drive data set (0 … 3) in the binary notation with p0821 as the most significant bit.

Drive data sets can be individually assigned to each command data set. The assignment is realized as follows.

Selecting and assigning the associated drive data set		Displays the selected drive data set
p0820[0] = 0/1	p0821[0] = 0/1	r0051 = 0 ...3
p0820[1] = 0/1	p0821[1] = 0/1	r0051 = 0 ...3
p0820[2] = 0/1	p0821[2] = 0/1	r0051 = 0 ...3
p0820[3] = 0/1	p0821[3] = 0/1	r0051 = 0 ...3

Assignment to the command data set via the index of the drive data set (= r0050)

A drive data set contains various adjustable parameters that are relevant with regard to open-loop and closed-loop drive control. 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 the VDC controller (p1240 ff)
- Motor parameters (p0300 ff)
- ...

For function diagrams, see the List Manual

- 8560 Command Data Sets (CDS)
- 8565 Drive Data Sets (DDS)

Important parameters, for details refer to the List Manual

Adjustable parameters

- 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
- 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

Display parameters

- r0836 CO/BO: Command data set CDS selected
- r0837 CO/BO: Drive data set DDS selected

9.3 BICO technology

Description

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

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

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

These parameters are identified accordingly in the parameter list or in the function diagrams.

Note

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

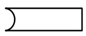
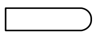
9.3.1 Binectors, connectors

Binectors, BI: Binector Input, BO: Binector Output

A binector is a digital (binary) signal without a unit which can assume the value 0 or 1.

Binectors are subdivided into binector inputs (signal sink) and binector outputs (signal source).

Table 9- 2 Binectors

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

Connectors, CI: connector input, CO: connector output

A connector is a digital signal, e.g. in the 32-bit format. It can be used to emulate words (16 bits), double words (32 bits) or analog signals. Connectors are subdivided into connector inputs (signal sink) and connector outputs (signal source).

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

Table 9- 3 Connectors

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

9.3.2 Structure of the parameter number of BI and CI parameters for fieldbus communication

In the case of communication via fieldbus systems, e.g. PROFIBUS DP, the number of the drive object must be entered in addition to the index of the parameter and the parameter number. For all CU230 Control Units, this is always 63 (or 111111 in binary format).

The following bits are reserved for the parameter number, drive object and index or bit number.

	Parameter number	Drive object	Index number or bit number
Bit	31 … 16	15 … 10	9 … 0

Example: P1001[2] (fixed speed setpoint, index 2) as signal source

0000 0011 1110 1001 bin 1001 dec	1111 11 bin 63 dec	00 0000 0010 bin 2 dec
03E9 hex	3F hex	0 hex

BI and CI parameters can also be assigned fixed values, 0 or 1, instead of a connector parameter. In this case, 0 must be entered for the drive object. The following internal coding applies:

	Parameter number	Drive object	Index number
Bit	31 … 16	15 … 10	9 … 0

Fixed value 0

0000 0000 0000 0000 bin 0 dec	0000 00 bin 0 dec	00 0000 0000 bin 0 dec

Fixed value1

0000 0000 0000 0001 bin 1 dec	0000 00 bin 0 dec	00 0000 0000 bin 0 dec

9.3.3 Interconnecting signals using BICO technology

A binector output is wired to a binector input by writing the number of the binector output as a parameter value into the binector input parameter.

Example 1: Instead of the direction reversal, an external error should be fed in via DI1, which inhibits the pulses with OFF2.

Factory setting for		Source
Direction reversal	P1113 = 722.1	DI1

Rewiring for		Source
External error	P0702 = 29 or p1113 = 0 P2106 = 722.1	DI1

The external fault results in a shutdown with OFF2 (pulse inhibit).

Example 2: In the factory setting, the ON/OFF1 command is wired to DI0, i.e. the inverter is started via an ON signal on digital input 0 and accelerates to the speed setpoint. In the factory setting, the speed setpoint is specified via the analog setpoint.

Factory setting for		Source
ON/OFF1	p0840= 722.0	DI0
Speed setpoint setting	P1000 = 2	Analog setpoint

The frequency inverter, however, should be operated via fixed frequencies rather than the analog setpoint, whereby fixed speed setpoint 1 should be activated simultaneously with the ON command via the DI0.

For this purpose, the following parameter settings are required:

Setting for		Source / explanation
ON/OFF1	p0840= 722.0	DI0
Speed setpoint setting	P1000 = 3	Fixed speed setpoint
Fixed speed setpoint 1	P1020 = 722.0	DI0

To interconnect two signals, the required BICO output parameter (signal source) must be assigned to a BICO input parameter (signal sink).

The following information is required for connecting a binector/connector input to a binector/connector output:

- Binectors: Parameter number and bit number
- Connectors with no index: Parameter number
- Connectors with index: Parameter number and index
- Data type (signal source for connector output parameter)

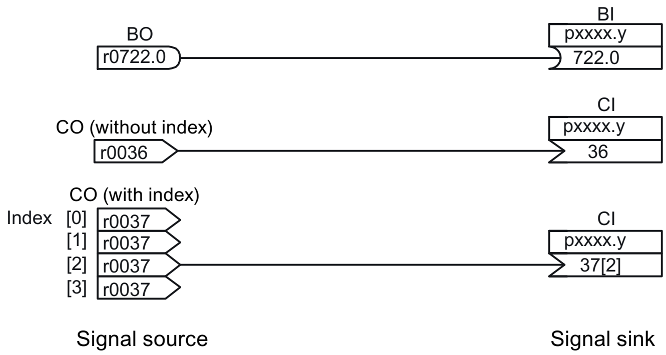


Figure 9-3 Interconnecting signals using BICO technology

Note

"Data type" in the parameter list provides information about the data type of the parameter and the data type of the BICO parameter for each CI and BI parameter.
Notation (example): "Data type: U32 / Binary"

For CO and BO parameters, only the data type of the BICO parameter is given.
Notation (example): "Data type: FloatingPoint32"

A connector input (CI) cannot be interconnected with any connector output (CO, signal source). The same applies to the binector input (BI) and binector output (BO).

The permissible interconnections between CI and CO, or between BI and BO parameters are described in the List Manual in the section entitled "Explanation of list of parameters".

The BICO interconnection can be established in each command data set (CDS) independently of the others. The relevant BICO interconnection comes into effect via the data set switchover.

9.3.4 Sample interconnections

Example: Interconnection of digital signals

A drive is operated via terminals DI 0 and DI 1 on the Control Unit using jog 1 and jog 2.

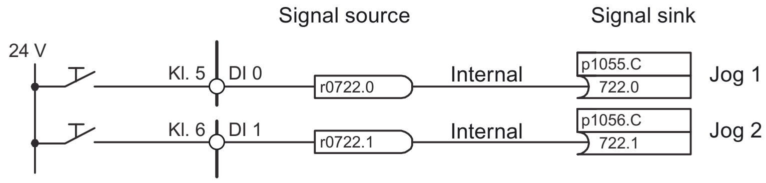


Figure 9-4 Interconnection of digital signals (example)

9.3.5 BICO technology:

Copying drive and motor data sets

When copying drive and motor data sets, the interconnection is also copied.

Binector-connector converters and connector-binector converters

Binector-connector converter

- Several digital signals are converted to a 32-bit integer double word or to a 16-bit integer word.
- p2080[0...15] BI: PROFIdrive PZD send bit-serial

Connector-binector converter

- A 32-bit integer double word or a 16-bit integer word is converted to individual digital signals.
- p2099[0...1] CI: PROFIdrive PZD selection receive bit-serial

Fixed values for interconnection using BICO technology

The following connector outputs are available for interconnecting any fixed value settings:

- p2900[0...n] CO: Fixed value % 1
- p2901[0...n] CO: Fixed value % 2
- p2902[0...14] CO: Fixed values %
- p2930[0...n] CO: Fixed value_M_1

Example:

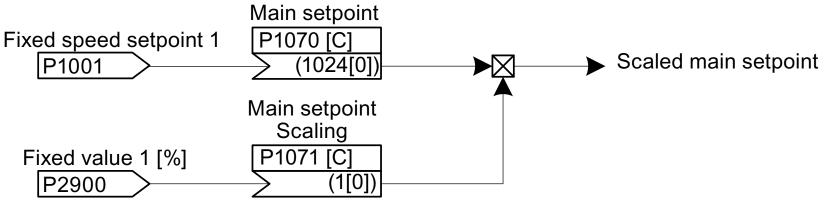


Figure 9-5 Main setpoint scaled with p2900

The parameters can be used to interconnect the scaling factor for the main setpoint or to interconnect an additional torque.

9.3.6 Scaling

Signals for the analog outputs

The BiCo interconnection of analog values requires percentages. The table below shows the reference parameters to which individual connector output parameters refer.

Table 9- 4 Analog values and reference parameters

Signal	Parameter	Unit	Reference parameter (parameter value equals 100 %)
Speed setpoint before the setpoint filter	r0060	Hz	p2000
Speed actual value	r0063	Hz	p2000
Drive output frequency	r0066	Hz	p2000
Absolute current actual value	r0068	Arms	p2002
Actual DC link voltage value	r0070	V	p2001
Total torque setpoint	r0079	Nm	p2003
Actual active power	r0082	kW	r2004
Control deviation	r0064	RPM	p2000
Current setpoint, torque-generating	r0077	A	p2002
Current actual value, torque-generating	r0078	A	p2002
Speed controller PI torque output	r1480	Nm	p2003
Speed controller I torque output	r1482	Nm	p2003

CAUTION

Note about changing reference parameters p2000 to p2007

If you change the value of a reference parameter, the physical value displayed in the connector parameter does not change, but the per cent value in the BiCo interconnection is adjusted.

Example:

p2000 = 50 Hz, speed setpoint = 40 Hz => 80 %.

Value in p2000 is changed

p2000 = 100 Hz, actual speed = 40 Hz => 40 %.

Index

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