SIEMENS

G120P BT

Planning

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Building Technologies

Table of contents

1 About this documentation

1.1 List of changes

Version	Date	Revisions	Segment	Page
V01		None (new document)		

1.2 Before you begin

1.2.1 Trademarks

This document uses registered (®) and unregistered (™) product names.

The use of trademarks is subject to international and country-specific legal requirements.

Trademarks	Legal owner
BACnet™	American National Standard (ANSI/ASHRAE 135-1995)
Microsoft …	Information on the Microsoft Corporation can be found at http://www.microsoft.com/TRADEMARKS/t-mark/nopermit.htm
MODBUS®	The Modbus Organization, Hopkinton, MA, USA
Windows …	Microsoft Corporation

On the basis of this information and in the interests of readability, no further use will be made of symbols such as ® and ™ to identify the trademarks.

1.2.2 Quality assurance

This documentation has been collated with the greatest care.

- The content of all documents is subject to regular checks.
- All necessary corrections are incorporated into subsequent versions.
- Adaptations and corrections to the products described require this document to be amended accordingly. Please ensure you are aware of the most up to date version of the documentation.

Should you come across any ambiguities when using this documentation, or if you have any comments or suggestions, please inform your local contact person at the nearest branch office. The addresses for Siemens company subsidiaries can be found at www.siemens.com/sbt.

1.2.3 Document usage/Read request

Before using the products, please ensure that you read the documentation offered with or purchased in addition to our products (devices, applications, tools, etc.) carefully and thoroughly.

Please note that to the extent permitted by law, Siemens accepts no liability for damage arising from non-compliance or improper compliance with the documentation.

Further information on the products and applications can be found:

- on the Intranet (for Siemens employees only) at https://workspace.sbt.siemens.com/content/00001123/default.aspx
- at your nearest Siemens branch office, at www.siemens.com/sbt, or from your system supplier
- from the support team at support.automation.siemens.com under "Contacts worldwide" if you do not know who your local contact person is

1.3 Purpose of the document

This document is intended for configuring and planning specialists in the heating, ventilation, and air-conditioning fields, HVAC enterprises, system suppliers, structural engineering companies, engineering firms in the HVAC sector, HVAC specialists, and control cabinet makers, along with other interested parties.

It serves as a basis for planning, configuring, dimensioning, and implementing drives in HVAC systems.

1.4 Validity

This Configuration Manual applies:

- to all G120P variable speed drives in frame sizes A to F with degree of protection IP20/Nema 0
- to all G120P variable speed drives in frame sizes A to F with degree of protection IP55/Nema 12

1.5 Available documentation

Title	Description	Source/Document ID
Getting Started	Design, installation, commissioning, and troubleshooting the SINAMICS G120P variable speed drive.	A5E03653438A AA
Getting Started Guide Power Module PM230 Hardware IP55	Quick guide with dimensions and design and installation notes.	A5E02923634A
Getting Started Guide Power Module PM230 Hardware IP20	Quick guide with dimensions and design and installation notes.	A5E03460238A
Hardware Installation Manual Power Module PM230 Hardware IP55	Guide with all the information needed to install, mount, connect, and service SINAMICS G120P systems.	A5E02923635A AA
Hardware Installation Manual Power Module PM230 Hardware IP20	Guide with all the information needed to install, mount, connect, and service SINAMICS G120P systems.	A5E03448282A AA
Application examples	Application examples and useful tips for using variable speed drives are available at:	http://support.automation.siemens.com/WW/view/de/20208582/136000
General product information	Detailed information and support tools for variable speed drives are available on the Internet at:	http://www.siemens.com/g120p
Operating Instructions Control Unit	Guide for installation engineers, commissioners, and operators on Control Unit CU230P-2	A5E02430659A AF
List Manual Control Unit	Manual with list information including parameters and error codes.	A5E02297932A AF
Desigo	Information on commissioning and integrating into Desigo systems including parameter settings	CM110576

Title	Description	Source/Document ID
PICS	SINAMICS BACnet Protocol Implementation Conformance Statement	CM2Y5111
Data sheet: Supplementary system components	Data sheet with general information on the IOP and BOP-2 devices and the blanking cover	CM1N5116de
SINAMICS G120P operation in the event of a fire	Use of Essential Service Mode (ESM)	Article ID: 63969509
Bundle sheet	Installation instructions FSA to FSC	A5E03879678 Index A
Line filters	Installation instructions FSA to FSC	A5E03879697A AB
Line filters	Installation instructions FSD to FSF	A5E31327192A AB

2 Safety instructions and CE conformity

2.1 Typographical conventions

The safety instructions in this document contain the following elements:

- **Symbol** to indicate the nature of the danger
- **Signal word** to indicate the severity of the danger
- **Type and source** of the danger
- **Consequences** of failing to heed the danger
- **Measures** to avoid the danger

Symbols to indicate the nature of the danger

The following symbols are used in the document:

Symbol	Meaning
	Warning of dangerous voltages
	Warning of moving parts
	General warning

Signal word to indicate the severity of the danger

The severity of the danger is indicated using signal words (in accordance with ANSI Z535).

The following signal words are used in this document:

Signal word	Severity of the danger
DANGER!	Characterizes an **immediate danger**. If the danger is ignored, **death or serious injuries** will result.
WARNING!	Characterizes a **possible danger**. If the danger is ignored, **death or serious injuries** may result.
CAUTION!	Characterizes a **possible danger**. If the danger is ignored, **minor or slight injuries** may result.
NOTE!	Characterizes a **possible** hazardous situation. If this is ignored, **damage** may occur to the plant or to the area around it.

Representation examples for safety instructions in this document

Example of a danger notice for hazardous voltages, which, if ignored, will result in death or serious injuries.

	⚠ DANGER
	Type and source of the danger Consequences of failing to heed the danger • Measures to avoid the danger

Example of a danger notice for moving parts, which, if ignored, may result in death or serious injuries.

	⚠ WARNING
	Type and source of the danger Consequences of failing to heed the danger • Measures to avoid the danger

Example of a general danger notice, which, if ignored, may result in minor or slight injuries.

	⚠ CAUTION
	Type and source of the danger Consequences of failing to heed the danger • Measures to avoid the danger

Example of a note, which, if ignored, may result in damage to the plant or to the area around it.

	*NOTICE*
	Important note Consequences of failing to heed the note • Measures to avoid the danger

Example of an informative note, which, if not heeded, does not entail any danger.

Supplementary information/tips that make it easier for the user to handle the product.

2.2 Safety

General warnings, precautionary measures, and hazard instructions which apply when working with the device are collated in this section. Safety information which

only applies to certain tasks is listed at the start of every section or is repeated or added at critical points within these sections.

1. Please read this information carefully.
2. Pay attention to all the warning signs which are affixed to the equipment. The warning labels must always be legible. Missing or damaged labels must be replaced.

⚠ DANGER

The device conducts hazardous voltages

The capacitors and the line and motor terminals may conduct hazardous voltages even when the device is not in service and is disconnected from the line

Electric shocks and short-circuits may occur if personnel come into contact with live parts, spill liquids on them, or touch them with objects.

- Avoid any contact with live parts, spilling liquids on them, or touching them with objects.
- After switching off the power supply, wait at least 5 minutes before opening the device.
- Take additional external measures if there is a risk of short-circuits; for example, independent limit switches or mechanical interlocks, etc.

⚠ WARNING

The device controls rotating mechanical parts

Contact with them can cause severe physical injuries and serious material damage.

- Only touch those parts in a stopped state.
- Certain parameter settings can cause the variable speed drive to restart automatically after a fault, or after a failure in the supply voltage once the fault is eliminated and acknowledged, or after the power supply is restored.
- Ensure that the DIP switches are correctly set, and that the inputs are properly configured. Otherwise, the drive can start inadvertently.

⚠ WARNING

The devices may only be installed, commissioned, and maintained by trained personnel.

Many dangers, some potentially fatal, are posed by permitting unqualified personnel to work on the device. They may also result in damage to the device and to the plant.

▷ Qualified personnel are specialists who possess the skills required to install, mount, commission, operate, and repair the devices. These people must have the following qualifications:

- They must have received training and be authorized to switch the variable speed drives on and off, to ground the devices in accordance with safety standards, and to tag the circuits. They are generally people with expertise in the area of electrical installation or people who work under the supervision of experts, such as qualified electricians.
- They have to be familiar with all the safety information, installation and operating instructions contained in this guide, and be trained to perform first aid.

⚠ CAUTION

It is only permissible to use the device for the purposes specified by the manufacturer.

Unauthorized use or modifications can result in fires, electric shocks, and injuries.

- The device may only be used for the intended purpose.
- Do not carry out any modifications to the device.
- Only use spare parts and accessories which are distributed or recommended by the manufacturer of the device.
- Do not use the device as an "emergency stop device" (see EN 60204, 9.2.5.4).

NOTICE

The required ambient conditions must be observed.

Unsuitable ambient conditions can affect the functions of the device.

- Only install the variable speed drive in areas which are free from jolts, vibrations, electromagnetic fields, and corrosive gases.
- Maintain the ambient conditions which are specified in the technical data, such as temperature, pressure, humidity, etc.

2.3 Disclaimer of liability

!	*NOTICE*
	In the event of operation in a fire or in emergency mode, the equipment and device protection functions are disabled. As a result, damage may occur to the device and the equipment. • Only activate fire or emergency mode if the continuous operation of the drive (fan) is absolutely necessary, e.g. in order to ensure that smoke and heat are extracted in the event of the building being evacuated.

In these operating modes, particular alarms and alarm messages are suppressed in the device, such as those indicating a temperature rise in the device or a breakdown in the bus communication. Other faults, such as overvoltage or overcurrent, constantly trigger restarts. The protection functions are suppressed to ensure that the drive continues to function for as long as possible in the event of operation in fire or emergency mode.

This does not totally eliminate the risk of damage to the device, however, whether that may be due to internal components breaking down or a fire resulting from extreme heat.

Other HVAC components, e.g. dampers, can also be damaged during fire or emergency mode, for example due to overpressure when the parameters for the maximum input speed have been assigned. This type of damage can result in malfunctions or HVAC system failures.

As a result, Siemens Building Technologies accepts no responsibility for faults, malfunctions, or damage either to the device or to components of the affected HVAC system. It also accepts no responsibility for direct or indirect damage arising as a result of the fire or emergency modes activating.

!	*NOTICE*
	Loss of warranty for the variable speed drive in Essential Service Mode In the case of the Essential Service Mode, the customer can no longer lodge any claims for warranty. Essential Service Mode and the faults which arise during this mode are logged in a password-protected memory and can be read by the repair center. • Only activate the Essential Service Mode in the event of an emergency.

2.4 CE conformity

Devices in the G120P product line conform with the following guidelines:

- 2004/108/EC Electromagnetic compatibility (EMC)
- 2006/95/EC Low Voltage (LVD)

The conformity has been checked using the harmonized EN standards:

- for EMC: EN 61800-3 (2004)
- for LVD: EN 61800-5-1 (2007)

The EC Declaration of Conformity (CE) was drawn up on 03/15/2013 (document CM2T51111xx).

3 Environment

3.1 Notes on environmental compatibility and disposal

Note the following information when disposing of the device:

	This device has been developed and manufactured using environmentally friendly materials and processes. It also conforms to Siemens environmental standards.
	Do not dispose of this device along with household waste. This is particularly relevant in the case of assembled printed-circuit boards. From an environmental perspective, it makes sense to treat specialized components in a particular way. In some circumstances, this is even a legal requirement. Please observe local regulations and the applicable laws in force.
	Make use of local collection points and disposal companies, or contact your supplier/manufacturer to find out whether they will take back your device or provide further information on environmental compatibility and disposal.
	Environmental compatibility: Siemens makes every effort to manufacture products in accordance with RoHS conformity RL 2011/65/EU (RoHS).

4 Basic technical principles

4.1 Descriptions of functions

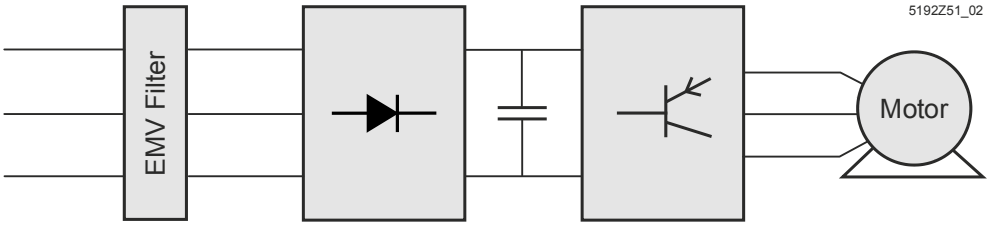
4.1.1 Variable speed drives

4.1.1.1 What is a variable speed drive?

In the past, AC and three-phase motors could only operate at a constant speed. This speed was determined solely by the frequency of the power supply (50 or 60 Hz) and the number of the motor's pole pairs.

Thanks to advances in the field of power electronics, compact devices known as variable speed drives have been developed which can convert the fixed frequency of the power supply into virtually any other frequency.

Block diagram

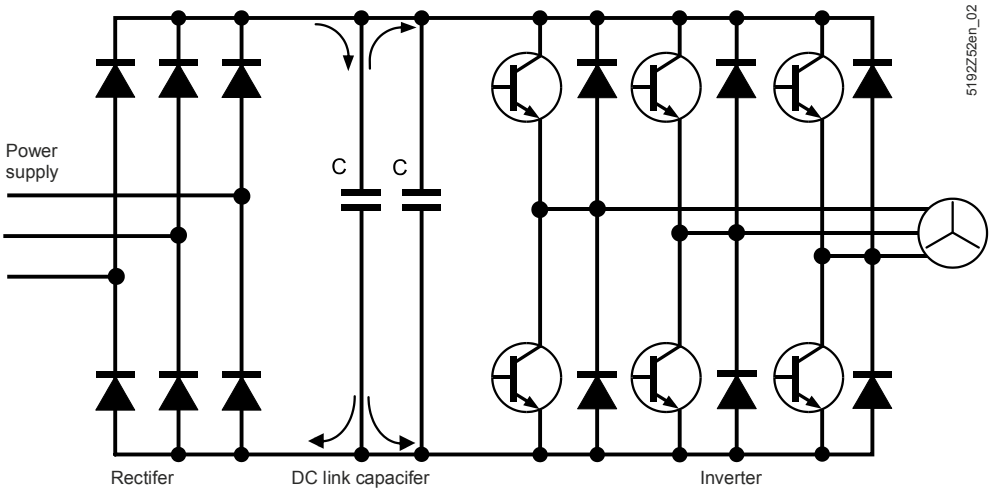


Line supply	Filter	Rectifier	DC link capacitor	Inverter	Motor

The variable speed drive transforms the AC line voltage (50 or 60 Hz) into a variable output voltage with variable frequency by means of a rectifier and an inverter. This output frequency can be greater than the line frequency.

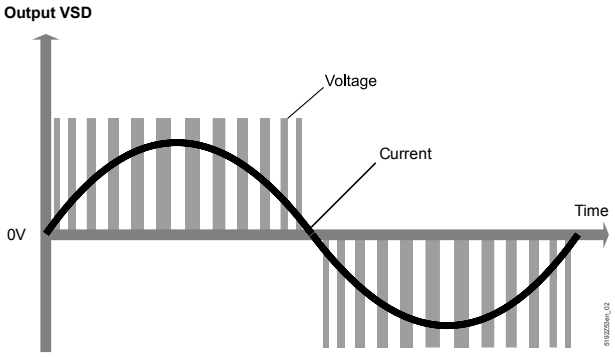
Once connected, this is how a motor alters its speed depending on the frequency and the associated output voltage, and so the speed can be varied as needed.

4.1.1.2 Operating principle of a variable speed drive



The rectifier (electronic transformer, inverter) transforms the alternating voltage (AC) into direct voltage (DC) using a non-regulated diode rectifier bridge. The direct voltage generated is then temporarily stored in the DC link capacitors.

An inverter is connected to this DC link, which generates a variable frequency and variable voltage at the output.



The direct voltage is transformed into alternating voltage in the inverter by means of pulse width modulation (PWM). The required output voltage is generated with a fixed pulse frequency by varying the switch-on and switch-off durations (duty cycle) of the output transistors (IGBTs = insulated gate bipolar transistors). The rectangular output voltage (PWM) is transformed into an almost sinusoidal motor current by the inductance of the motor coils. Typical pulse frequencies are 4, 8, and 16 kHz. The switching losses in the variable speed drive grow with increasing elementary frequency.

The motor must be suitable for operation on a variable speed drive, i.e. the motor winding must be able to withstand the peak voltages resulting from rectangular output voltages.

Voltage reflections are formed by operating with rectangular pulses in cable lengths of approx. 15 m and over. The motors must withstand the peak voltages arising from the voltage reflection at 1.9 times the DC-link voltage and 2.6 times the line voltage, as well as the voltage rise of up to 1.5 kV/us.

Otherwise, dv/dt or a sine-wave filter must be used. Also refer to the information in Section Adapting the motor to the variable speed drive (output filter) [→ 87].

4.1.1.3 Control modes of the G120P

The control for the G120P governs the relationship between the variable speed drive's output frequency and output voltage.

For HVAC applications (pumps and fans), the following control modes are used:

- V/f control (calculation of the motor voltage using a linear or square characteristic curve)
- Sensorless vector control (also known as: speed control, field-oriented control, or SLVC)

These control modes are described in Section Control modes [→ 109] .

See also

V/f control [→ 111]
Sensorless vector control (SLVC) [→ 114]

4.1.1.4 Advantages of a variable speed drive

Energy saving

Using electronic speed controllers in HVAC systems (pumps, fans, compressors) not only allows you to save energy, it also reduces system operating costs.

The more often a system operates within the partial load range, the greater the savings, and the investment in a speed controller pays for itself in just a few months.

As the systems are usually designed for full load, partial load operation is the predominant operating mode.

Operating point optimization

The speed is set to the actual required value, for example, by the flow, volume flow, pressure, or differential pressure. This allows the system to operate at the optimal operating point and achieve the best possible efficiency.

Adapting to the required speed is a very quick process, meaning the required volume flow or flow is available immediately.

Smooth operation

The soft starting and braking of the controlled motors (definable ramp up and ramp down time) reduces wear to the motor and system components as there are no abrupt pressure variations when switching on and off. The benefits of this can be seen in the form of lower maintenance costs and a longer system service life, and as a result, the total costs over the entire service life of the system are reduced.

The variable speed drive also protects the motor against overcurrent and overloading, which increases its service life further still.

It is possible to reduce the load on the system caused by mechanical resonances (e.g. in compressors) by skipping critical speed ranges.

Noise reduction

Lower speeds mean lower noise emissions. The noises transferred by pipelines and channels cause less disruption.

Fewer system components required

Using a variable speed drive allows the following mechanical and electrical components for a conventional control to be left out. As a result, the initial outlay for a variable speed drive has often already been covered.

- Mechanical reactors and valves for controlling the flow, volume flow, or pressure
- Motor circuit breakers and thermal overload relays are only required in bypass applications or where several motors are used in parallel with a G120P
- On/off switch and relay
- Star-delta (wye-delta) starter (Y/Δ) or soft starter
- Y/Δ startup requires 2 cables between motor circuit breaker and motor; the G120P only requires one
- Y/Δ startup requires 3 power contactors; the G120P requires none
- Time relays
- Operating hours counters and ammeters for the motor status are integrated into the variable speed drive
- Reactive current compensation can be reduced

Large integrated range of functions

Thanks to its many additional specific functions, the G120P is ideal for use in HVAC applications:

- Integrated PID controller for controlling the input speed depending on the pressure, temperature, flow, fill level, air quality, or other process variables, as well as 3 supplementary PID controllers for controlling additional HVAC system components such as dampers or valve actuators
- Multi-zone controller
- Pump cascade for up to 4 pumps

- Hibernation mode (energy-saving mode)
- 2 operating modes: Comfort mode and fire mode (e.g. overpressure ventilation)
- Bypass function for high availability
- V-belt monitoring without external sensor
- Many digital and analog inputs and outputs incl. direct inputs for LG-Ni1000 and Pt1000 temperature sensors
- Programmable time switches (x 3 units)
- Real-time clock for time-dependent process controls, e.g. temperature reduction for heating control at night
- Freely programmable logical function blocks for simulating simple PLC functions

Other key features:

- Significant reduction of harmonics (LHT = low harmonic technology), which improves the power factor (true power factor)
- Space-saving design of G120Ps with degree of protection IP20 in booksize format means they can be installed directly alongside each other
- G120Ps with degree of protection IP55 in frame sizes D to F do not require an additional rear panel for stand-alone installation. For frame sizes A to C, a rear panel can be ordered as an external accessory.
- One operator panel for all performance ranges
- Numerical operator panel with upload and download function and memory for one parameter set
- Plain text operator panel with upload and download function and memory for up to 16 parameter sets
- Possible to upload and download parameter settings using the operator panel without a tool, even for devices with degree of protection IP55
- MMC/SD memory card slot for backup, upload, and download functions, and memory for 100 parameter sets
- Possible to upgrade the firmware to the latest version using an MMC/SD card (for all devices from firmware version 4.6 and later)

Simple installation and fast commissioning

- All key feedback signals for setting the control loop appear on the display
- The appropriate information is provided immediately in the event of a fault
- Commissioning takes just a few minutes
- Direction of rotation can be easily reversed using parameters in the event of an incorrect phase sequence
- Volume flow or pressure can be set with ease by changing the motor speed between minimum and maximum speed
- No V-belt settings required to achieve the necessary pressure and/or volume flow
- Commissioning takes place via a Windows computer with graphical, intuitive operating software

Simple connection to building automation system

The simple connection to Siemens building automation systems means that driven pumps and fans within the building management systems can be monitored with ease and ideally controlled using the G120P.

Display for all relevant operating data

Key operating parameters such as output frequency, output current, output voltage, output power, and errors can be read.

Real power factor

Cosφ can only be used as a power factor for sinusoidal oscillations. As variable speed drives do not generate perfect sine waves, the real power factor (ratio between kW load and kVA load) is used instead of cosφ.

The G120P uses low harmonic technology (LHT), so the typical power factor is usually between 0.92 and 0.96 depending on the characteristics of the line supply.

Peaks in current are reduced

The starting current of an induction motor is 6 to 10 times the rated current. A star-delta (wye-delta) switch reduces this value to twice the rated current.

During basic commissioning/motor identification, the G120P calculates the required maximum current (approx. 150% of the rated current for the motor). The setting can then be modified manually.

When switching on, the current consumption is restricted to the set value, which leads to a reduction in voltage supply deviations and, as a result, more stable power supply conditions in the building.

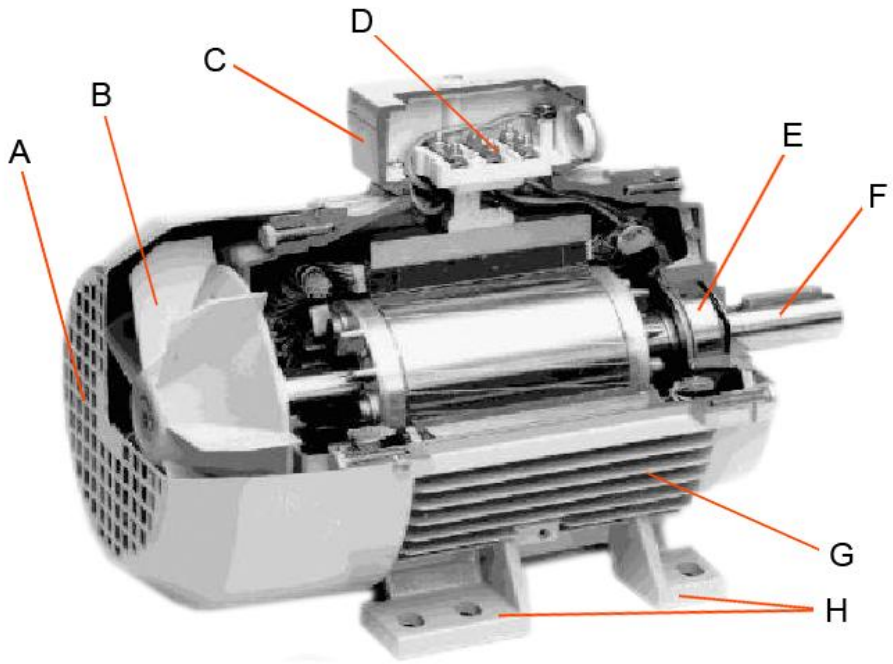
4.1.2 AC motors

4.1.2.1 Asynchronous motors

	• Also known as three-phase induction motors • Simple and rugged design • Inexpensive and reliable • Most widely used type of motor • Suitable for direct mains connection or using a variable speed drive/soft starter • Induction motors are primarily used for HVAC applications (pumps and fans)

The G120P is designed for use with induction motors. If your project involves controlling synchronous motors, please contact your local Siemens branch office for the best possible advice.

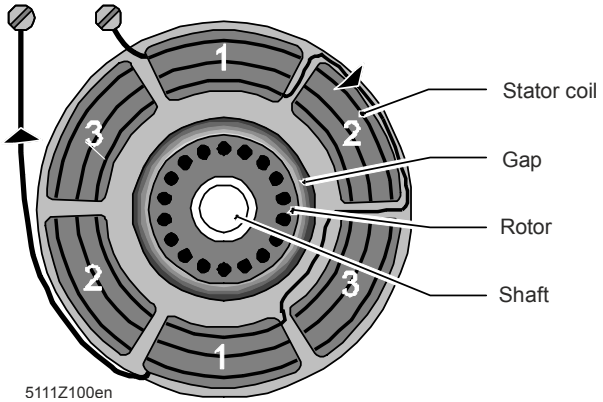
4.1.2.2 Components of an AC motor



A	Fan shroud	E	Bearings
B	Fan	F	Output shaft
C	Terminal box	G	Enclosure
D	Terminal block	H	Motherboard

An asynchronous induction motor functions just like a transformer. Connecting the stator (fixed external coil) to a 3-phase line generates a magnetic field. This rotates at the same speed as the line frequency.

The field bridges the air gap between the rotor and stator and generates a current flow in the rotor coils, which has its own magnetic field. This produces a force between the rotating stator field and the rotor field, causing the rotor to turn. This action of force is known as torque.



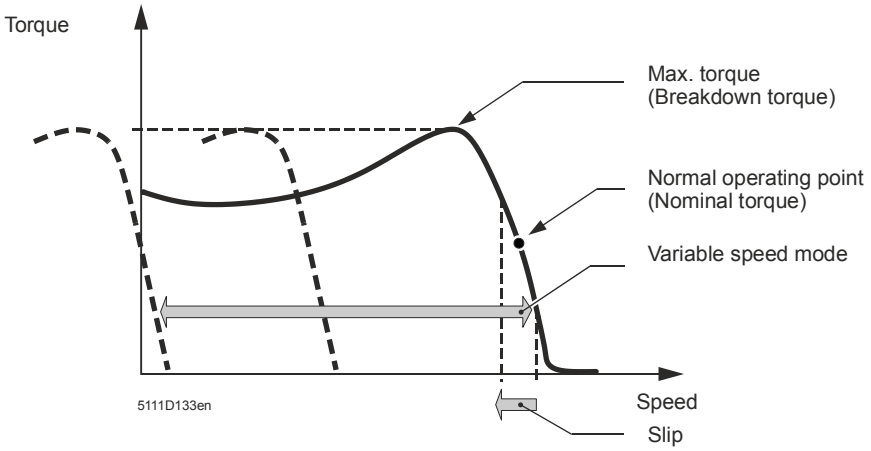
A changing magnetic field induces a voltage in the rotor conductor loops that drives a current through the short-circuited conductor loops. This current generates a magnetic field, which in turn generates the torque in conjunction with the stator field. If the rotor circulates at a synchronous speed, the magnetic field in the rotor

conductor loops does not change, no voltage is induced, and, as a result, no torque is applied either.

To generate torque, currents have to be induced in the rotor. This is why the motor always runs at a slower pace than the rotating field. This difference in speed is known as slip, and is typically 3% at 15 kW.

If the coils are arranged in several pairs (or poles), the frequency of the rotating field is lower than the applied frequency:

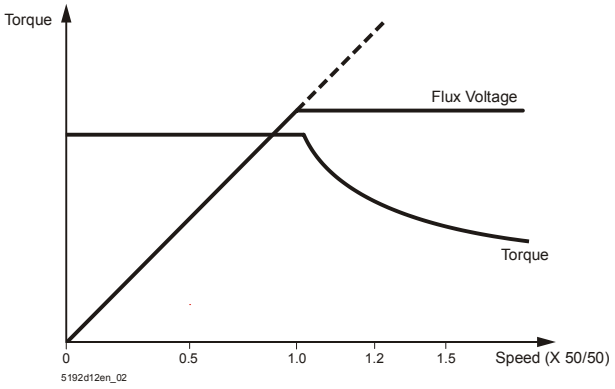
- For 2 poles and 50/60 Hz = a speed of 3,000/3,600 per minute
- For 4 poles and 50/60 Hz = a speed of 1,500/1,800 per minute



The speed of a motor depends on the frequency, coil arrangement, and load.

To control the motor speed, you must also control the frequency of the power supply.

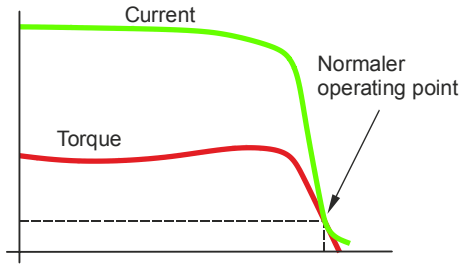
If the frequency is reduced, the voltage should also be reduced, otherwise the stator current and magnetic flux will be too high and cause the magnetic motor field to become saturated. For this reason, the voltage must also be controlled and reduced. If the frequency is increased above the normal value (line frequency), a higher voltage is required to achieve the maximum flux. As this is not generally possible, a lower torque is available at higher speeds (for example at speeds above the line frequency = field weakening mode). Also refer to the information in the Section on Operating motors at higher frequencies [→ 47].



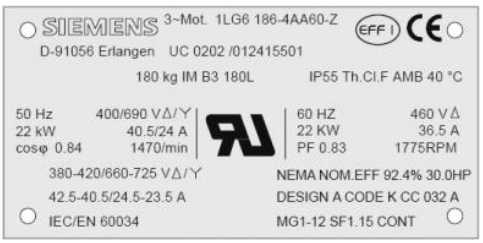
4.1.2.3 Electric motor parameters

Parameters

Typical parameters	Starting current: 600...1000 % Starting torque: 225 %

 5192D13en_02 Motor speed (4-pole motor) rpm	Depending on the motor, the starting current is roughly 6 to 10 times greater than the rated current. Particularly in larger motors, this can cause problems (sizes of upstream fuses, unwanted network loads, etc.).
Speed depending on the number of poles	Rated speed = (variable speed drive frequency - slip frequency) * 60 / number of pole pairs
	● 2-pole motor = approx. 2,910 rpm at 50 Hz ● 4-pole motor = approx. 1,455 rpm at 50 Hz ● 8-pole motor = approx. 727 rpm at 50 Hz The speed is proportional to the frequency with a constant number of pole pairs.

Rating plate

	A motor's rating plate contains a lot of information. We are only interested in the most important details, i.e. the information relating to motor operation and its applications.
Voltage	Voltage for which the motor was designed and with which it operates at the rated torque. A distinction is made between star and delta voltage. This is depicted on the rating plate with the symbols Y (star) and Δ (delta): ● In the example rating plate: 690 V for Y ● In the example rating plate: 400 V for Δ
Frequency	Frequency for which the motor was designed and with which it operates at the rated voltage: ● In Europe, this is 50 Hz ● In the USA, this is 60 Hz
Rated current	Current required by the motor to deliver the rated power in accordance with the rating plate. A distinction is made between Y (star) and Δ (delta): ● In the example rating plate: 24 A for Y ● In the example rating plate: 40.5 A for Δ
Rated power	The motor's output power as specified on the motor rating plate: ● In the example rating plate: 22 kW
Power factor (cos φ)	Reactive power of a motor at rated power: ● In the example rating plate: 0.84
rpm	Revolutions per minute. Rated speed of the output shaft in revolutions per minute at a

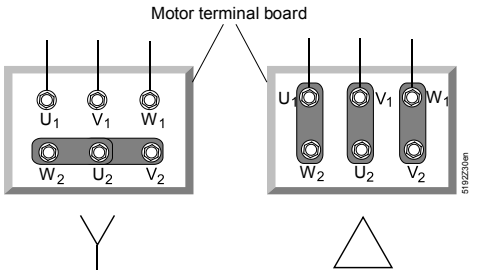
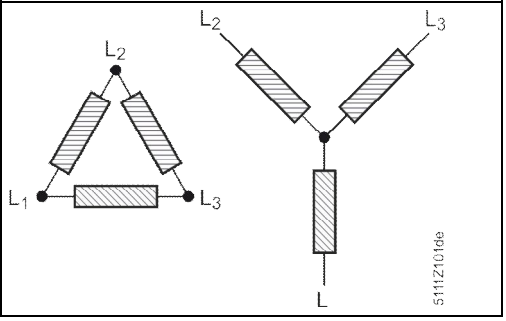
	line frequency of 50 or 60 Hz: ● In the example rating plate: 1,470 rpm ● In the example rating plate: 1,775 rpm

!	*NOTICE*
	Motors that are not suitable for use with variable speed drives The motor must be suitable for use with variable speed drives, otherwise damage may occur during operation, for example to the motor winding. ● Consult the motor manufacturer to find out whether the motor is suitable for direct variable speed drive operation.

4.1.2.4 Star and delta connection

Depending on the application, you can operate the motor in the star or delta connection (Y/Δ). The line voltage and connection type can be found on the motor's rating plate, for example 230/400 V Δ/Y.

- Ensure the interconnection is correct before connecting the motor.

	Delta connection/Star connection
	

Smaller motors (230/400 VAC Δ/Y) generally have a star connection, while larger motors (400/690 VAC Δ/Y) generally have a delta connection. The required connection is also dependent on the planned frequency range during operation.

Operation up to the rated speed

A motor is normally operated between standstill and its rated speed, i.e. a speed corresponding to the line frequency. In this case the motor must be connected in Y, or in Δ if this is specified by the rating plate In this case, it is only possible to operate the motor above its rated speed with field weakening, i.e. the available torque for the motor is reduced above the rated speed.

Operation with "87 Hz characteristic"

Operation with the "87 Hz characteristic" is only possible with 230/400 VAC Δ/Y motors. You also need to connect the motor in Δ. With the "87 Hz characteristic", the motor's power output increases. Also refer to the information in Section Operating motors at higher frequencies [→ 47].

5 Planning

5.1 Variable speed drive selection

5.1.1 Design

Overview

The SINAMICS G120P variable speed drive has a modular design.
The operator panel, Control Unit, and Power Module (power unit) can be combined to suit your needs.

The modular design means that each component can be individually replaced as required.

Order separately	G120 BT bundle	
		
Operator panels	**Control Unit**	**Power Module** (power unit)
IOP Intelligent operator panel (IP54) or **BOP-2** Basic operator panel (IP55) or **blanking cover** (IP55)	**CU230P-2 BT** incl. shield connection kit	**PM230** IP20 or IP55/UL Type 12 380 to 480 V 3-phase AC 0.37 to 75 kW (IP20) – Up to 18.5 kW, shield connection plates for the motor shield are included in the standard scope of delivery for these Power Modules 0.37 to 90 kW (IP55)

Optional accessories
● Memory cards ● PC inverter connection kit 2 ● Shield connection kit for the IP20 22 to 45 kW Power Modules

Optional accessories
● Shield connection kit for the IP20 45 to 75 kW Power Modules ● CU230P-2 DP (additional interface for PROFIBUS DP) ● CU230P-2 CAN (additional interface for CANopen) ● CU230P-2 PN (additional interface for Profinet) ● Blanking cover

Spare parts
● Mounting set ● Fan units

Bundle

The G120P variable speed drive is ordered as a bundle and includes:

- a Power Module PM230 (power unit)
- a Control Unit CU230P-2 BT (with I/O and control electronics, along with a Modbus RTU, BACnet MS/TP, P1 FLN, and USS communication)

The Control Unit is attached to the Power Module.

The following versions of the **Power Module PM230** are available:

- **IP55** with integrated EMC filter A (C2) or integrated EMC filter B (C1), see Product standard EN 61800-3 [→ 57]
- **IP20** with integrated EMC filter A (C2) or unfiltered with external EMC filter B (C1)
- **IP20** with integrated filter A or unfiltered in a push-through design
  Not available as a bundle and must be ordered separately.

A shield connection kit for the Power Module PM230 is included with the IP20 devices in frame sizes A to C. For frame sizes D to F, the shield connection kit must be ordered separately if required.

The following versions of the **CU230P-2 Control Unit** are available:

- **CU230P-2 BT** with RS485 interface for USS, Modbus RTU, P1 FLN, and BACnetMS/TP.
  Included as standard in the scope of delivery for the G120P bundle.
- **CU230P-2 CAN** with CANopen interface.
  Optional order.
- **CU230P-2 DP** with PROFIBUS DP interface.
  Optional order.
- **CU230P-2 PN** with Profinet interface.
  Optional order.

All Power Modules are also available separately from your Siemens sales office so you can combine them with the necessary Control Units. The BT bundle covers the latest HVAC requirements and simplifies the ordering process.

Operator panel and software

The commissioning, operation, and maintenance can either take place via:

- an optional BOP-2 (basic operator panel)
- an optional IOP (intelligent operator panel)
- the "STARTER" software. A STARTER license is included in each bundle. The latest version can be downloaded from www.siemens.com/starter

The operator panel is attached to the Control Unit and can be used for several variable speed drives.

The optional blanking cover allows you to protect the connections with a remote operator panel. The high degree of protection (IP55) is only achieved with the blanking cover or the BOP-2.

5.1.2 Type overview

Type code

G120P-a/bcd				
G120P	**a**	**b**	**c**	**d**
Type	Power [kW]	Voltage range	IP	Filter
		3 = 380 to 480 V	2 = 20	A = Class A filter B = Class B filter
		3 = 380 to 480 V	5 = 55	A = Class A filter B = Class B filter

Example

The type designation (ASN) **G120P-7.5/35A** defines a G120P variable speed drive for a power of 7.5 kW [aaaa] in the voltage range 380 to 480 V [b], degree of protection IP55 [c], and filter class A [d].

The G120P is only supplied for the voltage range 380 to 480 V and with class A or B filters. Unfiltered devices can also be supplied if required, although these are not normally used in building management systems as they do not meet the EMC standards.

Type code for G120P bundle IP55

The devices achieve degree of protection IP55 when a BOP-2 or blanking cover is used. Degree of protection IP54 is achieved with an IOP.

Order no./MLFB	Type	Filter class	Frame size	Power (kW) at LO (low overload)	Output current (A) at LO (low overload)	Efficiency	Power loss [kW]
6SL3200-6AM11-3AH0	G120P-0.37/35A	A	A	0.37	1.3	0.86	0.06
6SL3200-6AM11-7AH0	G120P-0.55/35A	A	A	0.55	1.7	0.90	0.06
6SL3200-6AM12-2AH0	G120P-0.75/35A	A	A	0.75	2.2	0.92	0.06
6SL3200-6AM13-1AH0	G120P-1.1/35A	A	A	1.1	3.1	0.94	0.07
6SL3200-6AM14-1AH0	G120P-1.5/35A	A	A	1.5	4.1	0.95	0.08
6SL3200-6AM15-8AH0	G120P-2.2/35A	A	A	2.2	5.9	0.96	0.1
6SL3200-6AM17-7AH0	G120P-3/35A	A	A	3	7.7	0.96	0.12
6SL3200-6AM21-0AH0	G120P-4/35A	A	B	4	10.2	0.97	0.14
6SL3200-6AM21-3AH0	G120P-5.5/35A	A	B	5.5	13.2	0.97	0.18
6SL3200-6AM21-8AH0	G120P-7.5/35A	A	B	7.5	18	0.97	0.24
6SL3200-6AM22-6AH0	G120P-11/35A	A	C	11	26	0.97	0.32
6SL3200-6AM23-2AH0	G120P-15/35A	A	C	15	32	0.97	0.39
6SL3200-6AM23-8AH0	G120P-18.5/35A	A	C	18.5	38	0.98	0.46
6SL3200-6AM24-5AH0	G120P-22/35A	A	D	22	45	0.97	0.52
6SL3200-6AM26-0AH0	G120P-30/35A	A	D	30	60	0.97	0.68
6SL3200-6AM27-5AH0	G120P-37/35A	A	E	37	75	0.97	0.99
6SL3200-6AM28-8AH0	G120P-45/35A	A	E	45	90	0.97	1.2

6SL3200-6AM31-1AH0	G120P-55/35A	A	F	55	110	0.97	1.4
6SL3200-6AM31-4AH0	G120P-75/35A	A	F	75	145	0.97	1.9
6SL3200-6AM31-7AH0	G120P-90/35A	A	F	90	178	0.97	2.3
6SL3200-6AM11-3BH0	G120P-0.37/35B	B	A	0.37	1.3	0.86	0.06
6SL3200-6AM11-7BH0	G120P-0.55/35B	B	A	0.55	1.7	0.90	0.06
6SL3200-6AM12-2BH0	G120P-0.75/35B	B	A	0.75	2.2	0.92	0.06
6SL3200-6AM13-1BH0	G120P-1.1/35B	B	A	1.1	3.1	0.94	0.07
6SL3200-6AM14-1BH0	G120P-1.5/35B	B	A	1.5	4.1	0.95	0.08
6SL3200-6AM15-8BH0	G120P-2.2/35B	B	A	2.2	5.9	0.96	0.1
6SL3200-6AM17-7BH0	G120P-3/35B	B	A	3	7.7	0.96	0.12
6SL3200-6AM21-0BH0	G120P-4/35B	B	B	4	10.2	0.97	0.14
6SL3200-6AM21-3BH0	G120P-5.5/35B	B	B	5.5	13.2	0.97	0.18
6SL3200-6AM21-8BH0	G120P-7.5/35B	B	B	7.5	18	0.97	0.24
6SL3200-6AM22-6BH0	G120P-11/35B	B	C	11	26	0.97	0.32
6SL3200-6AM23-2BH0	G120P-15/35B	B	C	15	32	0.97	0.39
6SL3200-6AM23-8BH0	G120P-18.5/35B	B	D	18.5	38	0.97	0.52
6SL3200-6AM24-5BH0	G120P-22/35B	B	D	22	45	0.97	0.52
6SL3200-6AM26-0BH0	G120P-30/35B	B	D	30	60	0.97	0.68
6SL3200-6AM27-5BH0	G120P-37/35B	B	E	37	75	0.97	0.99
6SL3200-6AM28-8BH0	G120P-45/35B	B	E	45	90	0.97	1.2
6SL3200-6AM31-1BH0	G120P-55/35B	B	F	55	110	0.97	1.4
6SL3200-6AM31-4BH0	G120P-75/35B	B	F	75	145	0.97	1.9
6SL3200-6AM31-7BH0	G120P-90/35B	B	F	90	178	0.97	2.3

Type code for G120P bundle IP20

Order no./MLFB	Type	Filter class	Frame size	Power (kW) at LO (low overload)	Output current (A) at LO (low overload)	Efficiency	Power loss [kW]
6SL3200-6AE11-3AH0	G120P-0.37/32A	A	A	0.37	1.3	0.86	0.06
6SL3200-6AE11-7AH0	G120P-0.55/32A	A	A	0.55	1.7	0.90	0.06
6SL3200-6AE12-2AH0	G120P-0.75/32A	A	A	0.75	2.2	0.92	0.06
6SL3200-6AE13-1AH0	G120P-1.1/32A	A	A	1.1	3.1	0.94	0.07
6SL3200-6AE14-1AH0	G120P-1.5/32A	A	A	1.5	4.1	0.95	0.08
6SL3200-6AE15-8AH0	G120P-2.2/32A	A	A	2.2	5.9	0.96	0.1
6SL3200-6AE17-7AH0	G120P-3/32A	A	A	3	7.7	0.96	0.12
6SL3200-6AE21-0AH0	G120P-4/32A	A	B	4	10.2	0.97	0.14
6SL3200-6AE21-3AH0	G120P-5.5/32A	A	B	5.5	13.2	0.97	0.18
6SL3200-6AE21-8AH0	G120P-7.5/32A	A	B	7.5	18	0.97	0.24
6SL3200-6AE22-6AH0	G120P-11/32A	A	C	11	26	0.97	0.32
6SL3200-6AE23-2AH0	G120P-15/32A	A	C	15	32	0.97	0.39
6SL3200-6AE23-8AH0	G120P-18.5/32A	A	C	18.5	38	0.98	0.46
6SL3200-6AE24-5AH0	G120P-22/32A	A	D	22	45	0.97	0.52

6SL3200-6AE26-0AH0	G120P-30/32A	A	D	30	60	0.97	0.68
6SL3200-6AE27-5AH0	G120P-37/32A	A	E	37	75	0.97	0.99
6SL3200-6AE28-8AH0	G120P-45/32A	A	E	45	90	0.97	1.2
6SL3200-6AE31-1AH0	G120P-55/32A	A	F	55	110	0.97	1.4
6SL3200-6AE31-4AH0	G120P-75/32A	A	F	75	145	0.97	1.9
6SL3200-6AE11-3BH0	G120P-0.37/32B	B	A	0.37	1.3	0.97	0.06
6SL3200-6AE11-7BH0	G120P-0.55/32B	B	A	0.55	1.7	0.86	0.06
6SL3200-6AE12-2BH0	G120P-0.75/32B	B	A	0.75	2.2	0.90	0.06
6SL3200-6AE13-1BH0	G120P-1.1/32B	B	A	1.1	3.1	0.92	0.07
6SL3200-6AE14-1BH0	G120P-1.5/32B	B	A	1.5	4.1	0.94	0.08
6SL3200-6AE15-8BH0	G120P-2.2/32B	B	A	2.2	5.9	0.95	0.1
6SL3200-6AE17-7BH0	G120P-3/32B	B	A	3	7.7	0.96	0.12
6SL3200-6AE21-0BH0	G120P-4/32B	B	B	4	10.2	0.96	0.14
6SL3200-6AE21-3BH0	G120P-5.5/32B	B	B	5.5	13.2	0.97	0.18
6SL3200-6AE21-8BH0	G120P-7.5/32B	B	B	7.5	18	0.97	0.24
6SL3200-6AE22-6BH0	G120P-11/32B	B	C	11	26	0.97	0.32
6SL3200-6AE23-2BH0	G120P-15/32B	B	C	15	32	0.97	0.39
6SL3200-6AE23-8BH0	G120P-18.5/32B	B	C	18.5	38	0.97	0.52
6SL3200-6AE24-5BH0	G120P-22/32B	B	D	22	45	0.97	0.52
6SL3200-6AE26-0BH0	G120P-30/32B	B	D	30	60	0.97	0.68
6SL3200-6AE27-5BH0	G120P-37/32B	B	E	37	75	0.97	0.99
6SL3200-6AE28-8BH0	G120P-45/32B	B	E	45	90	0.97	1.2
6SL3200-6AE31-1BH0	G120P-55/32B	B	F	55	110	0.97	1.4
6SL3200-6AE31-4BH0	G120P-75/32B	B	F	75	145	0.97	1.9

Filter A is integrated into IP20 devices with filter class A.

For the filter B design, an unfiltered PM230 is used with an external filter B. For devices up to 18.5 kW, this is pre-installed on the rear of the PM230 at the factory.

For devices between 22 and 75 kW, the external filter B is included in the bundle and must be installed separately, for example on the side of the device.

5.1.3 Overview of operator panels

The following table provides an overview of the performance features of the operator panels.

	IOP	BOP-2
		

	IOP	BOP-2
Operator panel	● Large plain text display ● Menu-based operation and application wizards	● 7-segment display ● Menu navigation
Possible uses	● Directly mounted on SINAMICS G120P ● IP54/UL Type 12 degree of protection ● 5 languages installed at the factory. More can be downloaded from the Internet	● Directly mounted on SINAMICS G120P ● IP55/UL Type 12 degree of protection
Startup	● Series commissioning via the clone function (max. 16 data records) ● User-defined parameter list with a reduced number of self-selected parameters ● Simple commissioning of standard applications using application-specific wizards, it is not necessary to know the parameter structure ● Commissioning largely possible without documentation thanks to additional explanations via the info button	● Series commissioning via the clone function (1 data record)
Operation and GUI	● Direct manual operation of the drive ● Simple switchover between automatic and manual operation ● Intuitive navigation with rotary-knob control ● Graphic display with trend functions for representing status values such as pressure and flow rate, for example, in bar charts ● Status display with freely selectable units to specify physical values	● Direct manual operation of the drive ● Simple switchover between automatic and manual operation ● Two-line display for indicating up to 2 process values with text
Minimal maintenance periods	● Diagnostics using plain text display, without documentation, and can be used locally on-site ● Simple update of languages, wizards, and firmware via USB ● Language packs, operating system updates, and expansions available free at http://support.automation.siemens.com/WW/view/en/30563514/130000	● Menu assisted diagnostics with 7-segment display

5.1.4 Accessories

Description	Order no./MLFB	Type (ASN)
BOP-2, SINAMICS G120P IP20/IP55, basic operator panel for snapping onto the variable speed drive ● Copying drive parameters ● Two-line display ● Guided commissioning	6SL3255-6AA00-4CA0	G120P-BOP-2
IOP, SINAMICS G120P IP20/IP54, intelligent operator panel for snapping onto the variable speed drive ● Copying drive parameters ● Plain text display ● Menu-based operation and application wizards	6SL3255-6AA00-4JA1	G120P-IOP-2
SINAMICS G120P blanking cover for POWER MODULE PM230, IP55/UL Type 12 degree of protection	6SL3256-6BA00-0AA0	G120P-BCover
SINAMICS G120P door mounting kit IOP (IP54) or BOP-2 (IP55), KIT UL TYPE 12 for intelligent operator panel (IOP) and	6SL3256-6AP00-0JA0	G120P-Door-Kit

Description	Order no./MLFB	Type (ASN)
basic operator panel (BOP-2) comprising: Seal, installation material, and connecting cable (5 m)		
STARTER Commissioning Tool (PC software) for Sinamics and Micromaster Drives (current version). DVD for Windows Server 2003 SP2, Windows XP Prof SP3, Windows 7 Professional, Ultimate, and Enterprise all SP1 (32 and 64-bit respectively), Windows Server 2008 (32-bit), and Windows Server 2008 R2 (64-bit). English, German, French, Italian, and Spanish. Free updates available online for license holders following a purchase. Connection to variable speed drive via USB cable.	STARTER on DVD: 6SL3072-0AA00-0AG0	G120P Starter
TX OPEN Module for Desigo integration	S55661-J100	TXI1.OPEN
SINAMICS G120P PC inverter connection kit 2 comprising: STARTER commissioning software on DVD and 3 m USB cable for Control Units CU230P-2. 	6SL3255-0AA00-2CA0	G120P-PC-Kit
Memory cards to save and transfer the variable speed drive settings  MMC	6SL3254-0AM00-0AA0	G120P-MMC-Card
SD	6ES7954-8LB00-0AA0	G120P-SD-Card
Control Unit CU230P-2 DP with PROFIBUS DP. I/O: 6 DI, 3 DO, 4 AI, 2 AO, 1 motor temperature sensor input, 2 PSU-OUT (10 VDC, 24 VDC), 1 PSU-IN (24 VDC), USB and MMC insert	6SL3243-0BB30-1PA2	CU230P-2 DP
Control Unit CU230P-2 CAN with CANOPEN. I/O: 6 DI, 3 DO, 4 AI, 2 AO, 1 motor temperature sensor input, 2 PSU-OUT (10 VDC, 24 VDC), 1 PSU-IN (24 VDC), USB and MMC insert	6SL3243-0BB30-1CA2	CU230P-2 CAN
Control Unit CU230P-2 PN with Profinet. I/O: 6 DI, 3 DO, 4 AI, 2 AO, 1 motor temperature sensor input, 2 PSU-OUT (10 VDC, 24 VDC), 1 PSU-IN (24 VDC), USB and MMC insert	6SL3243-0BB30-1FA0	CU230P-2 PM
SINAMICS G120P PM230, IP20 Screening Termination Kit for FSD and FSE. Contains: Screening plate and fixing accessories	6SL3262-1AD00-0DA0	G120P-Screen-FSDE
SINAMICS G120P PM230, IP20 Screening Termination Kit for FSF. Contains: Screening plate and fixing accessories	6SL3262-1AF00-0DA0	G120P-Screen-FSF
Air guide sheet for installing the G120P (PM230) IP55, FSA in systems without direct wall mounting	6SL3266-7SA00-0MA0	G120P-AirSheet-FSA
Air guide sheet for installing the G120P (PM230) IP55, FSB in systems without direct wall mounting	6SL3266-7SB00-0MA0	G120P-AirSheet-FSB
Air guide sheet for installing the G120P (PM230) IP55, FSC in systems without direct wall mounting	6SL3266-7SC00-0MA0	G120P-AirSheet-FSC
Installation set for the G120P (PM230) IP55, FSA	6SL3266-7LA00-0MA0	G120P-Ins-Kit-FSA
Installation set for the G120P (PM230) IP55, FSB	6SL3266-7LB00-0MA0	G120P-Ins-Kit-FSB
Installation set for the G120P (PM230) IP55, FSC	6SL3266-7LC00-0MA0	G120P-Ins-Kit-FSC
Installation set for the G120P (PM230) IP55, FSD	6SL3266-7LD00-0MA0	G120P-Ins-Kit-FSD
Installation set for the G120P (PM230) IP55, FSE	6SL3266-7LE00-0MA0	G120P-Ins-Kit-FSE
Installation set for the G120P (PM230) IP55, FSF	6SL3266-7LF00-0MA0	G120P-Ins-Kit-FSF

STARTER software

A license to use the STARTER commissioning software is included in the G120P BT bundle. You can find the latest version at www.siemens.com/starter

STARTER is also included as a DVD version in the SINAMICS G120P PC inverter connection kit 2 accessory and can be ordered separately.

5.1.5 Spare parts

Description	Order no./MLFB	Type (ASN)
Control Unit CU230P-2 BT with USS, MODBUS RTU, BACNET MS/TP. I/O: 6 DI, 3 DO, 4 AI, 2 AO, 1 motor temperature sensor input, 2 PSU-OUT (10 VDC, 24 VDC), 1 PSU-IN (24 VDC), USB and MMC insert.	6SL3243-6BB30-1HA3	CU230P-2 BT
SINAMICS G120P CU Screening Termination Kit 1 contains: Screening plate and fixing accessories for the CONTROL UNIT CU230P-2	6SL3264-1EA00-0FA0	G120P-CUScreen
SINAMICS G120P PM230, IP20 Screening Termination Kit for FSA. Contains: Screening plate and fixing accessories	6SL3266-1EA00-0KA0	G120P-Screen-FSA
SINAMICS G120P PM230, IP20 Screening Termination Kit for FSB. Contains: Screening plate and fixing accessories	6SL3266-1EB00-0KA0	G120P-Screen-FSB
SINAMICS G120P PM230, IP20 Screening Termination Kit for FSC. Contains: Screening plate and fixing accessories	6SL3266-1EC00-0KA0	G120P-Screen-FSC
SINAMICS G120P mounting set for the POWER MODULE PM230 IP55/UL TYPE 12 FSA G120P	6SL3200-0SK02-0AA0	G120P-MSetFSA-IP55
SINAMICS G120P mounting set for the POWER MODULE PM230 IP55/UL TYPE 12 FSB G120P	6SL3200-0SK03-0AA0	G120P-MSetFSB-IP55
SINAMICS G120P mounting set for the POWER MODULE PM230 IP55/UL TYPE 12 FSC G120P	6SL3200-0SK04-0AA0	G120P-MSetFSC-IP55
SINAMICS G120P mounting set for the POWER MODULE PM230 IP55/UL TYPE 12 FSD G120P	6SL3200-0SK05-0AA0	G120P-MSetFSD-IP55
SINAMICS G120P mounting set for the POWER MODULE PM230 IP55/UL TYPE 12 FSE G120P	6SL3200-0SK06-0AA0	G120P-MSetFSE-IP55
SINAMICS G120P mounting set for the POWER MODULE PM230 IP55/UL TYPE 12 FSF G120P	6SL3200-0SK07-0AA0	G120P-MSetFSF-IP55
External fan unit for PM230 IP20 and IP55/UL Type 12 FSA and PM2x0	6SL3200-0SF21-0AA0	G120P-FExtFSA
External fan unit for PM230 IP20 and IP55/UL type 12 FSB and PM2x0	6SL3200-0SF22-0AA0	G120P-FExtFSB
External fan unit for PM230 IP20 and IP55/UL Type 12 FSC and PM2x0	6SL3200-0SF23-0AA0	G120P-FExtFSC
External fan unit for PM230, IP20 FSD and FSE	6SL3200-0SF05-0AA0	G120P-FExtFSDE-IP20
External fan unit for PM230, IP20 FSF	6SL3200-0SF08-0AA0	G120P-FExtFSF-IP20
Internal fan unit for PM230 IP55/UL Type 12 FSA, FSB, and FSC	6SL3200-0SF31-0AA0	G120P-FIntFSAC-IP55
External fan unit for PM230, IP55/UL TYPE 12 FSD and FSE	6SL3200-0SF24-0AA0	G120P-FExtFSDE-IP55
External fan unit for PM230, IP55/UL TYPE 12 FSF	6SL3200-0SF26-0AA0	G120P-FExtFSF-IP55
Internal fan unit for PM230 IP55/UL type 12 FSD, FSE, and FSF	6SL3200-0SF32-0AA0	G120P-FIntFSDF-IP55

5.1.6 Service life of the fan

The average service life of fans is 40,000 hours. In practice, the service life may differ from this value, in particular in dusty environments.

The fan must be replaced in good time in order to ensure that the drive remains ready for operation.

Replacing the fan

Information about replacing the fan can be found in the following manuals:

- Hardware Installation Manual for Power Module PM230 IP55/UL Type 12 (A5E02923635A AA)
- Hardware Installation Manual for Power Module PM230 IP20 (A5E03448282A AA)

The fans are available as spare parts through your local Siemens branch office.

5.1.7 IP degree of protection

Structure of the IP code

IP		First code number			Second code number
International Protection		Meaning for protection of equipment (G120P)	Meaning for protection of persons		Meaning for protection of equipment (G120P)
		Ingress of solid foreign bodies:	Contact with dangerous parts using:		Ingress of water with harmful effects:
	0	Not protected	Not protected	**0**	**Not protected**
	1	≥ 50.0 mm diameter	Back of hand	1	Vertically-falling drops of water
	2	**≥ 12.5 mm diameter**	Finger	2	Drops of water (up to 15° from vertical)
	3	≥ 2.5 mm diameter	Tool	3	Spray (up to 60° from vertical)
	4	≥ 1.0 mm diameter	Wire	**4**	**Splashwater from every direction**
	5	**Protected against dust**	**Complete protection**	**5**	**Jets of water from every direction**
	6	Dust-proof	Complete protection	6	Strong water jet
				7	Temporary immersion
				8	Permanent immersion

IP degree of protection for the G120P

The G120P is supplied with IP20 and IP55 degrees of protection.

Devices with degree of protection IP20 are designed for use in a control cabinet.

Devices with degree of protection IP55 are suitable for mounting directly onto a wall without a control cabinet.

Devices with degree of protection IP55 achieve the following IP degrees of protection depending on which operator panel is attached:

- IP55 when a blanking cover or BOP-2 is used
- IP54 when an IOP is used

5.1.8 Calculating the enclosure size

When installing in an enclosure (in a control cabinet, for example), the variable speed drive's power loss must be dissipated so that the temperature in the control cabinet does not rise above the permissible ambient temperature for operating the variable speed drive. This can be achieved by means of a fan or heat conduction via the metal enclosure.

When installing in an enclosure, minimum clearances above and below the variable speed drive must be observed. This information can be found in Section Dimension drawings [→ 42].

The power loss used for the following calculations is used with 3% of the variable speed drive's rated power.

For the precise calculations, the power loss and efficiency can be found in Section Type overview [➞ 27].

Enclosure with fans

The required quantity of cooling air is calculated as follows:

(G120P power loss + other heat in the enclosure) x 3.1 / dT = m^3/h

With:
power losses and other heat in [W]
dT in [K]

Example:

Power loss of 66 W (3% of 2.2 kW for example)
No other heat sources
Permissible ambient temperature for the G120P at low overload (LO) and without derating = 40 °C
Room temperature = 25 °C
dT = 15 K (40 – 25)

Calculation: (66 + 0) x 3.1 / 15 = 13.65

A fan with a volume flow of 14 m^3 is required.

Enclosure without fan

The minimum enclosure surface required is calculated as follows:

(G120P power loss + other heat in the enclosure) / 5.5 / dT = m^2

With:
power losses and other heat in [W]
dT in [K]

Example:

Power loss of 66 W (3% of 2.2 kW for example)
No other heat sources
Permissible ambient temperature for the G120P = 40 °C
Room temperature = 25 °C
dT = 15 K (40 – 25)

Calculation: (66 + 0) / 5.5 / 15 = 13.45

An enclosure surface of at least 0.8 m^2 is required.

▷ **The following additional points are essential and must be observed:**

1. Enclosures that contain variable speed drives must not be installed in locations that are exposed to direct sunlight. Even on relatively cool days, the heating effect can quickly lead to high temperatures building up in the enclosure.
2. If ambient temperatures sink below 10 °C while the variable speed drive is not in operation, heaters must be provided to prevent the ingress of condensation.
3. If fans with filters are inserted, then cleaning these filters must be part of the normal maintenance routine.

⚠ WARNING

Hazardous voltages

The variable speed drive in the control cabinet carries lethal voltages which can still be present for 5 minutes after switching off the device.

- Warning signs for these hazardous voltages must be attached to the enclosures.

See also

Dimension drawings [→ 42]

5.1.9 Derating factors

Various influences can reduce the variable speed drive's power. During the configuring phase, take note of the expected power reductions in the following tables and diagrams, as the effective available output power is correspondingly lower. The G120P carries out the necessary reductions automatically during operation.

Derating as a function of the pulse frequency

Derating table

Increasing the pulse frequency reduces the noise from the driven motor, although it also increases the power loss in the variable speed drive along with its internal temperature.

Observe the maximum output current that the variable speed drive can achieve when the pulse frequency is increased.

NOTICE

Increasing the pulse frequency

Increasing the pulse frequency may also increase the radio-frequency emissions.

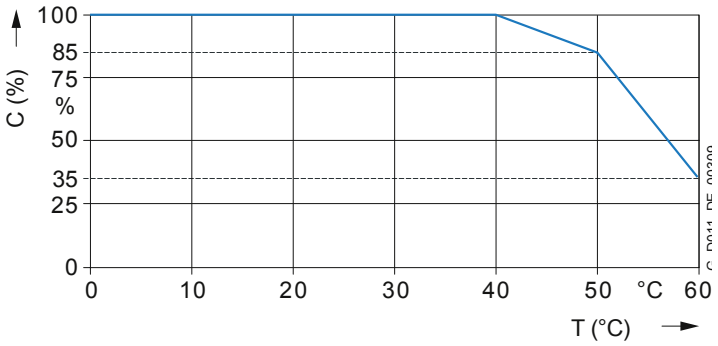
- Ensure the ground connections have been made properly and the cable shields are wired correctly.

Rated power at 400 V 3-phase AC/50 Hz		Rated output current in A for a pulse frequency of						
Kw	Hp	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz	14 kHz	16 kHz
0.37	0.5	1.3	1.11	0.91	0.78	0.65	0.59	0.52
0.55	0.75	1.7	1.45	1.19	1.02	0.85	0.77	0.68
0.75	1.0	2.2	1.87	1.54	1.32	1.10	0.99	0.88
1.1	1.5	3.1	2.64	2.17	1.86	1.55	1.40	1.24
1.5	2.0	4.1	3.49	2.87	2.46	2.05	1.85	1.64
2.2	3.0	5.9	5.02	4.13	3.54	2.95	2.66	2.36
3.0	4.0	7.7	6.55	5.39	4.62	3.85	3.47	3.08
4.0	5.0	10.2	8.67	7.14	6.12	5.1	4.59	4.08
5.5	7.5	13.2	11.22	9.24	7.92	6.6	5.94	5.28
7.5	10	18.0	15.3	12.6	10.8	9.0	8.1	7.2
11.0	15	26.0	22.1	18.2	15.6	13.0	11.7	10.4

Rated power at 400 V 3-phase AC/50 Hz		Rated output current in A for a pulse frequency of						
Kw	Hp	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz	14 kHz	16 kHz
15.0	20	32.0	27.2	22.4	19.2	16.0	14.4	12.8
18.5	25	38.0	32.3	26.6	22.8	19.0	17.1	15.2
22	30	45.0	38.25	31.5	27.0	22.5	20.25	18.0
30	40	60.0	52.7	43.4	37.2	31.0	27.9	24.8
37	50	75.0	63.75	52.5	45.0	37.5	33.75	30.0
45	60	90.0	76.5	63.0	54.0	45.0	40.5	36.0
55	75	110	93.5	77.0	–	–	–	–
75	100	145	123.3	101.5	–	–	–	–
90	125	178	151.3	124.6				

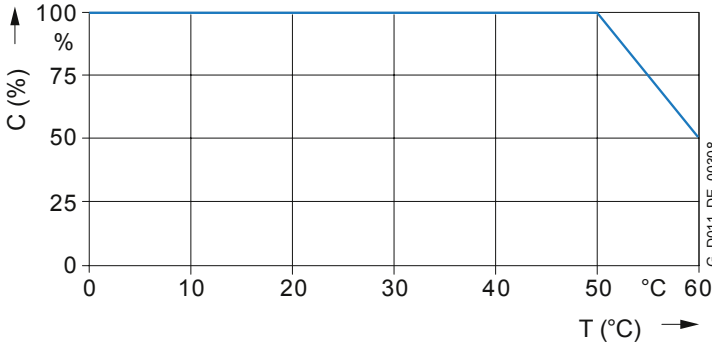
Derating in relation to the ambient temperature

Low overload (LO) for Power Modules PM230, frame sizes A to F



T (°C) = ambient temperature
C (%) = permissible output current

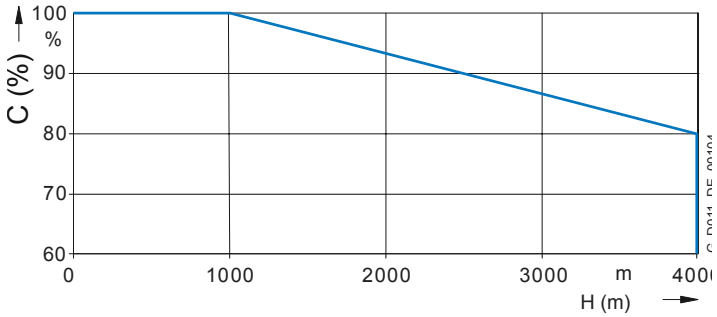
High overload (HO) for Power Modules PM230, frame sizes A to F



T (°C) = ambient temperature
C (%) = permissible output current

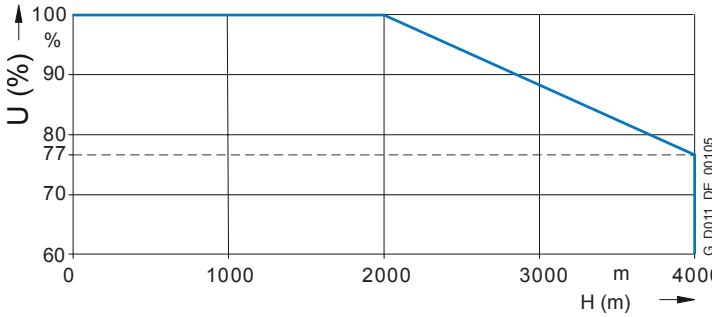
Derating in relation to the air pressure in meters above sea level

Permissible output current in relation to the installation altitude



H (m) = installation altitude above sea level
C (%) = permissible output current

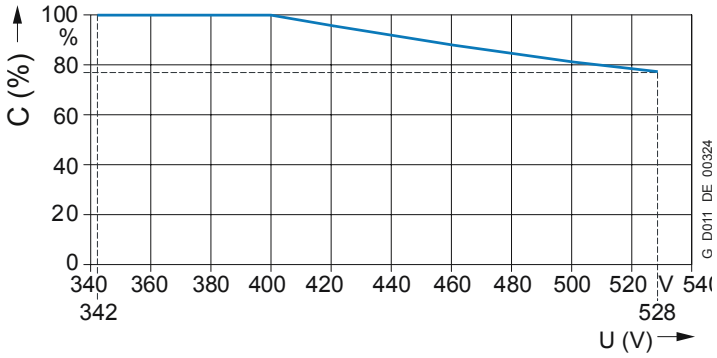
Permissible input voltage in relation to the installation altitude



H (m) = installation altitude above sea level
U (%) = permissible input voltage

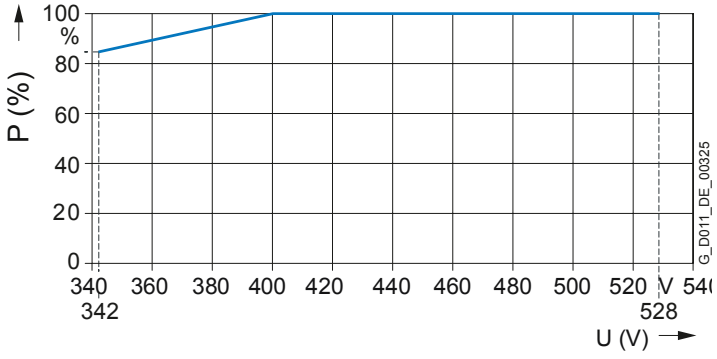
Derating in relation to the line voltage

Permissible output current in relation to the line voltage



U (V) = line voltage
C (%) = permissible output current

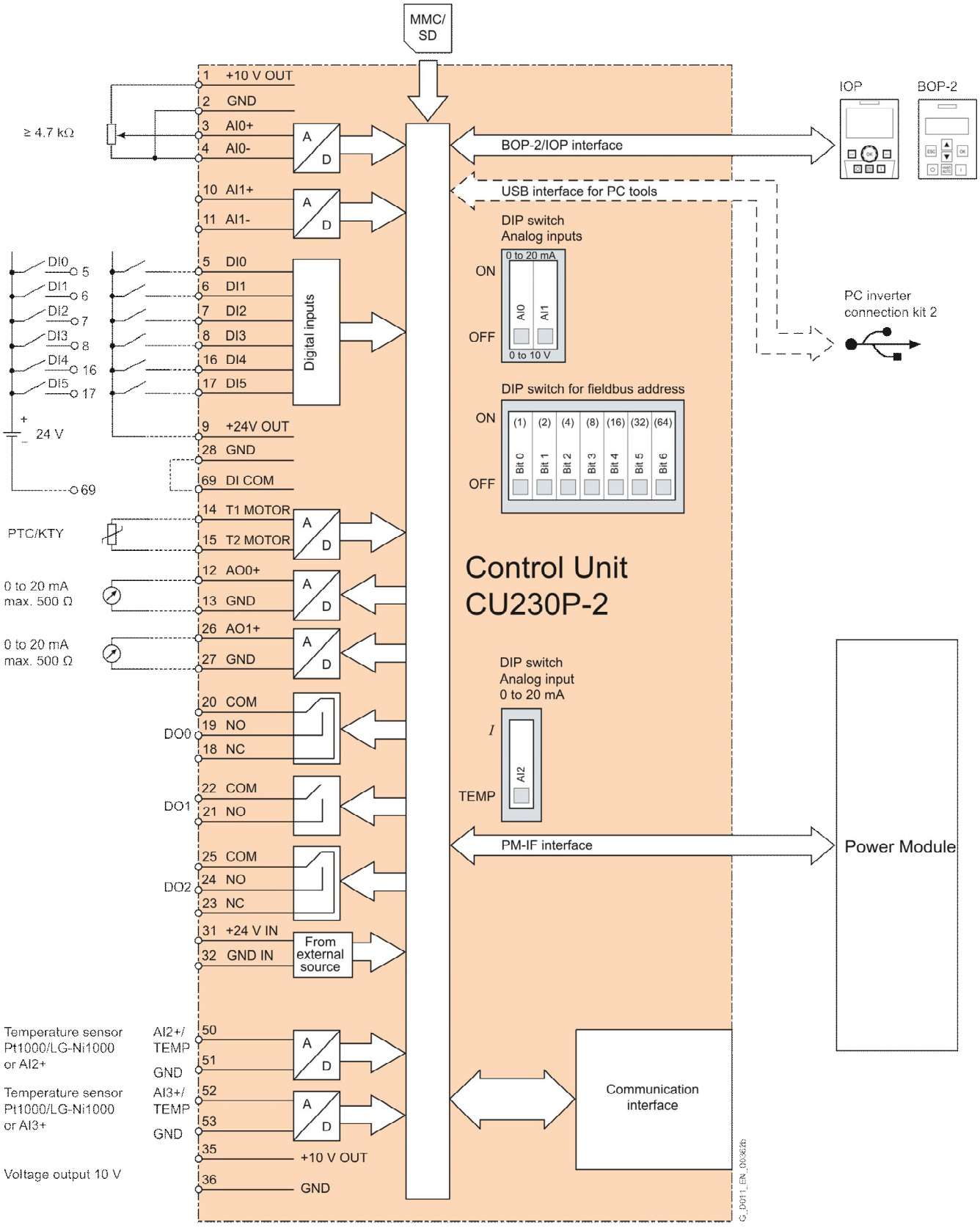
Permissible rated power in relation to the line voltage



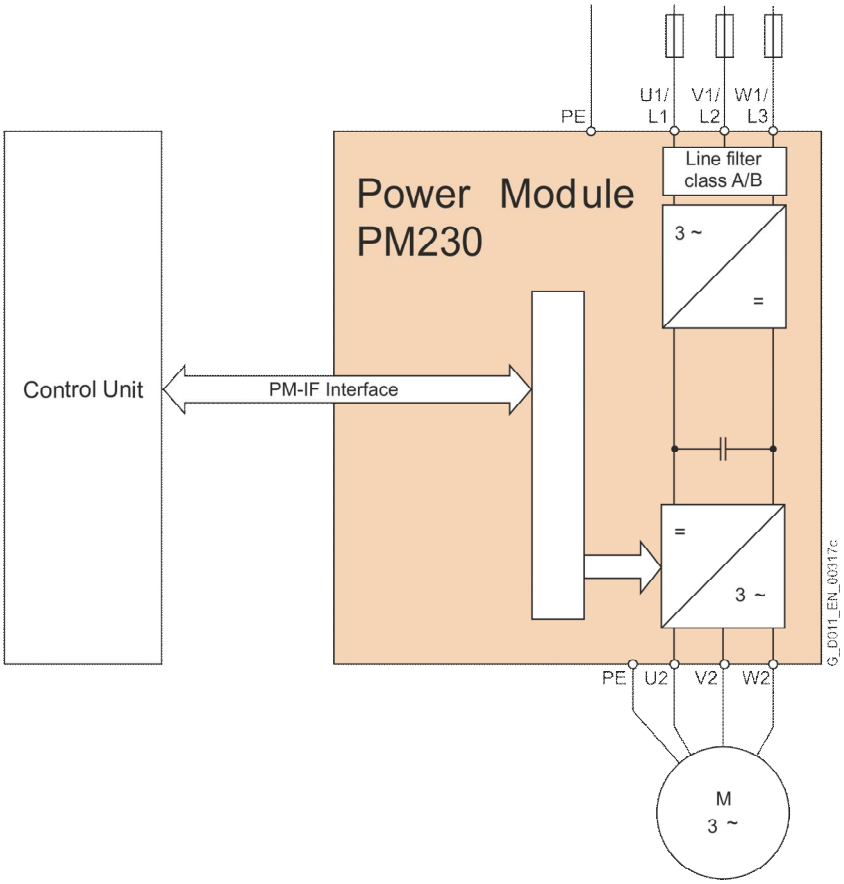
U (V) = line voltage
P (%) = permissible rated power

5.1.10 Internal circuit diagram

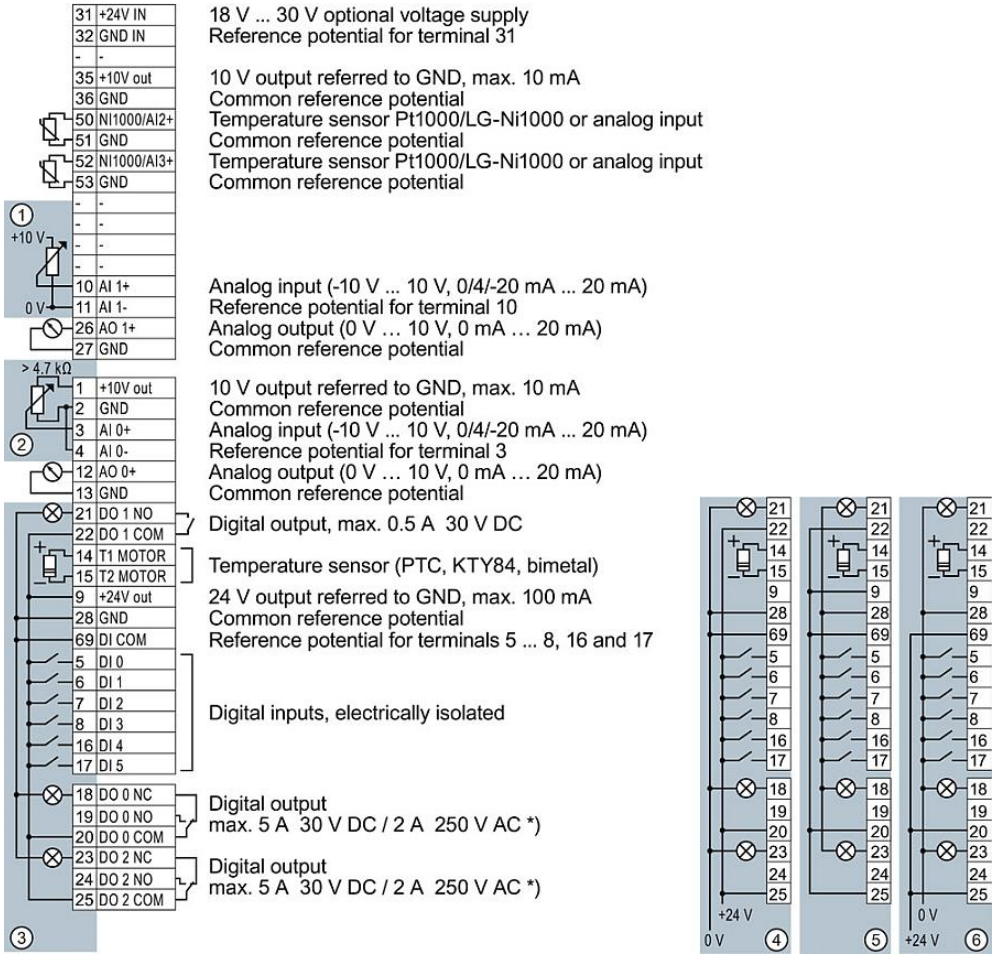
Connection diagramControl Unit CU230P-2 BT



Connection diagram for Power Module PM230 with integrated line filter class A or B



5.1.11 Terminal strips in the Control Unit



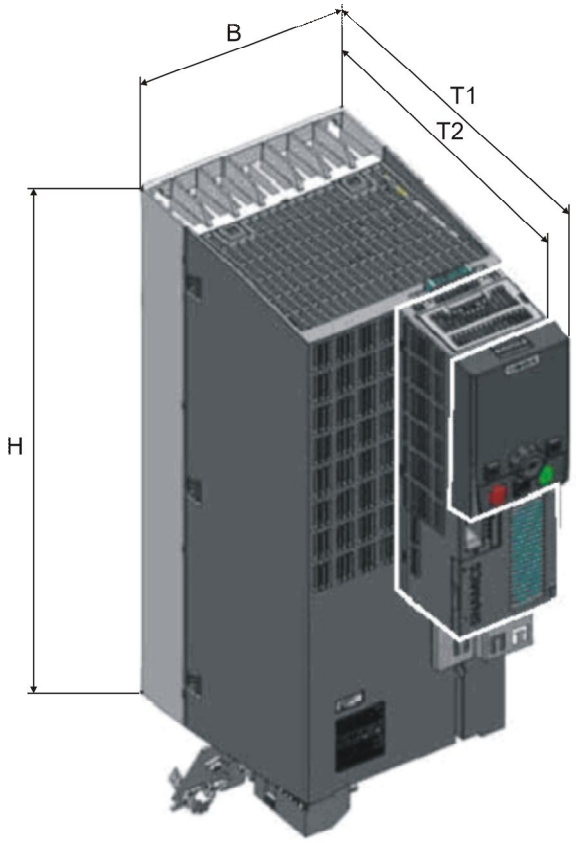
The wiring of the terminal strip is displayed by way of an example for every type of terminal.

If more than 6 digital inputs are required, use terminals 3 and 4 (AI 0) or terminals 10 and 11 (AI 1) as additional digital inputs DI 11 or DI 12.

1. Wiring when using the internal power supplies
   DI = high if the switch is closed
2. Wiring when using the external power supplies
   DI = high if the switch is closed
3. Wiring when using the internal power supplies
   DI = low if the switch is closed
4. Wiring when using the external power supplies
   DI = low if the switch is closed

5.1.12 Dimension drawings

5.1.12.1 IP20



Power Module PM230, IP20 with integrated line filter A

Frame size	Dimensions (mm)					Clearances (mm) 2)	
	H 1)	B	T1 with IOP	T1 with blanking cover/BOP-2	T2 without cover	Waste heat (top)	Cooling air (bottom)
FSA	196	73	243	233	223	80	100
FSB	292	100	243	233	223	80	100
FSC	355	140	243	233	223	80	100
FSD	512	275	282	272	262	300	300
FSE	635	275	282	272	262	300	300
FSF	934	350	394	384	374	350	350

Power Module PM230, IP20 with external line filter B

Frame size	Dimensions (mm)					Clearances (mm) 2)	
	H 1)	B	T1 with IOP	T1 with blanking cover/BOP-2	T2 without cover	Waste heat (top)	Cooling air (bottom)
FSA	202	73	308	298	288	80	100

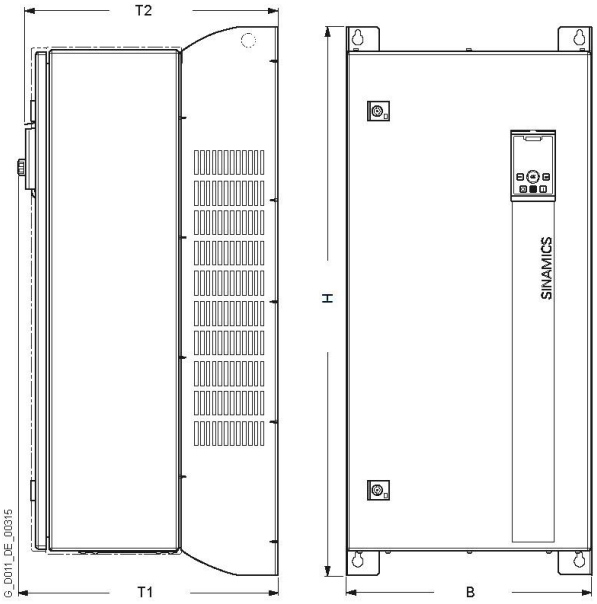
Frame size	Dimensions (mm)					Clearances (mm) [2]	
	H [1]	B	T1 with IOP	T1 with blanking cover/BOP-2	T2 without cover	Waste heat (top)	Cooling air (bottom)
FSB	297	100	328	318	308	80	100
FSC	359	140	338	328	318	80	100
FSD	512	375	282	272	262	300	300
FSE	635	385	282	272	262	300	300
FSF	934	500	394	384	374	350	350

[1] When using a shield connection kit: FSA: + 80 mm; FSB: + 78 mm; FSC: + 77 mm; FSD, FSE, FSF: + 123 mm

[2] The Power Modules can be mounted side-by-side. For tolerance reasons, we recommend a lateral clearance of approx. 1 mm.

For the frame sizes FSA to FSC, the external filter B is pre-mounted on the back at the factory. The frame sizes FSD to FSF have a side filter that has to be mounted separately. The dimensions above represent the total spatial requirements.

5.1.12.2 IP55



Dimensions for PM230, IP55

Frame size	Dimensions (mm)				
	B	H	T1 with IOP	T1 with blanking cover/BOP-2	T2 without cover
A	154	460	264	259	249
B	180	540	264	259	249
C	230	620	264	259	249
D	320	640	344	339	329
E	320	751	344	339	329

Frame size	Dimensions (mm)				
	B	H	T1 with IOP	T1 with blanking cover/BOP-2	T2 without cover
F	410	915	431	426	416

Rear panels

To ensure the cooling capacity, IP55 devices in frame sizes FSA to FSC must be mounted directly onto a flat wall. If this is not possible, for example in the case of a suspended installation on a busbar system, an air guide sheet (available separately) must be attached.

This is cut to size and comes with the corresponding holes so it can be screwed directly onto the rear of the Power Module.

You can find the available air guide sheets and their order numbers in Section Accessories [➙ 30].

5.2 Motor selection

The technical requirements and ambient conditions play a decisive role when selecting the motor.

Technical requirements

Rated frequency	3-phase AC 50/60 Hz
Rated voltage	400 or 500 V
Operating mode	Normal operation (continuous operation S1 according to
Degree of protection or type of explosion protection required	DIN EN 60034-1) IP…
Rated speed (number of poles)	n = ……rpm
Rated power	P = ……kW
Rated torque	M = P x 9,950 / n =…….Nm
Construction type	IM……

Consult the motor manufacturer to find out whether the motor is suitable for direct variable speed drive operation.

Ambient conditions

Ambient temperature	≤ 40 ºC	**> 40 ºC**
Installation altitude	≤ 1,000 m	**> 1,000 m**
Factors for changes in power	None	Determine the factor for changes in power (for reduction factor, see "Coolant temperature and installation altitude"). See Section Derating factors [➙ 35]

Rated torque

The induction motor must be able to provide the required torque, even in the process overload range. The thermal overload torque of the induction motor, however, must not be exceeded.

A reserve of approximately 10 to 30% is generally added to the motor torque/power requirements. This depends on whether the process is direct-driven or, for example, driven by a belt or gearbox.

!	*NOTICE*
	Undersized motors Undersized motors cause overvoltages and overcurrents in the variable speed drive and the motor. In the longer term, the permanent overloading leads to a reduction in the motor's service life and permanent overcurrent alarms in the upper output frequency range of the variable speed drive. The G120P calculates an I^2T model of the motor and outputs alarms indicating overcurrents and temperature rises. The G120P only controls the motor up to the rated current in order to protect both the motor and the variable speed drive. This means that motors with overly weak dimensions cannot reach the output frequency of 50 Hz. • Ensure that the motor and the variable speed drive are compatible with each other. • Ensure that the motor's planned operating point is not at the upper end of the rated torque.

Configuring tool for motors

With its comprehensive physical and technical background knowledge, SIZER software provides the user with motor configuration support. You can find it at:

www.siemens.com/sizer

5.3 Compressor operation

Compressors often require a starting current that is significantly above its base-load current. This means that the selected Power Module must be correspondingly larger to ensure that it is able to supply the required current.

The size of the Power Module also depends on permitted current overload setting.

HO and LO

The G120P has two settings (p0205) for current overload (in % based on the variable speed drive's base-load current):

- **HO** Duty cycle with high overload (setting 0)
  Up to 15 kW
  200% for 3 s and 150% for 57 s (once per 300 s cycle)
  From 18.5 kW
  150% for 60 s (once per 300 s cycle)
- **LO** Duty cycle with slight overload (setting 1)
  Up to 18.5 kW
  150% for 3 s and 110% for 57 s (once per 300 s cycle)
  From 22 kW
  110% for 60 s (once per 300 s cycle)

Selecting HO instead of LO reduces the G120P's power rating by one frame size. In doing so, the operating temperature is increased from 40 °C to 50 °C without power reduction (derating) and a larger overload is possible.

Example

A semi-hermetic reciprocating compressor with a rated power of 4.5 kW has a base-load current of 8 A, yet requires a starting current of 16 A when starting up.

The closest Power Module that can produce this starting current is the 7.5 kW model. This produces a LO output current of 18 A at an ambient temperature of max. 40 °C.

Order number	6SL3200-6AM21-0AH0	6SL3200-6AM21-3AH0	6SL3200-6AM21-8AH0
Type	G120P-4/35A	G120P-5.5/35A	G120P-7.5/35A

LO power	4 kW	5.5 kW	7.5 kW
LO input current	10.5 A	13.6 A	18.6 A
LO output current	10.2 A	13.2 A	18 A
HO power	3 kW	4 kW	5.5 kW
HO input current	8.0 A	10.5 A	13.6 A
HO output current	7.7 A	10.2 A	13.2 A

The HO output power is still 13.2 A. At an overload of 150% and a permissible ambient temperature of 50 °C, its 19.8 A are significantly higher than the required 16 A.

▷ We have used the HO solution as an example. Please proceed as follows:

1. Set the overload to HO (p0205 = 0)
2. Perform basic commissioning with motor identification
3. Set the current limit (p0640) to 16 A

The size and duration of the required compressor starting current are dependent on various factors. There are no general statements that can be made in this regard, so either contact the compressor manufacturer for the values or use your own experience.

V/f vs. SLVC

For **centrifugal or turbo compressors** (axial or radial) the "V/f" open-loop control operating mode is adequate. This is the default operating mode.

For **rotation compressors** (rotary piston, root, scroll, screw, liquid ring, and rotary slide compactors) and **piston compressors** the sensorless vector control (SLVC) closed-loop operating mode is better suited.
This has a higher dynamic power than the V/f operating mode (calculation based on the characteristic only) and is less susceptible to false tripping as a result of various load-related issues. More information about the control modes is provided under Control modes of the G120P [→ 17].

The setting can be made using the STARTER software, IOP, or BOP-2. Please proceed as follows:

1. Select the **open-loop/closed-loop control operating mode** parameter on line **p1300**
2. Select the setting **20: (Encoderless) speed control**
3. Perform the motor identification by selecting **motor data identification** on line **p1900**
4. Select the setting **1: Motor data identification at standstill and when the motor is rotating**

   ⇨ A corresponding alarm is generated
5. Switch on the drive – the motor data identification is now performed
6. Switch the drive back off

⇨ The variable speed drive is now in the SLVC control mode and the motor identification is complete. The alarm disappears.

The motor data identification can take from 0.3 s to a few minutes. This allows the motor to align itself by up to a quarter of a revolution.

You can also make these settings as part of the basic commissioning process.

▷ You can then save the settings by transferring them to the non-volatile memory.

1. Select the **Save parameters** parameter on line **p0971**
2. Select the setting **10: Save in a non-volatile memory as setting 10**

⇨ The settings have now been transferred from the RAM to the ROM.

If you would like to use the V/f control operating mode, select p1300 = 1 (V/f control with linear characteristic).

5.4 Operating motors at higher frequencies

5.4.1 General

In addition to variable speeds of up to n_{rated}, operation on a variable speed drive also enables speeds that are above the rated speed. There are two possibilities:

- Field weakening mode
- Operation with 87 Hz characteristic

To operate a motor above the rated motor speed, the variable speed drive and motor must be laid out accordingly with the appropriate parameters assigned. Pay attention to the following values:

- The mechanical limit speeds
- The increased thermal stress
- The increased voltage stress on the motor
- The variable speed drive's modulation depth

To achieve higher speeds, it is better to select a motor that has a rated speed close to the operating speed.

Example

To achieve an operating speed of 1,800 rpm, consider what would be best suited to the application: a 4-pole motor with a synchronous motor speed of 1,500 rpm and a correspondingly higher frequency, or a 2-pole motor with a synchronous motor speed of 3,000 rpm and a correspondingly lower frequency.

Motor rating plate as a calculation example

A motor with the following rating plate is taken as a basis for the following calculation examples for both field weakening mode and operation with the 87 Hz characteristic:

5.4.2 Field weakening mode

In a physical sense, the field weakening of a motor begins when the variable speed drive's output voltage can no longer be increased but the frequency continues to rise.

Generally speaking, "field weakening mode" refers to operating a motor above the rated motor frequency with a constant supply voltage.

The parameters assigned to the variable speed drive for this operating mode have a maximum speed that is greater than the rated speed (for example 1,800 rpm/400 V). As the variable speed drive frequency is increased, the output voltage remains constant, the speed increases, but the torque decreases as the flux in the machine decreases.

At constant power, the torque decreases at a rate which is inversely proportional to the speed.

Operation in field weakening mode does not depend on the motor's connection type (star or delta).

Example for calculation purposes

The example motor should run at an (asynchronous) operating speed of 2250 rpm.

Star connection.

Required settings

The motor data is set according to the rating plate. Only the data for the maximum speed (p1082) and the reference speed (p2000) has to be set to the required value.

Example parameter settings

Parameters	Description
p0304	Rated motor voltage: 400 V
p0305	Rated motor current: 0.42 A
p0307	Rated motor output: 0.12 kW
p0308	Motor cosPhi: 0.75
p0310	Motor frequency: 50 Hz
p0311	Rated motor speed: 1350 rpm
p0314	Motor pole pairs: 2
p0350	Stator resistance according to measurement (MotID)
p1082	Maximum speed 2,250 rpm
p2000	Reference speed: 2,250 rpm

Internal calculations

The following calculations are made within the device. The G120P automatically sets the parameters according to the calculation results.

Abbreviations

f	=	Frequency according to rating plate = 50 Hz
$f_{operation}$	=	Required operating frequency
$M_{operation}$	=	Operating torque
MK_{red}	=	Reduced breakdown torque
n	=	Speed according to the rating plate = 1,350 rpm
$n_{synchron1}$	=	Synchronous speed at 50 Hz = 1,500 rpm
$n_{operation}$	=	Required operating speed
p	=	Pole pair
s	=	Slip

Calculating the required operating frequency

Calculate the 50 Hz slip speed n_{S1}:

$S = n_{synchron1} – n = 1,500 – 1,350 = 150$ rpm

$$f_{operation} = \frac{n_{operation} + s}{60} * 2 = \frac{2250 + 150}{60} * 2 = 80Hz$$

As a result of the specified operating speed (2,250 rpm), the operating frequency is identified as 80 Hz.

Calculating the motor torque for the field weakening range

Motor catalog data:

- Δ 230 V; 50 Hz; 0.73 A; 0.12 kW; 1,350 rpm
- Y 400 V; 50 Hz; 0.42 A; 0.12 kW; 1,350 rpm
- Rated torque M_N = 0.85 Nm
- Motor breakdown torque M_k = 2 Nm
- Operating frequency $f_{operation}$ = 80 Hz

$$M_{operation} = \frac{f}{f_{operation}} \times M_N = \frac{50Hz}{80Hz} \times 0.85Nm = 0.53Nm$$

In the case of the motor in the example, this produces an operating torque of 0.53 Nm at an operating frequency of 80 Hz.

Calculating the reduced breakdown torque for the field weakening range (MKRed)

$$M_{K\mathrm{Red.}} = \left(\frac{f}{f_{operation}}\right)^2 \times M_K = \left(\frac{50Hz}{80Hz}\right)^2 \times 2Nm = 0.78Nm$$

In the case of the motor in the example, this produces a reduced breakdown torque of 0.78 Nm for 80 Hz.

In order to guarantee reliable operation in the field-weakening range, the difference between the reduced breakdown torque (MK_{red}) and the (maximum possible) operating torque ($M_{operation}$ max) must be more than 30%.

This is calculated as follows:

$$Stall\ limit = \frac{M_{operation}}{M_{K\mathrm{Red.}}} \times 100\% = \frac{0.53Nm}{0.78Nm} \times 100\% = 68\%$$

The breakdown limit for the motor in the example is 147% of the operating point. In the case of the motor in the example, this results in a margin of 47% (MKRed - MKOperation = 147% - 100%). Under the prerequisite that the motor is not subject to a load higher than 0.53 Nm in continuous operation at the operating point, then it may be operated at up to 80 Hz in field weakening.

Example parameter settings

If changes are made to p2000, the analog input and the serial connection are automatically re-scaled so that the full scale corresponds to this value. An additional parameter that is re-scaled as a consequence of changing p2000 is, for example, the frequency displayed at the analog output.

For scaling f*, parameters p0757 - p0760 should be observed.

5.4.3 87 Hz characteristic

As a result of the relatively constant flux in the range above the rated motor frequency, the 87 Hz characteristic offers an interesting variant.

Information regarding the motor

Operation with the 87 Hz characteristic is only possible with 230/400 VAC Δ/Y motors. For this reason, the motor must be connected in Δ despite a 400 V supply. The variable speed drive is connected to a 400 V line voltage and assigned the parameters 87 Hz/400 V. For the motor, this means that it is operated at up to √3 times its Δ data (230 V/50 Hz).

For this operating mode, the frequency is increased above the rated frequency with increasing voltage. This means that the variable speed drive's output voltage increases from f_{rated} (50 Hz) to the value parameterized for fmax (87 Hz), and as a consequence, both the magnetic flux and the available torque remain relatively constant.

However, the torque has to be reduced due to the iron losses that increase with the frequency, although this technique produces a significant increase in power compared to the rated power.

As the frame size increases, this power increase becomes lower and therefore no longer economical.

For operation with the 87 Hz characteristic, the motor must meet the following criteria:

- It must be 230/400 VAC Δ/Y. A 400/590 V motor cannot be operated with 590 V by the G120P.
- It must be connected in the delta circuit configuration.
- It must have the appropriate proof voltage – not all motors are suitable for 87 Hz operation.
- The mechanical motor limit values must be taken into account, especially for 2-pole motors.
- The higher noise levels when compared to 50 Hz must be taken into account.
- The 87 Hz characteristic generally only makes sense for motors with a lower power rating, that is, up to approximately 45 kW. Above the rated motor frequency, the iron losses increase overproportionately. This is the reason that, above this frequency, the thermal motor torque must be reduced.

Information regarding the variable speed drive

For the 87 Hz characteristic, the motor must be connected in Δ. As the variable speed drive software cannot make a distinction between star and delta circuit configurations, the appropriate parameters for the motor model must be assigned.

- The 230 V Δ data serves as a basis for configuring/assigning parameters to the 87 Hz characteristic.
- The variable speed drive must be dimensioned for the higher current demand of the motor (delta connection); this means that under certain circumstances, the variable speed drive must be selected one power stage larger.
- The 87 Hz characteristic is not dependent on the control mode and can therefore be used both in V/f control as well as in sensorless vector control.

Example for calculation purposes

Task

The example motor should run at an (asynchronous) operating speed of 2,250 rpm.

Abbreviations

f	=	Frequency according to rating plate = 50 Hz
$f_{operation}$	=	Required operating frequency
n	=	Speed according to the rating plate = 1,350 rpm
$n_{operation}$	=	Required operating speed
$n_{synchron1}$	=	Synchronous speed at 50 Hz = 1,500 rpm

$n_{synchron}$		Synchronous speed at 87 Hz
n_{S1}		Slip speed at 50 Hz
n_S		Slip speed at 87 Hz
p	=	Pole pair
s	=	Slip
U_N	=	Line voltage 50 Hz (230 V)
U_{N1}	=	Line voltage 87 Hz (400 V)

The following calculations are made automatically when using STARTER or IOP. The calculations must be performed manually when using BOP-2.

Calculating the required operating frequency

- Calculate the 50 Hz slip speed nS1:
- S = nsynchron1 – n = 1,500 – 1,350 = 150 rpm

$$f_{operation} = \frac{n_{operation} + s}{60} * 2 = \frac{2250 + 150}{60} * 2 = 80Hz$$

Calculating the synchronous speed at 87 Hz

$$f_{N1} = \frac{U_{N1}}{U_{N\Delta}} * f_{N\Delta} = \frac{400V}{230V} * 50Hz = 87Hz$$

$$n_{synchron} = \frac{f}{p} * 60 = \frac{87Hz}{2} * 60 = 2610U/\min$$

Calculating the slip speed at 87 Hz

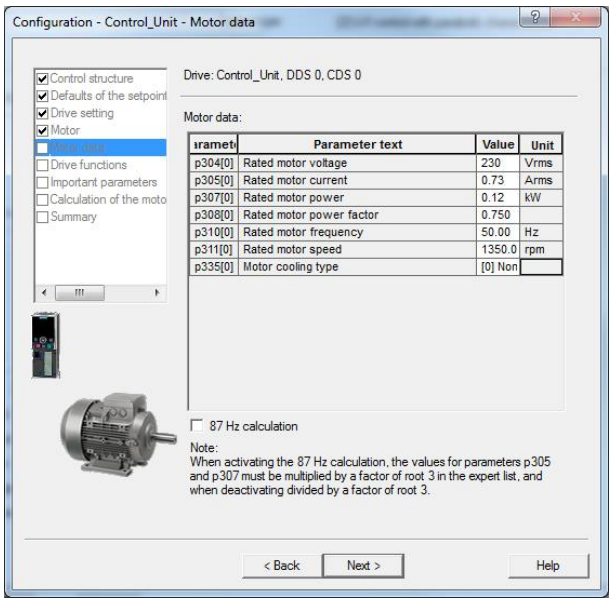
$n_S = n_{synchron} – n = 2610 – 150 = 2460$ U/min

Setting parameters with STARTER

The STARTER software uses an algorithm to convert the settings to those for the 87 Hz characteristic. The process is slightly different depending on which firmware version is used.

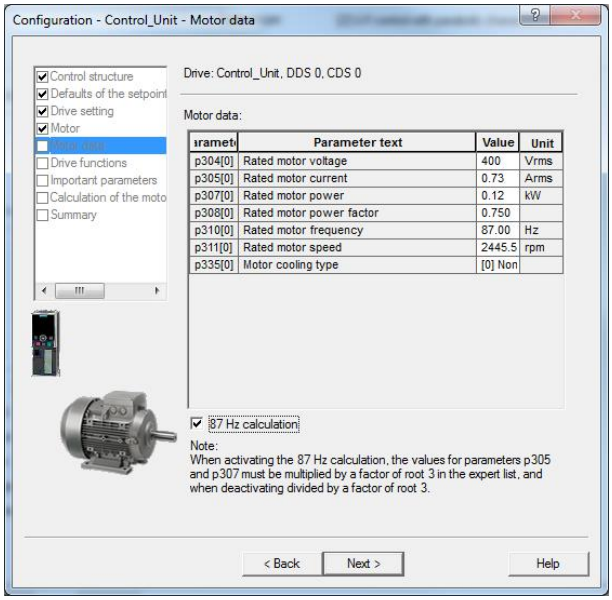
▷ From firmware 4.4.1

1. During the commissioning process, enter the 230 V motor data in the "Configuration/Drive data" screen.
2. Then select the check mark to calculate the 87 Hz characteristic.



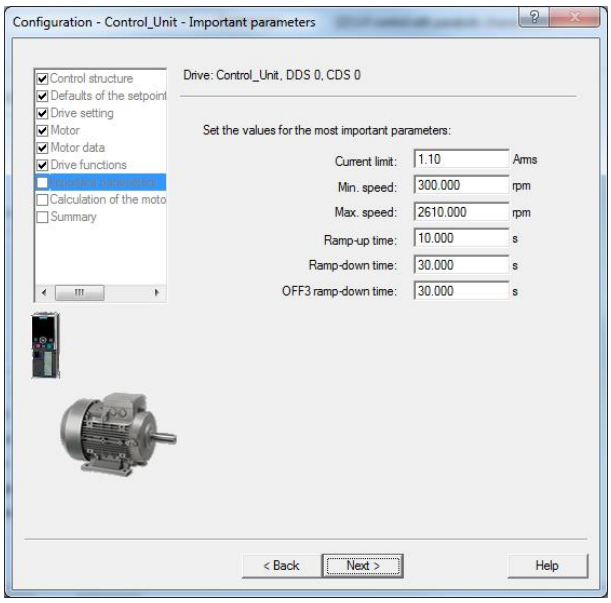
3. Click **Continue**.

   ⇨ The motor data has been converted automatically.



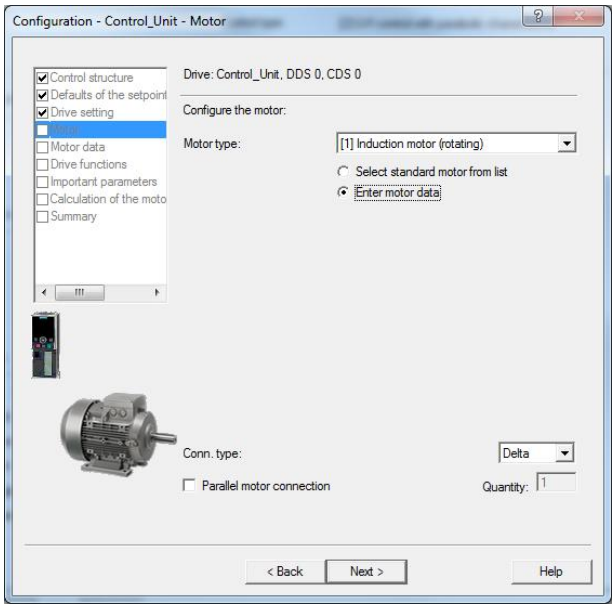
4. Click **Continue**.

⇨ The maximum speed has been increased automatically to the corresponding value.



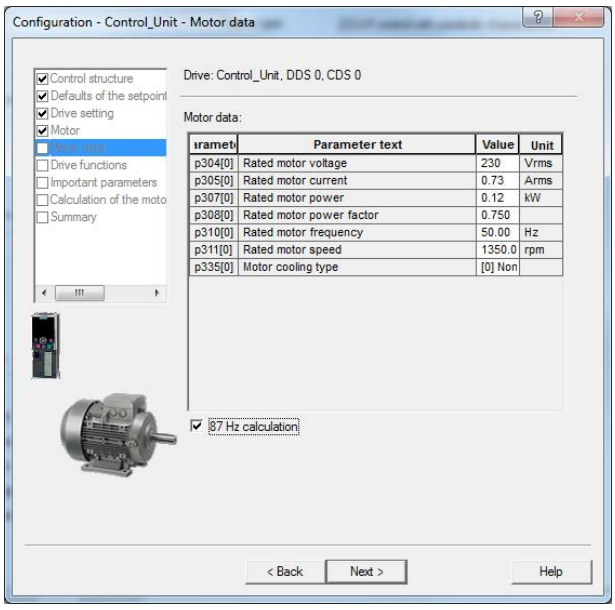
▷ From firmware 4.6

1. During the commissioning process, select the "delta" connection type in the "Configuration/Motor" screen.



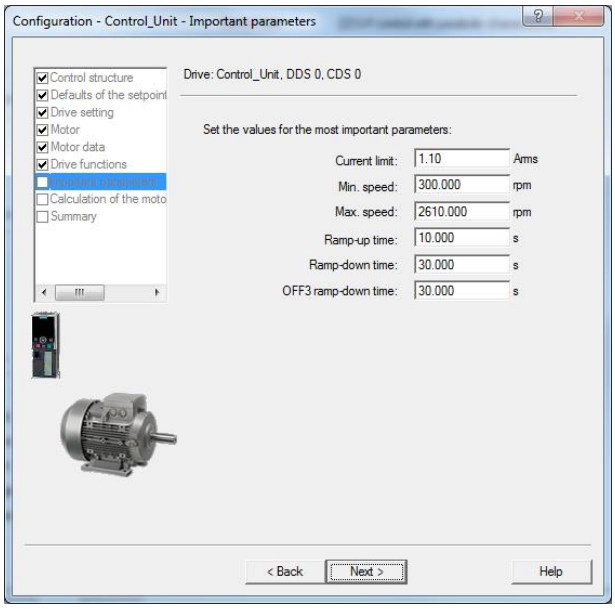
2. Click **Continue**.
3. Enter the 230 V motor data in the "Configuration/Drive data" screen and select the check mark to calculate the 87 Hz characteristic.

   ⇨ The motor data is not changed in the process.



4. Click **Continue**.

⇨ The motor data has been internally adjusted and the maximum speed has been increased automatically to the corresponding value.



Setting parameters with IOP

When assigning parameters using an intelligent operator panel (IOP), the 87 Hz characteristic option can be selected. Then you can simply enter the 230 V motor data, just like for the configuration with the STARTER software. The G120P then converts the values automatically.

Enter the data as follows:

Parameters	Description
p0304	Rated motor voltage: 230 V
p0305	Rated motor current: 0.42 A
p0307	Rated motor output: 0.12 kW
p0308	Motor cosPhi: 0.75
p0310	Motor frequency: 50 Hz
p0311	Rated motor speed: 1,350 rpm

Once the calculation is complete, the parameters are set as follows for this example: (From firmware 4.6, the rating plate data is no longer changed):

Parameters	Description
p0304	Rated motor voltage: **400 V**
p0305	Rated motor current: 0.73 A
p0307	Rated motor output: 0.21 kW
p0308	Motor cosPhi: 0.75
p0310	Motor frequency: **87 Hz**
p0311	Rated motor speed: **2,455 rpm**
p1082	Maximum speed: 2,610 rpm
p2000	Reference speed: 2,610 rpm

Setting parameters with BOP-2

From firmware 4.4.1

▷ The BOP-2 basic operator panel does not have an integrated conversion algorithm for the 87 Hz characteristic. This means the appropriate calculations have to be completed manually. You can make the necessary settings (including motor parameters) during the setup process.

- For this example, enter the following values:

Parameters	Description
p0304	Rated motor voltage: 400 V
p0305	Rated motor current: 0.73 A
p0307	Rated motor output: 0.21 kW
p0308	Motor cosPhi: 0.75
p0310	Motor frequency: 87 Hz
p0311	Rated motor speed: 2,460 rpm
p1082	Maximum speed: 2,610 rpm
p2000	Reference speed: 2,610 rpm

From firmware 4.6

1. Make the settings for p0010=3 (motor commissioning)
2. Make the settings for p0133.0=1 (delta connection) and for p0133.1=1 (87 Hz)
3. Make the settings for p0010=0 (ready)
4. Now complete the setup (without restoring the factory settings) and enter the motor data for the delta connection

Further information regarding the 87 Hz characteristic

If changes are made to p2000, the analog output and the serial connection are automatically re-scaled so that the full scale corresponds to this value. The frequency displayed at the analog output is also re-scaled as a consequence of changing p2000.

For scaling the scaling characteristic, parameters p0757 - p0760 should be observed.

p0350 applies for the phase value of the stator resistance; the value of the equivalent circuit diagram can be written directly into parameter p0350.

5.5 EMC

5.5.1 Basic principles

EMC stands for "electromagnetic compatibility" and essentially refers to the requirement that there must be no unacceptable mutual interference or damage when operating electrical devices.

A distinction is made between various known phenomena, such as radio frequency interferences, line harmonic distortions, overvoltages, electromagnetic interferences, and other such interferences by the increased use of power electronic devices, microelectronics in automation engineering, and an increasing number of radio services, etc.

5.5.2 Standards

To ensure no disturbances arise, you must observe the emission limit values and the tolerance of specific immission limit values (immunity).

The following standards are particularly significant to variable speed drives with regard to EMC:

- Environment standard **EN 55011**
  Radio frequency interferences – limit values and measuring procedures for industrial, scientific, and medical devices
- Product standard **EN 61800-3**
  EMC requirements/test methods for variable-speed electrical drives
- Standard for connecting to public low-voltage networks **EN 61000-3-12/EN 61000-3-2.** Requirements and limit values for harmonic component currents

All G120Ps are CE-certified and therefore manufactured in accordance with the standards. Different EMC grades are offered depending on the type. Depending on the location of use (environment), the following classes should be observed to ensure smooth operation:

Use in	Class according to EN 55011	Class according to EN 61800-3
First environment (residential and commercial areas)	Class B, A1	Class C1, C2
Second environment (industrial areas)	Class A2	Class C3, C4

The most cost-effective way to ensure a system runs smoothly is to consider the subject of EMC as early as possible, for example, EMC zones should be defined, cable types determined, and filters provided as early as the planning phase.

5.5.2.1 Environment standard EN 55011

The environment standard is a universal standard for devices without a specific product standard. It defines emission limit values and the device immunity requirements depending on the location of use.

The following 2 classes are relevant for variable speed drives:

Use in	Class according to EN 55011
First environment (residential and commercial areas)	Class B, A1

Use in	Class according to EN 55011
Second environment (industrial areas)	Class A2

The limit values for class B (residential and commercial areas) are significantly lower than those for class A1 (industrial areas).

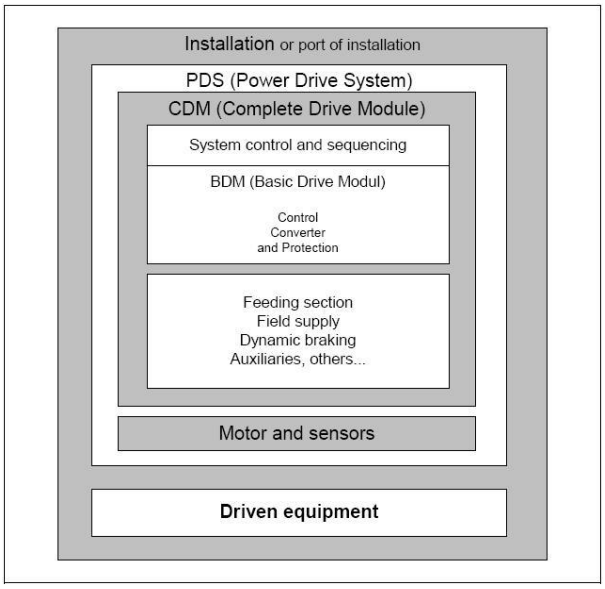
Industrial areas also have class A2 for high-frequency applications. This class is not relevant for variable speed drives.

5.5.2.2 Product standard EN 61800-3

In EMC product standard EN 61800-3, criteria for performance during interference have been established and the immunity requirements and interference emission limiting values have been defined according to the ambient conditions at the location of use.

The standard does not apply directly to a variable speed drive but to a complete drive system, which comprises the complete circuitry, motor and cables in addition to the variable speed drive.

Drive system (PDS) according to EN 61800-3:



PDS: Power Drive System

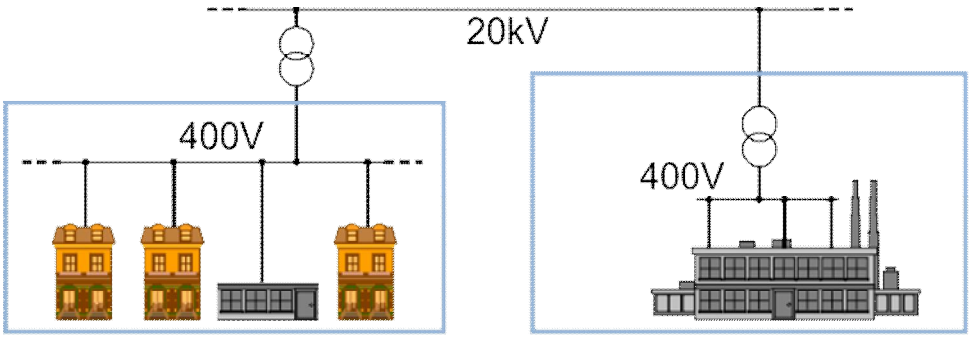
CDM: Complete Drive Module

BDM: Basic Drive Module

Applications

The permitted limit values are dependent on the application area. A distinction is made between "first environment" and "second environment". Depending on the environment, various device categories are admitted and diverse requirements are placed on filters and shielding.

Connected to public low-voltage network "Residential area" = **"First environment"**	Connected to medium-voltage network via own transformer "Industrial network" = **"Second environment"**



- Large volume of low-cost equipment
- Few potential sources of interference
- Low limit values

- Many potential sources of interference
- Interference-resistant devices
- High limit values

Category C1

- Integrated filter class **B** according to EN 55011
- Shielded motor cable,
  IP55 max. 25 m
  IP20 max. 50 m
- Line harmonic distortions according to EN 61000-3-2 and EN 61000-3-12 must be observed

Category C2

- Integrated filter class **A1** according to EN 55011
- Shielded motor cable, max. 25 m
- Other conditions must be met for use in the first environment (sales and installation by professionals, supply voltage < 1,000 V, approval of the network operator, etc.)

Category C3, C4

- Filter is unnecessary
- Unshielded motor cable is possible
- Separate EMC planning

The Power Module PM230 is typically inserted in categories C1 and C2.

The PM230 IP20 or PT are available with an integrated class A line filter or with an external class B filter.

The PM230 IP55/UL type 12 are available with an integrated class A or B line filter.

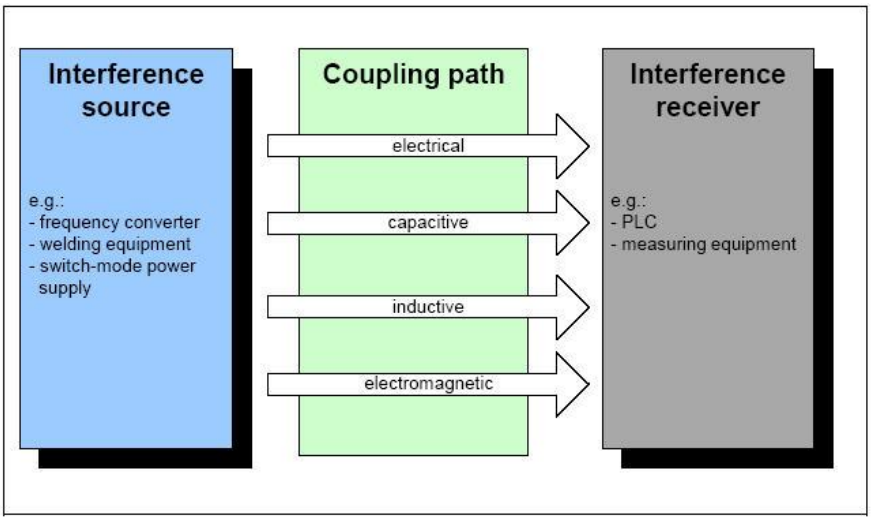
Unfiltered devices can also be supplied if required, although these are not normally used in building management systems as they do not meet the EMC standards.

!	*NOTICE*
	Using unshielded cables and insufficient shield support It is not possible to observe the limit values with unshielded cables and insufficient shield support, as the effect on interference sinks from resulting disturbance variables can be too great. The limit values are only achieved with shielded cables and good shield support. • Please refer to the relevant specifications in Section EMC-compliant wiring [→ 75].

EMC model

The EMC model serves as a basis for describing electromagnetic phenomena:

- **Source of interference** (sender)
  Cause of the interference. Appropriate measures must be taken to eliminate or at least reduce the disturbance variables and their effects produced by the source of interference.
- **Coupling path** (path)
  Transmission path for the disturbance variables produced by the source of interference. This allows disturbance variables to spread from the source of interference to the interference sink and involves various coupling mechanisms (see graphic).
- **Interference sink** (receiver)
  Electrical device whose function can be affected by disturbance variables.



Electromagnetic disturbances can only affect devices or systems if all three components of the EMC model are present. Once the individual components have been localized, the mutual electromagnetic compatibility can be increased via the following measures:

- **Suppressing the source of interference**
  Minimizing or eliminating the interference emissions
- **Increasing the immunity of the interference sink**
  Minimizing or avoiding damage to the functions caused by disturbance variables
- **Reducing the coupling paths**
  Attenuating or suppressing the interference coupling

⚠ WARNING

Electrical, magnetic, and electromagnetic fields (EMF)

Electrical, magnetic, and electromagnetic fields (EMF) that occur during operation can pose a danger to persons who are present in the direct vicinity of the product – especially persons with pacemakers, implants, or similar devices.

- The machine/system operator and the people present near the product must observe the relevant guidelines and standards. These are, for example, EMF Directive 2004/40/EEC and standards EN 12198-1 to -3 in the European Economic Area (EEA) and, in Germany, the accident prevention regulation BGV B11 and the associated rule BGR B11 "Electromagnetic fields" from the German Employer's Liability Insurance Association.
- Hazard analyses must be drawn up for every workplace, from which measures for reducing dangers and their impact on persons are derived and applied, and exposure and danger zones are defined and observed.
- The relevant safety information in the Storage, Transport, Installation, Commissioning, Operation, Maintenance, Disassembly, and Disposal sections must also be taken into account.

Interference emissions

Interference emissions include all types of electrical and magnetic disturbance variables emitted from a source of interference. The causes and coupling paths involved are essentially dependent on the frequencies that occur.

Low-frequency interference emissions < 9 kHz

Conducted line harmonic distortions are particularly significant in the low-frequency range. This includes the following phenomena with the corresponding test standards:

- Voltage distortions due to higher-level harmonic currents (EN 61000-3-2/-12)
- Periodic voltage dips due to commutation processes in the variable speed drive's input circuits (EN 60146-1-1)
- Voltage supply deviations/flickers due to rapid load changes, particularly reactive powers (EN 61000-3-3/-11)

Causes

The input circuit for G120P devices typically consists of an uncontrolled rectifier (B6 diode bridge) and the voltage-source DC link composed of capacitors. If the line voltage exceeds the DC-link voltage, the diodes become conductive and the capacitors are reloaded. This temporarily causes high current pulses to flow, i.e. a non-sinusoidal current is removed from the line.

Effects

The interference can have the following typical effects:

- Overloaded cables, contactors, and switches
- Reduced real power factor
- Measuring instrument malfunctions
- Noise disturbances such as buzzing from fluorescent lamps

Corrective measures

Keep the source impedance at the infeed point to a minimum in order to reduce the voltage distortion for other consumers.

For additional information, see Chapter . Reduction procedures [→ 69]

The G120P meets the following specifications:

- THC (Total Harmonic Current): The G120P meets the standard for RSCE values > 250
- PWHC (Partial Weighted Harmonic Current): The G120P meets the standard for RSCE values: >=250

High-frequency interference emissions > 9 kHz

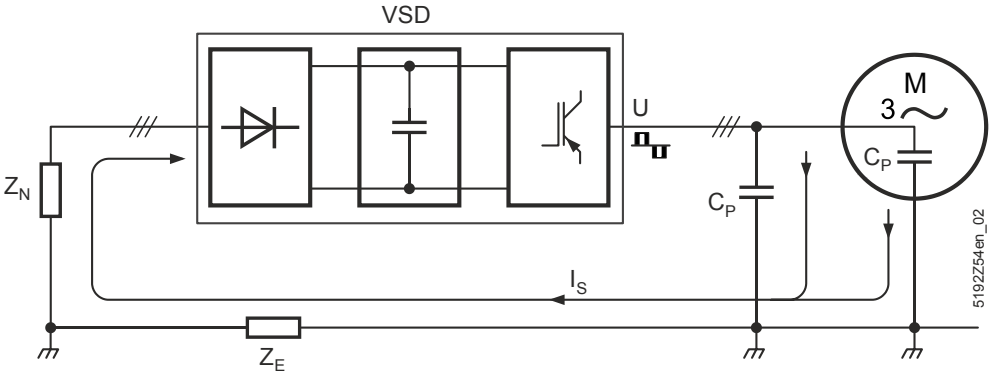
The high-frequency interference emissions include:

- Disturbance voltages according to EN 61800-3
- Emitted interference according to EN 61800-3

Causes

A variable speed drive's output circuit typically consists of rapidly switching IGBT modules that operate with switching frequencies between 4 and 16 kHz. By switching the IGBT appropriately, the DC-link voltage is switched to the motor winding.

Course of the interference current I_s with unshielded motor cables:



The parasitic capacitances (C_P) are charged and discharged by the variable speed drive's pulsed output voltage, the interference current I_S flows, and high-frequency electromagnetic fields (HF radiation) are radiated by the variable speed drive and motor cables in particular.

Effects

The interference current must flow back to its source, i.e. to the variable speed drive's DC link. When using unshielded cables, the interference current flows back, undefined, via the ground (Z_E) and mains supply conductor (Z_N) impedances such as grounding rods and cable racks, etc. The interference current and its resulting disturbance voltage can have a negative impact on – and even damage – plant units and devices.

The electromagnetic fields radiated by the variable speed drive and the motor cable transfer energy and can lead to interference irradiation in other devices.

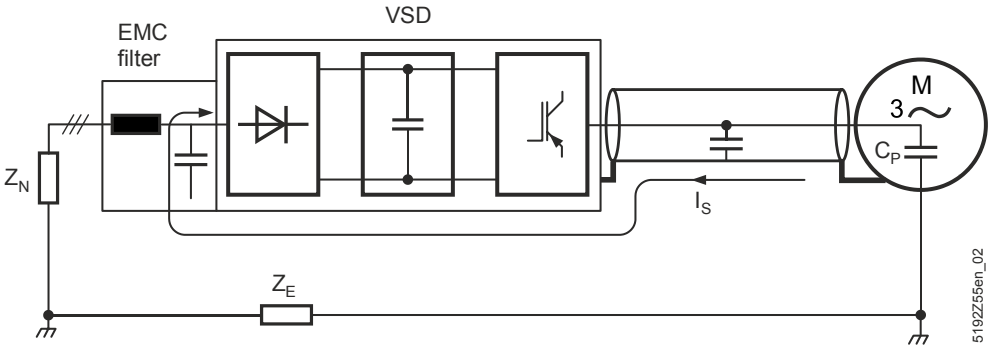
Corrective measures

The following measures should be taken to minimize the high-frequency interference emissions:

- Using shielded motor cables
- Installing a special EMC filter on the line side of the variable speed drive

!	*NOTICE*
	High-frequency emitted interference and interference current High-frequency interference emissions and undefined interference current feedback can affect the functions of other devices. • Be sure to use special EMC motor cables with a high shielding factor and low parasitic capacities. • Connect the cable shield to the variable speed drive enclosure and the motor enclosure over a large area. The cable shield must not contain any gaps. Equipotential bonding must be ensured on both sides to prevent large, unwanted equalizing currents from flowing along the cable shield.

Interference current when using unshielded motor cables and installing an EMC filter:



The G120P meets the criteria for the following categories according to EN 61800-3:

		≤ 25 m shielded motor cable		≤ 50 m shielded motor cable	
		Conducted	Emitted noise	Conducted	Emitted noise
IP 55	With integrated B filter	C1	C2	C2	C2
	With integrated A filter	C2	C2	C3	C3
IP 20	With external B filter	C1	C2	C1	C2
	With integrated A filter	C2	C2	C3	C3

Regardless of the elementary frequency set, all emission limit values are achieved between 4 and 16 kHz.

!	*NOTICE*
	Using ferrite cores Some frame sizes come with ferrite cores in IP20 and IP55. These are crucial for maintaining the limit values listed here, otherwise the device emits greater interference. • Mount the ferrite core on the motor/mains supply conductor according to the installation instructions.

Immunity

A specific degree of immunity is required from all devices depending on their location of use. Immunity describes the immunity against individual emissions of adjacent sources of interference. Immunity in this respect means that, to a certain degree, a certain level of a disturbance can lead to interference. Should the interference level be exceeded, it can lead to power failures which are no longer tolerable, malfunctions, or even the destruction of devices.

Typical disturbance variables

In the low frequency range < 9 kHz

- Harmonic components corresponding to EN 61000-2-2/-4
- Commutation interruptions corresponding to EN 60146-1-1
- Voltage changes, fluctuations, dips, and interruptions corresponding to EN 61000-2-1
- Voltage imbalances and frequency changes corresponding to EN 61000-2-2/-4

In the high-frequency range > 9 kHz

- ESD: electrostatic discharge corresponding to EN 61000-4-2
- HF radiation corresponding to EN 61000-4-3
- Burst: fast transient interferences corresponding to EN 61000-4-4
- Surge: high-energy transients corresponding to EN 61000-4-5
- HF current on cables corresponding to EN 61000-4-6
- Influence through homogeneous high-energy magnetic fields (same and alternating fields) corresponding to EN 61000-4-8

Corresponding check values and assessment criteria are required for individual disturbance variables in the product standard EN 61800-3 or in the generic standards EN 61000-6-1/-2.

The limit values listed in the following table are met by the Siemens G120P variable speed drive.

The SINAMICS G120P is interference resistant in accordance with category C3 of EN 61800-3, and is capable of withstanding the higher fault values found in the industrial environment.

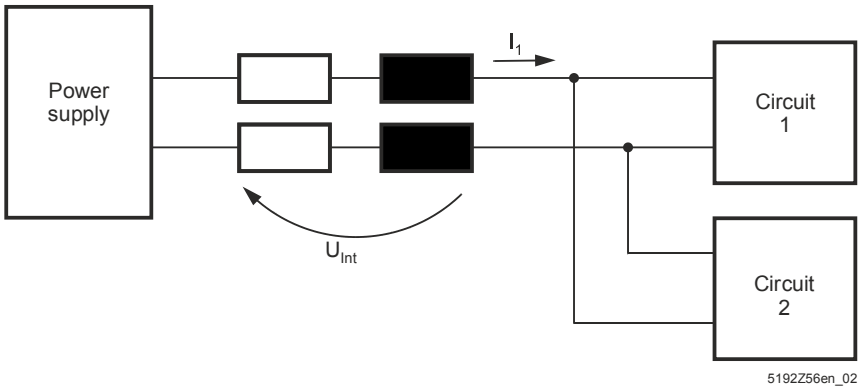
EMC phenomena	Remark	Criterion	Limit value
ESD immunity EN 61000-4-2	ESD by air discharge	Test level 3	8 kV
	ESD by contact discharge	Test level 3	6 kV
Immunity against electrical fields EN 61000-4-3	Electrical field applied to unit	Test level 3 26 MHz to 1 GHz	10 V/m
Immunity against interference pulses EN 61000-4-4	Applied to all cable terminations	Test level 4	4 kV
Impulse withstand voltage EN 61000-4-5	Applied to the line supply cable	Test level 3	2 kV
Immunity against HF interference, conducted EN 61000-4-6	Applied to mains, motor, and control cables	Test level 4 0.15 MHz to 80 MHz 80% AM (1 KHz)	10 V

Interference coupling

Interference coupling describes the type of coupling between a source of interference and an interference sink for a disturbance variable. The various coupling mechanisms for this can either be graded or in parallel.

Direct coupling

Direct or metallic coupling takes place when two electric circuits share a single conductor (for example, ground connections).



The disturbance voltages lead to different potentials or potential displacement, for example, in devices with a shared power supply.

Corrective measures

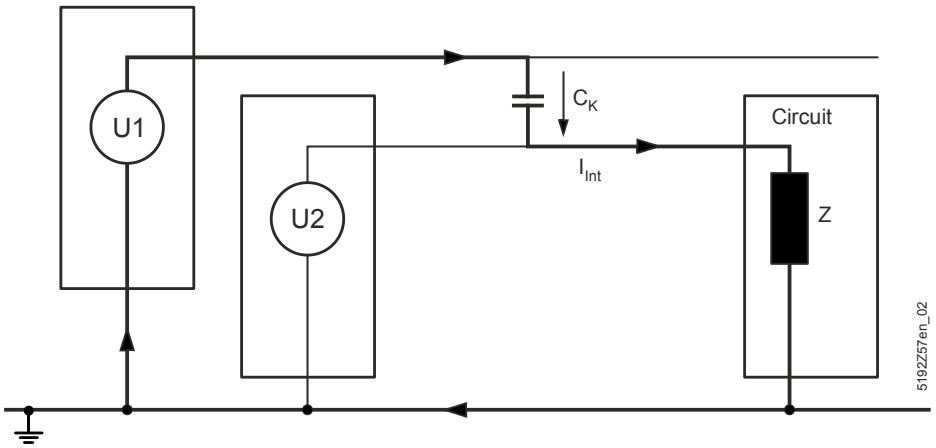
- Use separate supply and return conductors for each electric circuit
- Ensure joint reference conductors are short
- Use a star connection to the joint reference point
- Establish galvanic isolation between the systems (transformer, relay, and optocoupler)
- Ensure the building's equipotential bonding is carried out professionally

Capacitive coupling

Capacitive or electrical coupling occurs between mutually isolated conductors located at different potentials. As a result of the difference in potentials, a dominant electrical field can be found between the conductors, which is represented in the figure using a C_K capacitance. A fault current ($I_{Stör}$) is coupled via C_K into the interference sink, which leads to a disturbance voltage at the impedance (Z).

- Interference coupling via parallel conductors (heavy current signal lines)
- Static discharge by personnel
- Switching contactors/inductances
- High dv/dt voltage change speeds

Capacitive coupling with parallel conductors:



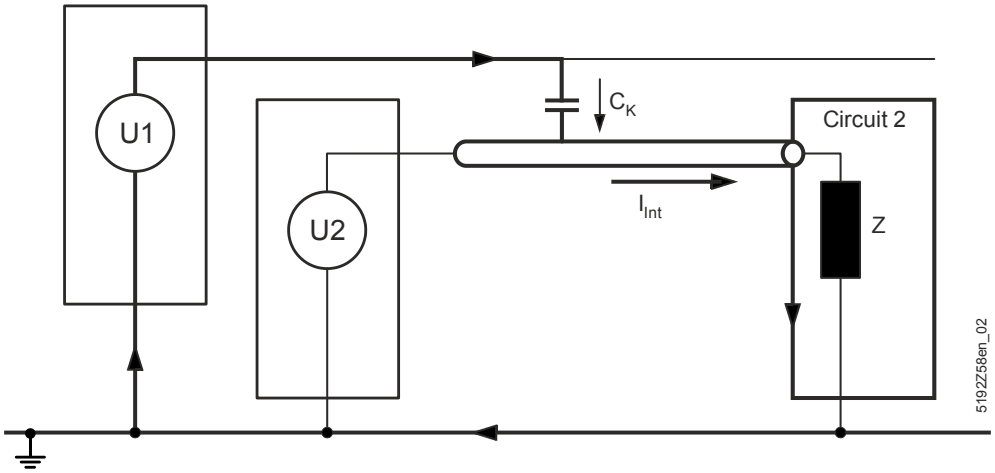
The level of interference current is dependent on the size of the electrical field. The strength of the electrical field depends in turn on the potential difference and the distance between the cables.

Corrective measures

The simplest measure is to lay the cables and lines appropriately. The following rules apply:

- Increase the distance between the cables
- Lay motor cables separately to mains, control, and signal cables. When doing so, use separate metallic and grounded cable channels
- Reduce the lengths of parallel cables
- If cables have to be crossed, do so with an angle of 90° as far as possible
- Use shielded cables with low capacitance for the motor cables
- Ensure the building's equipotential bonding is carried out professionally

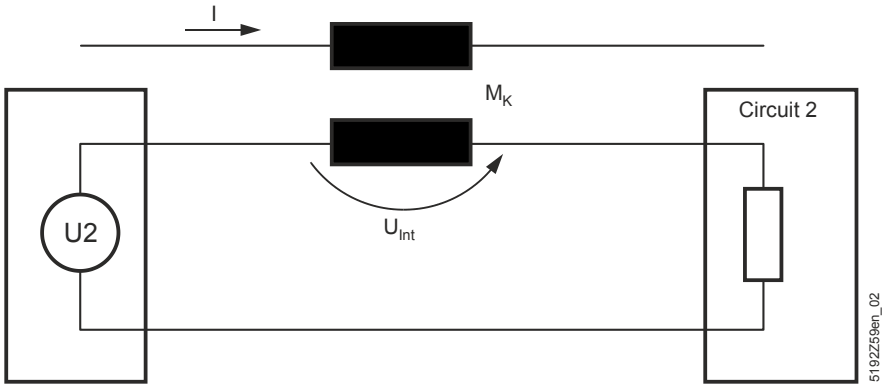
Interference current flow:



When using shielded signal lines and good shield connections, the interference current (I_S) is grounded via the enclosure and has no effects on the internal electric circuit. To shield against capacitive couplings, the cable shield only has to be laid on one side.

Inductive coupling

Inductive or magnetic coupling takes place between lines that carry current. The alternating current that flows through the conductors generates a magnetic field that induces a disturbance voltage in a neighboring conductor or in a conductor loop.



The coupling is not affected by whether or not there is a direct connection between both conductors. Typical sources of interference are:

- Transformers, motors, electric welding devices
- Switching high currents
- High di/dt current changing speed
- Signal lines with high frequency

Corrective measures

The inductive and capacitive couplings co-exist between unshielded cables. Both sides must be grounded when shielding against inductive influences. Be aware of the potential equalizing currents when grounding the shielding on both sides.

Additional measures for reducing the interference:

- Twist supply and return conductors and signal lines
- Suppress contactors
- Increase the distance between the cables

Radiative coupling

Radiative coupling, also known as electromagnetic coupling, is the interaction between inductive and capacitive coupling in the form of a radiated electromagnetic field.

Typical sources of interference are:

- Neighboring senders (for example, mobile communication devices)
- High-frequency appliances
- Spark gaps in devices (such as spark plugs and welding devices)

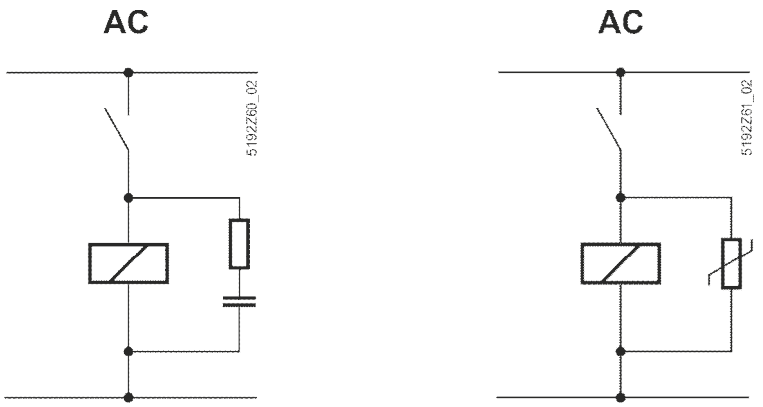
Corrective measures

Essentially, the same measures as listed previously also apply in this case. Ensure that the radiated electromagnetic fields are, for the most part, in the high-frequency range. Use suitable shielding materials and protective braided shields to ensure a good shield. Lay the "radiating" cables as close to the ground plane as possible, i.e. reduce the effective antenna height.

Inductances (such as contactor, relay, and solenoid valve coils) caused by **current and/or voltage peaks** can lead to problems when operating the variable speed drive, particularly if they are operating on the same network as the G120P.

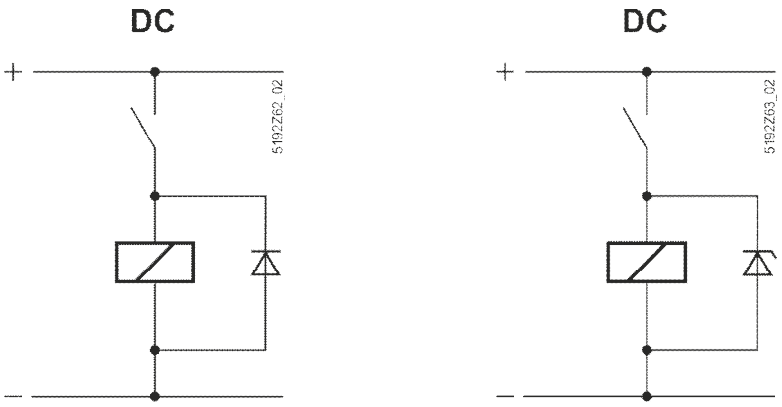
In such cases, the appropriate windings for the contactors and relays operated on the AC network must be reduced by quenching elements in the form of an RC series connection or a varistor.

Circuit with AC-operated inductances (coils)



Freewheeling diodes must be used for relays, contactors, and magnet coils that are connected to direct voltages (DC). The corresponding diodes should be rapid models with a short recovery time, and must be connected in reverse, parallel to the winding.

Circuit with DC-operated inductances (coils)



5.5.2.3 Network standard EN 61000-3-12

The standard for connecting to public low-voltage networks EN 61000-3-12 defines limit values for harmonic components that could strain the network. In particular, the total harmonic distortion for the fifth and seventh harmonics should not exceed the set limit values.

The standard refers to the entire installation, i.e. to the variable speed drive, including any additional (external) filters, if applicable.

With its low harmonic technology (LHT), the G120P offers a technology that does not ordinarily require any additional components.

See also

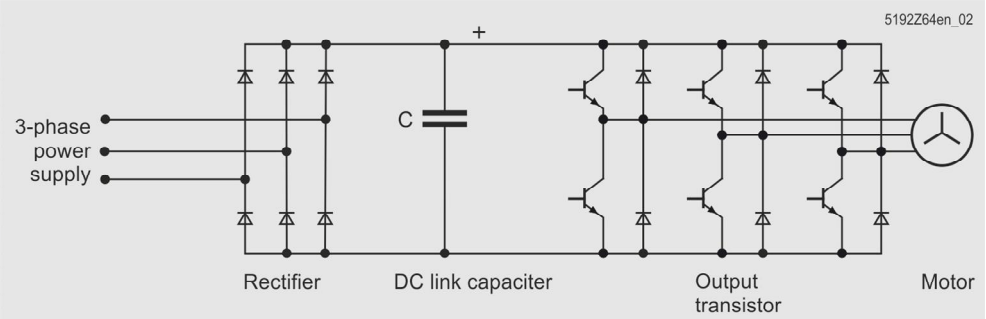
- Reduction procedures [→ 69]
- Effects [→ 69]
- Line harmonic distortions [→ 68]

5.5.3 Line harmonic distortions

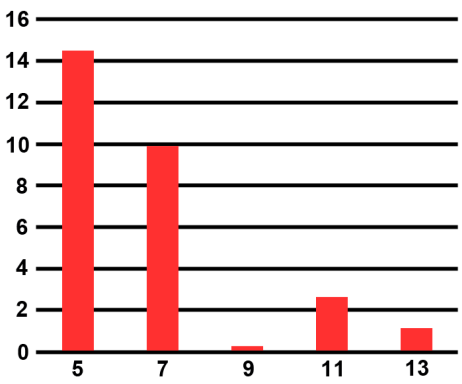
5.5.3.1 Creation

Line harmonic distortions arise due to non-linear network loads that produce temporary current pulses with steep flanks. These impulses cause distortions in the line voltage and also appear as line harmonic distortions in other areas of the supply network.

In variable speed drives, harmonics appear on the smoothing capacitor (also known as a DC link capacitor) that is switched parallel to the line-side 6-pulse diode rectifier. After a half-wave, the capacitor is charged to the maximum value of the sinusoidal alternating voltage (to the maximum value of 565 $V_{peak\ value}$ at 400 V_{eff}). The supply voltage at this capacitor is removed for the downstream electric circuits. When reloading the smoothing capacitor, temporary (pulse-like) currents, known as harmonic currents, occur at the maximum voltage.

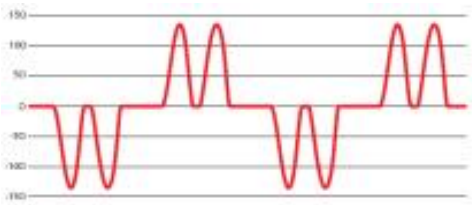


Harmonic currents (or voltages) consist of frequencies with integral multiples of the basic frequency. At a basic frequency of 50 Hz, the frequency of the second harmonic component is 100 Hz, the third, 150 Hz, etc.



Current harmonic spectrum up to the 13th ordinal Harmonic for a typical 6-pulse three-phase rectifier

When harmonic currents flow through the impedances of the supply network, they cause a corresponding voltage drop along with line harmonics that affect the waveform of the supply voltage. This causes the normal, sinusoidal waveform of the line voltage to be distorted. As this line voltage also reaches other consumers in the system, harmonic currents flow through loads that are otherwise linear. If, for example, the system voltage has a fifth-ordinal line harmonic component and this voltage is led to an induction motor, this means that a fifth-ordinal harmonic current now flows through the motor.



Current waveform

The measured THC can exceed 120% at the input terminal of a 6-pulse variable speed drive.

(THC = Total Harmonic Current)

The AC harmonic currents with a 6-pulse wire jumper have characteristic frequencies of 6n±1 times the ordinal, where «n» is a whole number. A 6-pulse variable speed drive on a normal line only generates line harmonics for odd numbers starting from the fifth ordinal (5th, 7th, 11th, 13th, etc.). Even line harmonics and multiples of 3 are eliminated. The amplitude of the harmonic current is dependent on the impedance of the AC network, the size of the DC link capacitor, and the induction motor load. In standard variable speed drives, harmonic currents of the 5th and 7th ordinal are mostly large.

5.5.3.2 Effects

General problems resulting from line harmonics

Line harmonics can lead to a whole host of system problems: They can cause an additional temperature rise in the motor, along with higher RMS currents in connected transformers or other line supply devices. Sensitive devices such as instruments, computers, and communication systems can fail or even be damaged by voltage distortions. In addition to device failures or malfunctions, line harmonics can also result in additional costs as a result of transformers being dimensioned too large, having been calculated for an incorrect power rating.

5.5.3.3 Reduction procedures

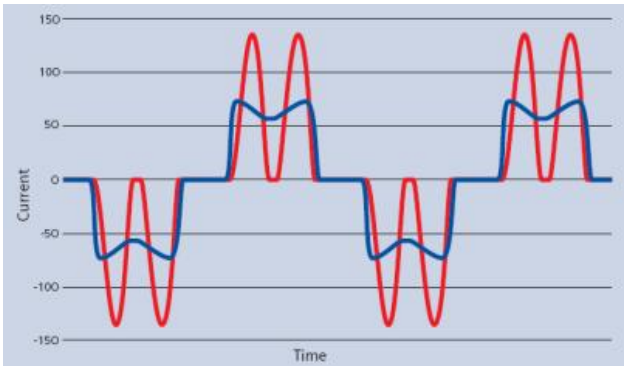
The IEEE 519 guideline (IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems) and EN 61000-2-2 provide limit values for a maximum voltage distortion at the utility's point of common coupling – the PCC.

The network standard EN 61000-3-12 defines the limit values for **harmonic component currents** caused by devices with an input current between 16 A and 75 A for each conductor connected to the public low-voltage network. This means that devices between 7.5 kW and 37 kW are affected by this standard. EN 61000-3-2 defines the limit values for harmonic component currents for devices with input currents ≤ 16 A per conductor. However, the limit values in EN 61000-3-2 only apply to devices up to and including 0.75 kW. Above this, the variable speed drives are classed as "professional devices", for which no limit values exist.

In conventional variable speed drives, AC line harmonic distortion reactors or DC link reactors are used to reduce the amount of 5th and 7th ordinal harmonic current to the recommended level.

The G120P offers a technology that reduces line harmonics without the need for additional components, known as LHT (low harmonic technology). This uses DC

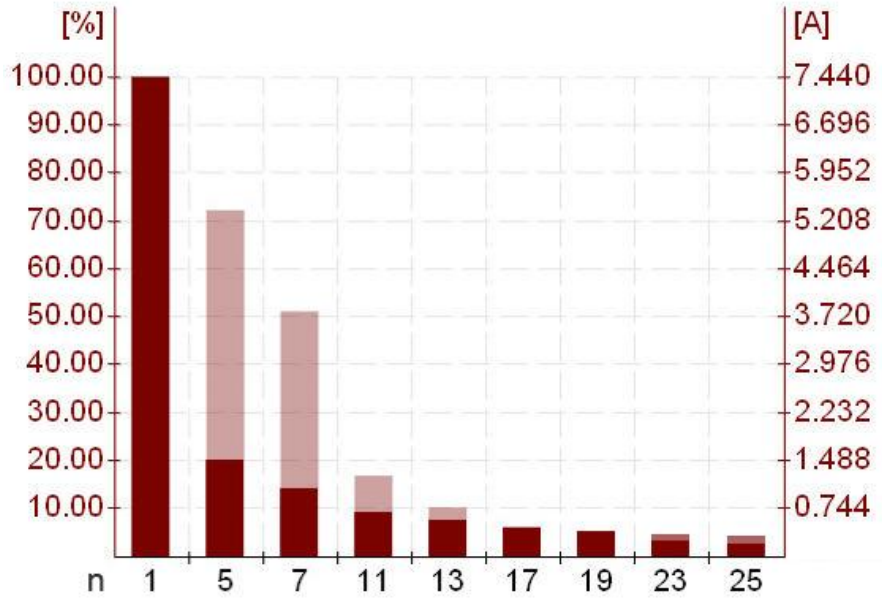
link capacitors with significantly reduced capacities – typically only 2% of a conventional variable speed drive – meaning that the level of DC-link voltage for the G120P is lower, and the amount of ripples is larger than a conventional variable speed drive. The result of this is that the diodes for the 6-pulse rectifier remain conductive for longer. When charging, the input for the G120P no longer has the narrow, high-amplitude pulse found in other variable speed drives, but rather has a conducting period of 120º per diode. The resulting current in the G120P broadly corresponds to that of a standard variable speed drive that is fitted with additional AC line harmonic distortion reactors or a DC link reactor.



Current waveform for a typical 6-pulse variable speed drive compared to a G120P.

Without filters (AC line harmonic distortion reactors or DC link reactors) the THC can exceed 120% at the input terminal of a 6-pulse variable speed drive. The G120P only has a THC of 30%.

Tests provide evidence of the G120P's ability to significantly reduce the low-ordinal line harmonic currents obtained from the AC utilities without using additional components. The harmonic behavior of the G120P is the same as, or even better than, conventional variable speed drives, which are equipped with additional AC line harmonic distortion reactors or DC link reactors.



Comparison of the reduction during total harmonic distortion.

Tests with a typical 6-pulse variable speed drive without AC line harmonic distortion reactors or DC link reactors (lighter bars) and a G120P (darker bars), clearly demonstrate the superiority of the G120P when it comes to line harmonics. In typical HVAC applications, the reduction of line harmonics in G120Ps is up to 72% better than in other variable speed drives, even when these are fitted with AC line harmonic distortion reactors or DC link reactors.

With the G120P's low harmonic technology, a line harmonic distortion reactor is no longer required to meet EN 61000-3-2 and EN 61000-3-12 standards when RSCE>250.

If the non-linear load in a system essentially originates from the G120P, a simple rule of thumb allows you to make an initial estimate. If the quotient in the following formula has a value of >5, no excessive harmonic components can be expected in this device:

Transformer power [kVA] / variable speed drive power [kW]

If the quotient has a value of ≤ 5, it is strongly recommended that you inspect the line harmonic components on the system closely.

The SINAMICS G120Ps are designed for a network with an RSCE > 100 or a UK < 1%. This means a utilization of 25% in a mains transformer with a UK of 4% (i.e. a factor of 4), and a utilization of 16.6% in a mains transformer with a UK of 6% (i.e. a factor of 6). Compliance with standards is only upheld with an RSCE of 250 or above and a UK of less than 0.4%

5.5.3.4 SIZER

The SIZER for Siemens Drives calculation tool supports you when dimensioning variable speed drives and motors. It also enables you to configure other system components, such as fuses.

You can also use SIZER to calculate the existing harmonic currents and voltage distortions. The tool immediately shows you its compliance with the applicable standards.
www.siemens.com/sizer

5.5.4 Summary of the basic EMC regulations

Cables

- Use shielded, low-capacitance, 4-wire motor cables
- Lay the motor cable and PTC/KTY cable separately. Connect the PTC/KTY to the variable speed drive with a separate cable. From the perspective of the EMC, the PTC/KTY cables are treated like control lines
- Cover the signal data lines with shielding to minimize interference coupling

Cable routing

- When laying the signal data lines, ensure that they are spaced apart from the motor cables. In the control cabinet, maintain a minimum distance of approx. 200-250 mm or separate the cables with grounded separating plates
- Lay filtered mains supply conductors separately from unfiltered line supply cables and motor cables
- As far as possible, do not lay control data cables and line supply cables in parallel to motor cables. The longer the cables are when combined, the greater the distance between the cables has to be
- Cross the control data cables and line supply cables so that they are perpendicular to motor cables
- Avoid unnecessarily long cables
- Route cables as closely as possible to grounded enclosure parts, such as mounting plates, supporting bars, and cable channels, etc.

- Lay the signal lines and accompanying equipotential-bonding cable as closely as possible to each other
- Ground spare cores at both ends. This achieves an additional shielding effect
- Whenever possible, route signal lines/data cables into the cabinet on one side only (from the bottom only, for example)
- Ensure signal lines, particularly reference value and actual value lines, are laid free of interruptions. Ensure that the shielding connection is continuous at separation points

Shield

- Foil shields are not suitable. This is because they are at least 5 times less effective than braided shields.
- Lay the cable shields directly onto a busbar from the cable's point of entry into the cabinet and continue to route it from here
- The shields must be grounded with good conductivity on both sides over a large area. They must also be connected to the grounded enclosures with surface conductivity. This is the only way to make them effective against electromagnetic interference
- To fix the protective braided shields, it is best to use metal cleats. The cable clamps must connect the shield over a large area and make good contact
- Do not leave any gaps in the shield
- Only use metallic or metalized connector enclosures at the plug-in connections for shielded cables

Equipotential bonding

- Use equipotential-bonding cables that have been appropriately dimensioned (with a cross-section of at least 16 mm^2 CU) to avoid potential differences between devices
- Connect all equipotential-bonding cables in the control cabinet on the central grounding bar or on a separate, low resistance, grounded potential equalizing bar
- Use flat ribbon cables to establish a ground connection for devices

5.5.5 EMC-compliant installation

Without interference suppression measures, variable speed drives send out permanent interfering signals. These interfering signals can cause the following problems in the area surrounding the device:

- Analog signal errors, for example in sensors, resulting in falsified measured values
- Sporadic faults
- Unstable controls
- Errors in other devices in the vicinity of the variable speed drive
- Interference from communication devices

To ensure safe, reliable, and trouble-free operation, the devices must be professionally installed, and the following interference suppression measures must be followed in the context of EMC:

An overview of control cabinet configuration and cabling, along with information on how to connect the variable speed drive, can be found in the following sections. You will find further details in the installation instructions for the Power Module.

Variable speed drives with degree of protection IP20 must be installed and operated in an EMC-compatible control cabinet.

Variable speed drives with degree of protection IP55 can also installed outside a control cabinet.

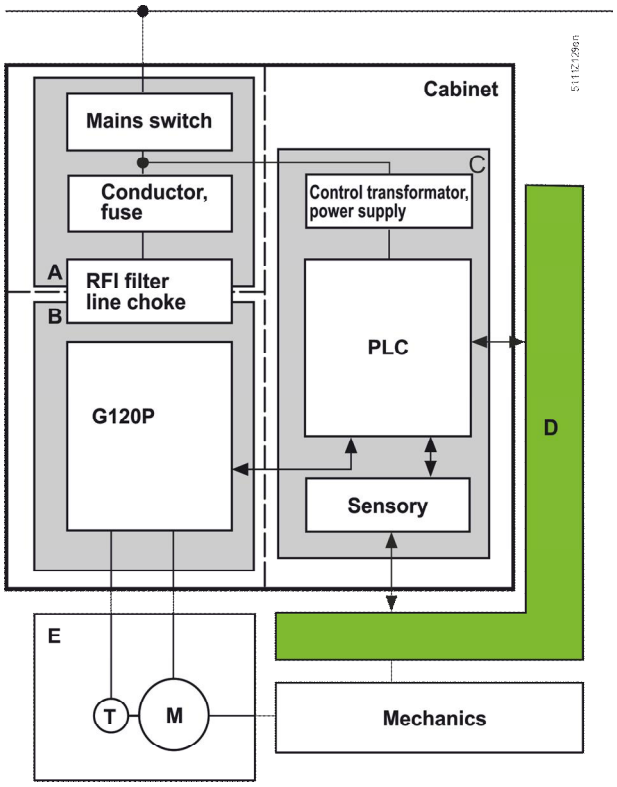
5.5.6 EMC-compliant design

The cheapest way to suppress interference is to keep sources of interference separate from interference sinks, so bear this in mind in the planning phase.

You should divide the devices in use into potential sources of interference or interference sinks:

- In this context, variable speed drives, braking modules, and contactors, for example, can be counted as **sources of interference**
- Examples of **interference sinks** include PLCs, encoders, and sensors

The entire drive system then has to be divided into EMC zones with the devices assigned to these zones. The zone concept is clarified in the following diagram:



Zone A	Mains connection limit values for the conducted interference emissions and interference immunity must be observed
Zone B	Power electrics/electronics, potential sources of interference
Zone C	Control/sensor technology, potential interference sinks
Zone D	Periphery/interface limit values for the interference immunity must be observed
Zone E	Power electrics/electronics, potential sources of interference
-- -- --	Grounded separating plates

Specific requirements regarding the interference emission and the interference immunity apply within each zone. Separate the zones, ideally using metal housing or, within a control cabinet, using grounded separating plates. Filters may have to

be installed at the zone interfaces. Route cables from the various zones separately/shielded from each other.

5.5.6.1 Control cabinet design

Correct installation of the control cabinet components (controllers, contactors, display elements, variable speed drive, etc.) produces significant protection against internal/external disturbance variables. The essential points in this regard are to use conductive materials, establish good contact and connections for all enclosure parts, and avoid large openings in the cabinet walls. Special EMC cabinets can be installed in the case of particularly large shielding attenuation requirements.

It is possible to avoid unacceptable mutual interference by installing the components properly within the control cabinet in the defined EMC zones. The correct cable routing and shielding treatment are also crucial.

For a standard version control cabinet made of coated sheet steel, good shielding attenuation can be achieved by following a few simple rules. The fundamental principle is to install the control cabinet as a Faraday cage.

- Conventional aluminum or steel control cabinets with a tightly screwed mounting grate generally have the required ground connections. The necessary ground connections are provided in the basic version.
- Connect all the metallic parts and components of the control cabinet (side plates, rear panels, cover and base plates) to the frame of the cabinet with a good electrical connection. The best way to achieve this is by using the largest possible contact surface, a variety of individual screwed connections, or extensive connections through wide grounding straps.
- Connect the PE busbar and EMC shielding bus to the control cabinet frame using a strong electrical connection produced with the largest possible surface area.
- Connect all metal enclosures for the devices and the additional components installed in the control cabinet (such as the variable speed drive or line filter) to the control cabinet frame via a strong electrical connection and the largest possible surface area. The most effective way to set this out is to install the devices and additional components on a blank, highly conductive metal plate, which, in turn, is connected to the control cabinet frame via a strong electrical connection and the largest possible surface area. It is particularly crucial to connect them to the PE busbar and EMC shielding bus.
- All connections must be made durable.
  Screwed connections with painted or anodized metal components must either be made with special (toothed) contact washers that cut through the insulating surface to make contact with a metal conductor, or else the insulating surface must be removed from the contact points.
- The material of the components to be connected, including the connection elements (screws, toothed lock washer, rivets, etc.), should be positioned close to each other in the electrochemical series.
- Coils of contactors, relays, solenoid valves, and motor holding brakes must be equipped with interference suppressors in order to dampen high-frequency radiation when switching-off (RC elements or varistors with AC coils and free-wheeling diodes or varistors for DC coils). Connect the protective circuit directly to the coil.

Gaps in the control cabinet wall

The shielding effect of the control cabinet is deteriorated by adding ventilation holes, inspection windows, and operator controls, etc. Each opening with the size

of half of the wavelength λ of the interference frequency functions as an antenna and radiates electromagnetic fields. In practice, the slit lengths should be less than λ/20.

Ventilation slits

Offset holes or HF grids are generally better as ventilation openings than slits are. Lots of small holes are more effective than a few large ones.

Control elements

When installing operator controls and operator panels, ensure that the metallic installation frames have good all-round contact. Otherwise, EMC seals or covers may have to be installed.

Cable entries

The best way to ground shields is to use cable entries that have good all-round contact with the shield and an HF-proof connection with the enclosure (cabinet wall). This prevents interference fields that arise in the cabinet from being radiated outwards via the shielded cable. For this reason, ensure that there is good conductivity when connecting the outer shield at the control cabinet entry point for all shielded cables to the cabinet enclosure.

Shielding, equipotential bonding, and protective conductor busbars

The shielding, equipotential bonding, and protective conductor busbars are connected to the control cabinet ground. Inside the control cabinet, they have the same reference potential.

Shields carry interference currents to reduce unwanted mutual influences. The purpose of the shielding busbar is to lay the cable shields when entering the cables into the control cabinet. Its connection with the shared control cabinet ground (mounting plate) must be large in surface area, high frequency, and low resistance.

Protective conductors (PE, protective earth) only carry current in the event of a fault. The central protective conductor busbar must be connected to the grounding bar. The central grounding bar must have a conductive connection with the control cabinet ground (metal-metal connection). This is the only way for fault and interference currents to be safely discharged.

Under normal operating conditions, reference conductors (neutral conductors, switching ground, 0 V) carry current.

The protective and reference conductors must be dimensioned according to the relevant standards and guidelines.

The grounding, protective conductor, and shielding concepts must be compatible with each other to ensure that unwanted potential displacement/interference currents are avoided.

For optimal EMC, perform consistent low and high-frequency equipotential bonding with good conductivity for all metallic enclosures, cabinets, machines, and devices.

5.5.7 EMC-compliant wiring

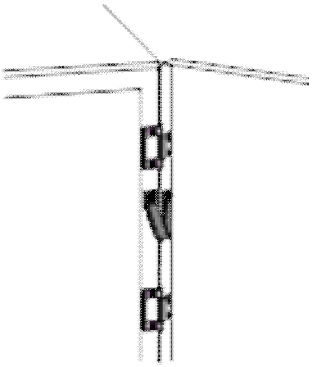
- Use a **shielded cable** for the motor. The shield should have the lowest possible HF impedance and must not contain any gaps.
- For signal, control and data cables, only use shielded cables with twisted wires.
- Keep the HF contact resistance as low as possible at the connection points between the shield and enclosure.
- Ground the shields for motor and control cables on both sides using EMC cable glands (EMC fittings, EMC cable clamps, EMC terminals, or similar) to establish a good 360° contact with the shield.
- Avoid high equalizing currents in the shields by establishing a connection with the lowest possible resistance (min. 16 mm^2 Cu) and impedance between the variable speed drive enclosure and the ground (equipotential busbar).
- Connect the return ground of the motor controlled by the variable speed drive directly at the ground terminal (PE) of the associated variable speed drive.

- Avoid loops in the cables. Ensure that all devices are connected to the supply with star grounding.

Use flexible grounding straps to connect moving parts (e.g. cabinet doors and swing frames).

In the event of a fault, the ground must not take on any dangerous touch voltages, and must be grounded to avoid this occurring. Avoid grounding loops.

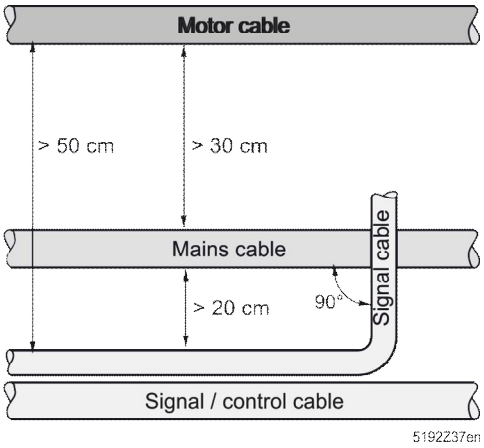
Grounded cabinet door:



5.5.7.1 Cable routing in the control cabinet

Always route power cables and signal lines separately. For this purpose, the various cables are arranged according to cable groups. Cables belonging to a group can be combined in a bundle. Lay the various cable groups with the necessary distance between them.

- Whenever possible, route signal lines/ data cables into the cabinet at one point only
- Route all cables inside the control cabinet so that they are always as close as possible to mechanical enclosure parts, for example, control cabinet walls, mounting plates, supporting bars, and metal bars. Laying cables in free space leads to increased interference coupling and radiation (antenna effect)
- Lay associated cables (supply and return conductors) together
- Lay all variable speed drive power cables (line supply cables and motor cables) so that they are spaced apart from signal and data cables. The minimum clearance is approximately 25 cm. Alternatively, the decoupling in the control cabinet can be established by means of metal barriers that are connecting to the mounting plate via a good electrical connection
- Ensure that the cables from the line supply to the line filter are routed separately from non-filtered power cables with a high interference level, for example cables between the line filter and variable speed drive, connecting cables between the braking chopper and the associated braking resistor as well as motor cables
- Route control circuits for contacts (230 VAC) as far as possible from signal lines
- Only cross signal and data cables, as well as filtered line supply cables, at right angles to unfiltered power cables
- Keep all lines as short as possible
- Always lay signal lines, data cables, and the associated potential equalizing cables in parallel with the smallest possible distance between them



Shielding

The correct shield contacting, design, and material have a significant impact on the quality of the shielding. All shielding connections must have an "HF-proof" design, i.e. coaxial, low resistance, and low inductance.

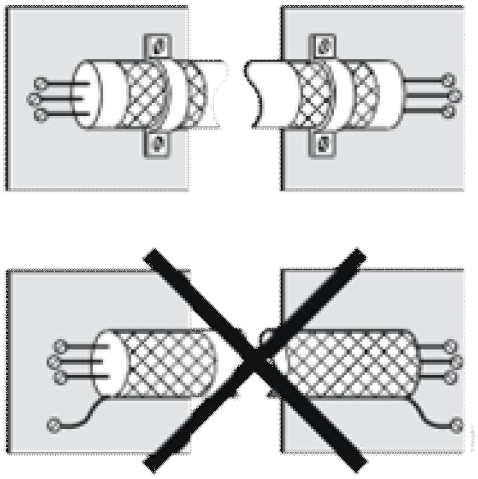
- Use shielded motor cables
- Route the shielded motor cable separately from the cables to the motor temperature sensors (PTC/KTY)
- Use shielded signal and data cables
- Route especially sensitive control lines – such as setpoint and actual value cables – without any interruptions and with optimum shield support at both ends
- Connect the shields to the grounded enclosure at both ends with a good electrical connection and large surface area
- Connect the cable shields as closely as possible to the point where the cable enters the control cabinet.
- Keep the HF contact resistance as low as possible at the connection points between the shield and enclosure
- Use EMC shielding busbars for power cables;
- Use the shield connection elements in the variable speed drive for signal and data cables
- Use intermediate terminals to avoid interruptions in the cable shields
- In the case of power cables, signal lines, and data cables, connect the cable shields using suitable EMC clamps. The shield connection clamps must connect the shielding with the EMC shielding busbar or, in the case of control lines, with the shield connection element via a connection with weak conductivity and a large surface area.

For variable speed drives with degree of protection IP55, use EMC metal cable glands for bushing and contacting shielded cables, as shown here.

- It is best to use shields made of nickel-plated copper braiding. Foil shields should be avoided

Shields must not take over the role of N or PE conductors. Ensure that there is good equipotential bonding inside both the control cabinet and the entire system.

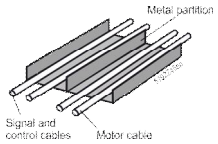
Do not use pigtails (wire shield extensions to the terminal) to connect shields



5.5.7.2 Cable routing outside the control cabinet

Ensure that there is as much space as possible between the signal and power cables. If it is not possible to establish a large enough distance between them, use shielded cables in protective, grounded cable channels made of metal.

- Lay signal, control, and data cables free of interruptions
- Ensure that there is a continuous shield connection to cable separating points for shielded cables
- Ground the shields for motor and control cables on both sides using EMC cable glands (EMC fittings, EMC cable clamps, EMC terminals, or similar) to establish a good 360° contact with the shield
- Avoid high equalizing currents in the shields by establishing a connection with the lowest possible resistance (min. 16 mm² Cu) and impedance between the variable speed drive enclosure and the ground (equipotential busbar)
- Lay the motor cable so that it is as short as possible, generally less than 25 m, see Section Motor connection cable [→ 85]
- Lay cables on metallic, grounded cable holders or in cable channels



If it is not possible to feed control, supply, and motor cables into separate cable channels or holders, the cable channel/holder must at least have metallic, electrically conductive separators throughout.

- The longer the cables are when combined, the greater the distance between the cables has to be
- Connect the cable holder's intersection points with each other over a large area and with good electrical connectivity
- Twist unshielded cables from the same electric circuit (supply and return conductors) or ensure that the surface area between the supply and return conductors is as small as possible
- Lay the signal lines and accompanying equipotential-bonding cable as closely as possible to each other
- Signal lines must not pass devices that generate strong magnetic fields, such as motors and transformers

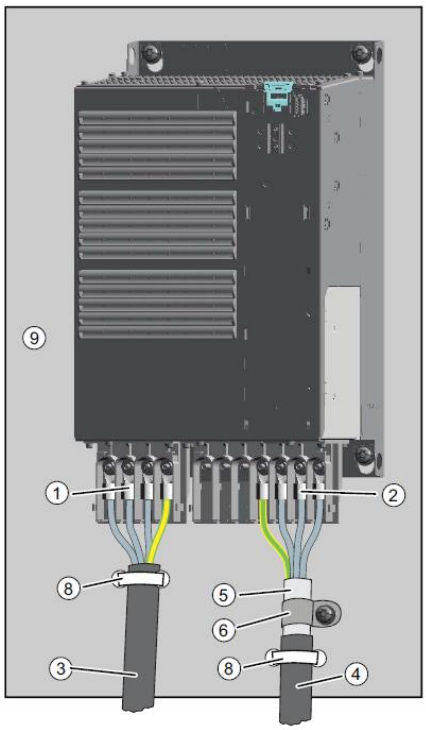
- Connect the return ground of the motor controlled by the variable speed drive directly at the ground connection (PE) of the associated variable speed drive. We recommend the use of 4-wire motor cables. The G120P's motor plugs/terminals have four connections
- Avoid loops in the cables
- Ensure that all devices are connected to the supply with star grounding
- Avoid unnecessary cable lengths, even for spare cables
- Complete the internal and external lightning protection and grounding measures according to the applicable standards

5.5.7.3 EMC-compliant wiring for Power Modules with degree of protection IP20

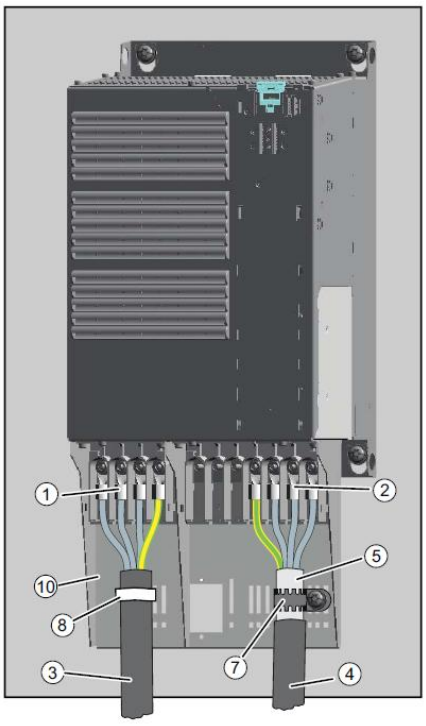
Using two examples, the following diagram shows the EMC-compliant installation of Power Modules with and without a shield plate.

The display in the following diagram is not to scale. The terminal cover cannot be removed. It was only taken out of the diagram to better show the cable connection.

Without shield plate

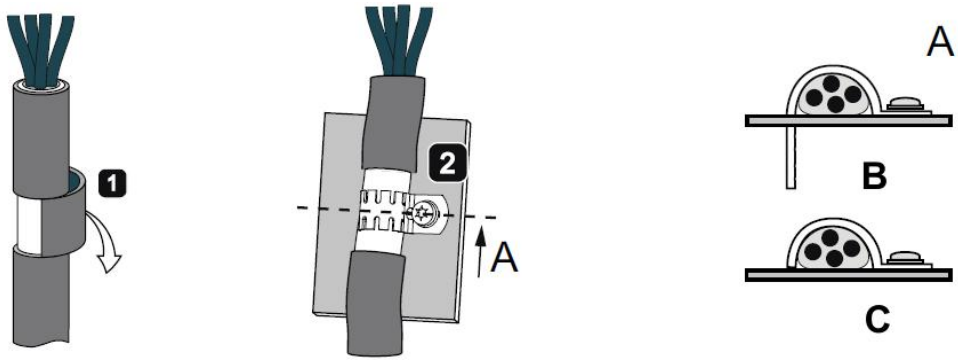


With shield plate



1 Mains connection
2 Motor connection
3 Line supply cable (unshielded)
4 Motor connection cable (shielded)
5 Cable shield
7 Steel band
8 Cable tie
9 Metal mounting plate (unpainted and with a good electrical conductivity)
10 Shield plate (optional)

6 Cable clamps for a good conductive electrical connection through a large surface area between the shield and mounting plate



1 Expose cable shield

2 Press cable shield onto the shield/mounting plate

B Shield plate

C Mounting plate

Connect a Power Module with integrated line filter with an unshielded cable to the mains power. If you use an external line filter, you will need a shielded cable between the line filter and the Power Module. This is included in the scope of supply for the bundle.

Shielding with a shield plate

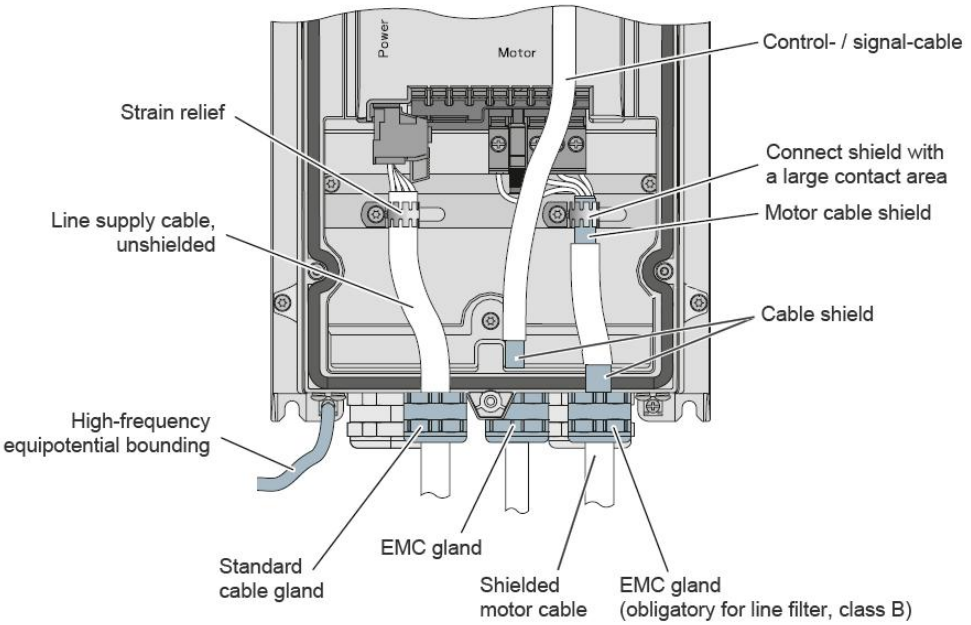
There are shield connection kits for all sizes of Power Modules. Connect the cable shields to the shield plate over a large area with shield clamps. For frame sizes A to C, these form part of the G120P BT bundle

Shielding without a shield plate

EMC-compliant shielding can also be implemented without using a shield plate. In this case, you must ensure that the cable shields are connected to the ground potential through the largest possible surface area.

5.5.7.4 EMC-compliant wiring for Power Modules with degree of protection IP55

The following diagram shows the EMC-compliant installation of Power Modules with degree of protection IP55/UL type 12.



You must use a shielded cable if you use the control terminals of the Control Unit. The cable shield must be connected to the gland plate through a good electrical connection using an EMC gland. If a standard gland is used, the shield must be laid on the CU's shield connection kit.

In devices with filter B, it is essential to use an EMC gland to achieve maximum shielding. The shield must be fed through the EMC shield and then laid separately again on the gland plate.

5.5.7.5 Cable gland plate in IP55 models

Overview

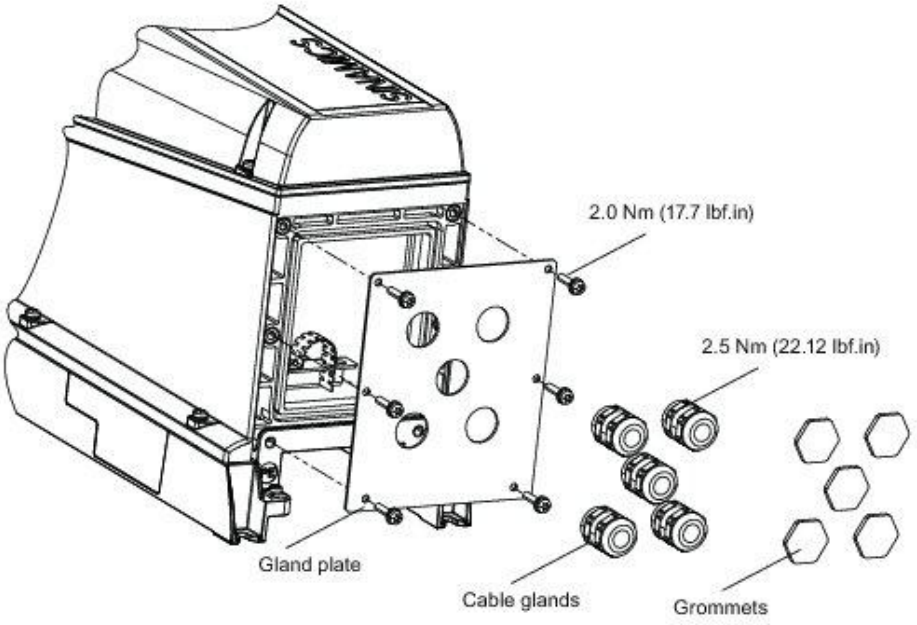
A cable gland plate with pre-drilled cable glands can be found on the bottom of the variable speed drive enclosure. This plate allows you to route the line supply and control cable out of the device and, at the same time, meet the requirements of both EMC and degree of protection IP55/UL type 12.

The following figures display the cable gland plate as well as its fixing points.

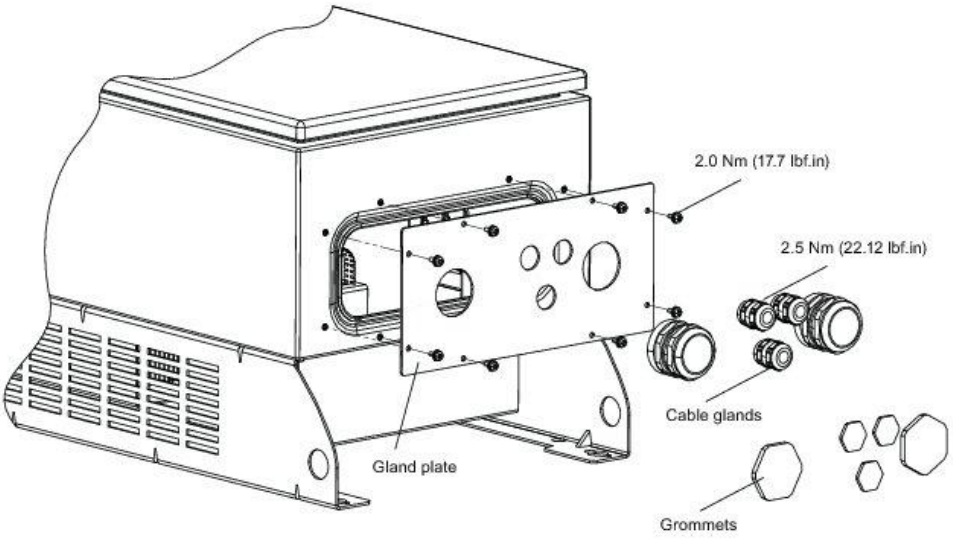
Plug unused cable glands with a rubber sleeve to ensure that the cable gland plate is sealed.

When re-fitting the gland plate, ensure that the seal on the bottom of the device is attached correctly and that the correct tightening torques are observed, otherwise the variable speed drive does not fulfill the degree of protection IP55.

FSA to FSC gland plates



FSD to FSF gland plates



Drilling dimensions for the gland plate

The following table provides the gland plate drilling dimensions for all frame sizes of the PM230. Rubber sleeves are included in the scope of supply for the product. The cable glands are not included in the scope of supply. To ensure the variable speed drive is protected in accordance with degree of protection IP55, dimension the cable glands so that they fit into the corresponding holes with ease.

Frame size	Power range (LO)	Diameter of power supply cable gland	Diameter of control cable gland
A	0.37 to 3.0 kW (0.5 to 4.0 PS)	20.5 mm (0.80 inches)	20.5 mm (0.80 inches)
B	4.0 to 7.5 kW (5.0 to 10.0 PS)	25.5 mm (1.0 inches)	20.5 mm (0.80 inches)
C	C 11.0 to 18.5 kW (14.0 to 24.0 PS)	32.5 mm (1.27 inches)	20.5 mm (0.80 inches)
D	D 22.0 to 30.0 kW (29.0 to 40.0 PS)	40.5 mm (1.59 inches)	20.5 mm (0.80 inches)

Frame size	Power range (LO)	Diameter of power supply cable gland	Diameter of control cable gland
E	E 37.0 to 45.0 kW (50.0 to 60.0 PS)	50.5 mm (1.98 inches)	20.5 mm (0.80 inches)
F	F 55.0 to 90.0 kW (73.0 to 120.0 PS)	63.5 mm (2.5 inches)	20.5 mm (0.80 inches)

EMC cable glands

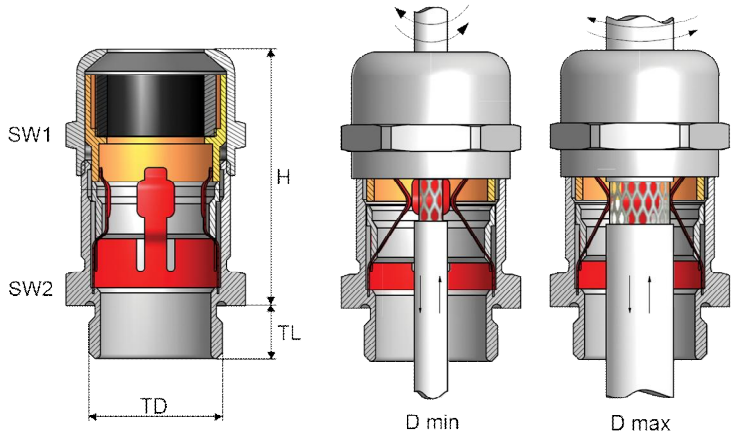
To ensure compliance with the relevant EMC standards, all communication and I/O cables of the Control Unit must be routed through a gland plate. EMC-compliant cable glands must be used for this.

For the Power Modules PM230, frame sizes A to F, an EMC cable gland must be used for the motor cables, which is in compliance with the current standards regarding radiated interference emissions.

Example of a 4th generation EMC cable gland

The following figure displays an example of an EMC cable gland. If properly attached on the gland plate, this cable gland achieves degree of protection IP68.

The fourth generation EMC series facilitates cable entry on both sides as well as good radial and axial alignment of the cable without damaging the braiding.



Size	TL	Terminal area	Shield diameter	H	SW 1	SW 2	Type
	(mm)	D min/max (mm)	min/max (mm)	(mm)	(mm)	(mm)	
M20 x 1.5	8.0	7.5 - 14	5.5 - 11.5	38	24	24	BMEM-E2(M20T)
M25 x 1.5	8.0	10 - 18	7 - 14	42	30	30	BMEM-E3(M25T)
M32 x 1.5	9.0	16 - 25	12 - 20	50	40	40	BMEM-E4(M32T)
M40 x 1.5	9.0	22 - 32	18 - 27	57	50	50	BMEM-E5(M40T)
M50 x 1.5	9.0	30 - 38	26 - 34	67	58	60	BMEM-E6(M50T)
M63 x 1.5	10.0	37 - 53	33 - 49	72	75	75	

Installation set

An appropriate installation set can be ordered for every frame size from FSA to FSF. This allows you to ensure that all necessary installation material for correct cabling is available.

The sets comprise polyamide cable glands (with separate rubber seals for a larger terminal area) for the power supply and control cables, as well as a high-quality EMC cable gland for the motor cable, which enables the shield to be fed into the enclosure. This is required in order to comply with the EMC C1 standard. In addition, the sets also include cable lugs for attaching the equipotential bonding and end sleeves/cable lugs (FSD and up) for the motor and power supply cable.

You can find the available installation sets and their order numbers in Section Accessories [➞ 30].

A set contains the following components:

	FSA	FSB	FSC	FSD	FSE	FSF
Brass EMC cable gland for motor cables incl. EMC lock nuts	1 x M20x1.5	1 x M25x1.5	1 x M32x1.5	1 x M40x1.5	1 x M50x1.5	1 x M63x1.5
Polyamide cable gland for power supply cable incl. lock nuts	1 x M20x1.5 Terminal area 5-12 mm	1 x M25x1.5 Terminal area 8-17 mm	1 x M32x1.5 Terminal area 11-21 mm	1 x M40x1.5 Terminal area 16-28 mm	1 x M50x1.5 Terminal area 21-38 mm	1 x M63x1.5 Terminal area 27-44 mm
Polyamide cable gland for control lines incl. lock nuts	3 x M20x1.5 Terminal area 5-12 mm	3 x M20x1.5 Terminal area 5-12 mm	3 x M20x1.5 Terminal area 5-12 mm	4 x M20x1.5 Terminal area 5-12 mm	4 x M20x1.5 Terminal area 5-12 mm	4 x M20x1.5 Terminal area 5-12 mm
Cable lugs for equipotential bonding	1 x Ø 10 mm² 1 x Ø 16 mm²	1 x Ø 10 mm² 1 x Ø 16 mm²	1 x Ø 10 mm² 1 x Ø 16 mm²	1 x Ø 16 mm²	1 x Ø 16 mm²	1 x Ø 16 mm²
End sleeves for power supply and motor cables in accordance with DIN 46228 T 1	8 x Ø 1 mm² 8 x Ø 1.5 mm² 8 x Ø 2.5 mm²	8 x Ø 2.5 mm² 8 x Ø 4 mm² 8 x Ø 6 mm²	8 x Ø 6 mm² 8 x Ø 10 mm² 8 x Ø 16 mm²	-	-	-
Cable lug for power supply and motor cables	-	-	-	8 x Ø 10 mm² 8 x Ø 16 mm² 8 x Ø 25 mm² 8 x Ø 35 mm²	8 x Ø 25 mm² 8 x Ø 35 mm² 8 x Ø 50 mm² 8 x Ø 16 mm²	8 x Ø 70 mm² 8 x Ø 95 mm² 8 x Ø 120 mm²

5.5.7.6 Equipotential bonding and grounding

Route all electrical components separately (with star grounding) to the equipotential bonding.

For each variable speed drive, connect the enclosure for the IP55 device version – and the ground connection for the IP20 – to the central ground (grounding/equipotential busbar) via the shortest possible low-resistance equipotential-bonding cable with low impedance.

For equipotential-bonding cables, it is best to use flat, strap-shaped conductors made of tin-coated copper braiding or similar (min. cross-section 16 mm²), as these have a lower impedance at higher frequencies.

The conductors create the skin effect, which is stronger in conductors with a round cross-section than those that are strap-shaped. The effect increases as the frequency does, because the current density in the outer conductor range is significantly higher than at the conductor core, as eddy currents cause the current flow to decelerate in the conductor core.

You should also connect each of the motors controlled by the variable speed drive to ground/the monoblock's grounding point using an equipotential-bonding cable with a large cross-section.

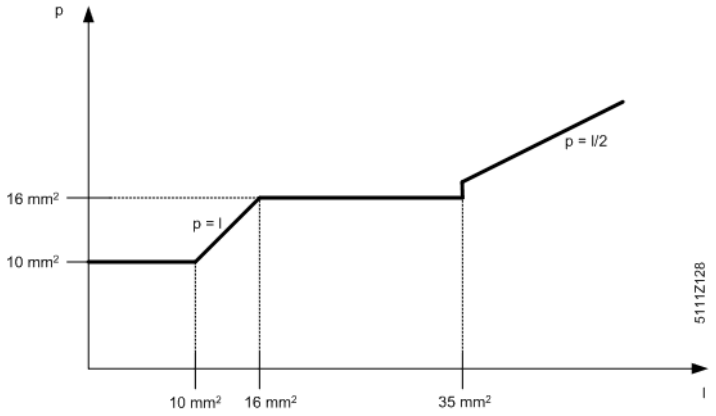
Connect all control devices that are connected to the variable speed drive (for example, a BMS, BAS, or PLC) to the same ground or same grounding point as the variable speed drive (equipotential busbar) using the shortest possible equipotential-bonding cable.

As the ground must not take on any dangerous touch voltages, even in the event of a fault, it must be connected to ground using protective conductors.

Avoid grounding loops.

Grounding conductor/Line conductor

The minimum required grounding conductor cross-section for the equipotential bonding according to EN 61800-5-1 can be found in the following diagram:



p Cross-section of grounding conductor

l Cross-section of line conductor

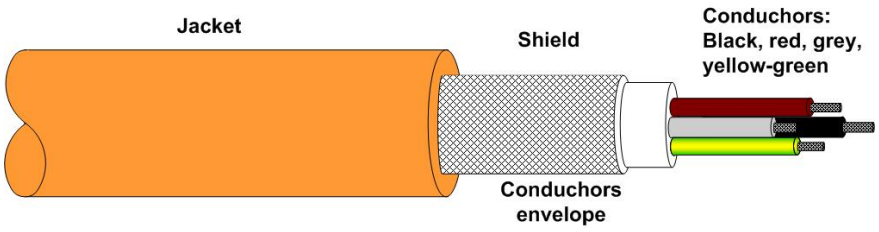
5.5.7.7 Cables

5.5.7.7.1 Supply cable

No special cable types are required for the supply line. Ensure that the wire cross-section corresponds to the current to be fed. All cable manufacturers have standard cables of 4 x n mm².

5.5.7.7.2 Motor connection cable

The motor cables have a high interference intensity. To limit the emitted interference, use shielded, low-capacitance, 4-wire motor cables (U, V, W, and PE with shielding).



Cable types recommended by Siemens AG:

Manufacturer	Description	Type	Scaling
Prysmian	Protoflex EMC-FC	2YSLCY-J 0.6/1 kV	DIN VDE 0250
Helukabel	TOPFLEX® EMC-3 PLUS 2YSLCY-J	2YSLCY-J 0.6/1 kV	DIN VDE 0250
Lapp Kabel	Ölflex Servo	2YSLCYK-JB 0.6/1 kV	DIN VDE 0250

If you use cables made by other manufacturers, ensure that the type designations correspond. These describe the physical properties required for EMC-compliant operation.

5.5.7.7.2.1 Conductor cross-sections for supply and motor cables

Observe the minimum cross-section requirements of the site supplying the energy.

Input voltage range 380 to 480 VAC, 3-phase

Frame size	Power (kW)	Min. cross-section mm2 (AWG)	Max. cross-section mm2 (AWG)
A	0.37	1 (18)	2.5 (14)
	0.55	1 (18)	2.5 (14)
	0.75	1 (18)	2.5 (14)
	1.1	1 (18)	2.5 (14)
	1.5	1 (18)	2.5 (14)
	2.2	1.5 (16)	2.5 (14)
	3	1.5 (16)	2.5 (14)
B	4	2.5 (14)	6 (10)
	5.5	4 (12)	6 (10)
	7.5	4 (12)	6 (10)
C	11	6 (10)	16 (5)
	15	10 (7)	16 (5)
	18.5	10 (7)	16 (5)
D	22	16 (5)	35 (2)
	30	25 (3)	35 (2)
E	37	25 (3)	50 (1/0)
	45	35 (2)	50 (1/0)
F	55	70 (2/0)	120 (4/0)
	75	95 (3/0)	120 (4/0)
	90	95 (3/0)	120 (4/0)

5.5.7.7.2.2 Cable lengths

The performance data according to the specifications is only valid if the motor cables do not exceed the following lengths:

- 50 m for shielded cables
- 100 m for unshielded cables

Longer motor cables can be used if output filters are inserted. For more information in this regard, see the REO CNW 833 dv/dt filter and REO CNW 933 sine-wave filter in Section Filter Overview [→ 89].

Where several motors are connected to a variable speed drive, the motor cable length is made up of the sum of all the individual motor cables.

5.5.7.7.3 Signal and data cables

To minimize interference coupling, only use shielded cables to wire analog inputs and outputs and for communication conductors. The PTC and Klixon temperature sensors must also be connected to the variable speed drive with a shielded cable. From the perspective of the EMC, the PTC/KTY cables are treated like control lines. For additional information, see Section EMC-compliant wiring [→ 75].

5.6 Filters

5.6.1 Adapting the motor to the variable speed drive (output filter)

Frequency-controlled three-phase asynchronous motors offer many advantages. However, supplying motors with non-sinusoidal currents and voltages from the variable speed drive also places additional strain on the motors and pressure on the overall drive and environment.

These aspects must be observed when selecting the motor and configuring the drive. The possible problems are defined below.

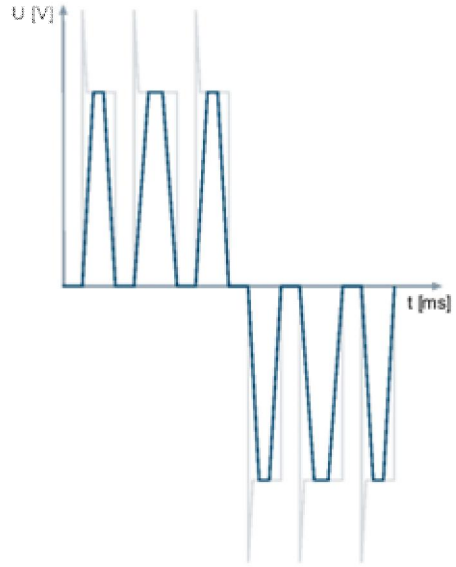
The problem essentially arises from the rapid switching operations in the variable speed drive's Power Module. In variable speed drives with pulse width modulation (PWM), which also includes the G120P, the elementary frequency determines the quality of the interference emitted by the variable speed drive. This interference can spread, amongst other things, conducted as symmetrical or asymmetrical interference currents, even via the motor cables. A proportion of the high frequency current flows as leakage current, amongst other things, via the motor mount to ground. In the case of unshielded motor cables, high interference fields can also be generated (non-conducted interference). Shielded motor cables considerably reduce the amount of this interference that is radiated.

A further problem lies in the rate of voltage rise for the motor voltages at the variable speed drive output. With their short switching times, modern power units with IGBTs, such as those used in the G120P, achieve voltage pulse slew rates of between 2 and 10 kV at the variable speed drive output. These voltage pulses pass along the motor cable between the variable speed drive and motor as travelling waves. These are reflected at the motor windings, which leads to high voltage peaks at the motor connections.

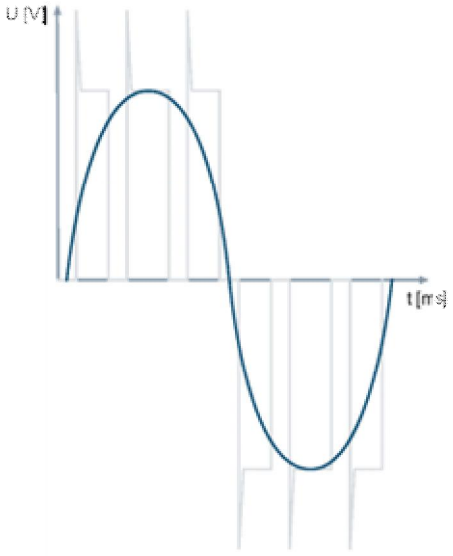
The excessive voltage peaks can reach double the value of the DC-link voltage, approx. 1,200 V for a 400 V line voltage, for example. These permanently high voltage pulses lead to premature aging of the winding insulation. Nevertheless, the supply for three-phase asynchronous motors via variable speed drives with DC-link voltages of up to 560 V for conventional motor insulations (standard motor) has no negative effects on the service life.

If motors are used that are not insulated according to requirements, then output filters must be used.

Dv/dt filter



Sine-wave filter



In summary, the following effects can arise when using the variable speed drive:

- High-frequency reactive currents in the motor cable
- Overvoltage at the motor caused by a high rate of voltage rise and a long motor cable
- Damage to the mount due to leakage currents in the motor mount
- Motor noises
- EMC problems
- Damage to the motor insulation

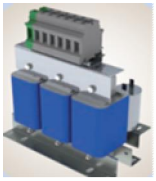
If operating motors directly (without output filter) on a variable speed drive, please observe the following:

- Motors for IGBT variable speed drives (pulse variable speed drives with the same voltage-source DC link as the G120P) must be designed in insulation class F according to the rating plate This is the only way that they can withstand the voltage peaks that arise periodically. You should always obtain confirmation of suitability from the motor manufacturer, as this is only listed in the catalog in exceptional cases. In the 400 V range (560 V DC-link voltage), newer production engines can generally be used safely with the conventional insulation (Class F) for standard motors
- Be sure to include a filter circuit (output filter) as part of the drive system configuration for older motors, as well as for motors that have not been confirmed as suitable for variable speed drives by the manufacturer
- It is possible to make any predictions regarding noise and vibrational excitations from conventional motor or drive parameters. Use external insulation measures against the increased noise levels. Establish resonance points empirically and mask them by assigning appropriate parameters in the G120P. The use of an output filter can reduce the motor's noise levels.
- Self-ventilated motors are well-suited to pump or fan drives with adjustable speeds

If the motor to be used or environment in which the entire drive system is installed require an output filter, there are 2 filter types that can be used, see Filter Overview [➞ 89].

The installation information and technical data can be found in the manufacturer's documentation.

5.6.2 Filter Overview

Filter	no filter		du/dt REO CNW 833		sine wave REO CNW 933 / CNW9332	
Picture						
Features			• Longer lifetime of motors • Reduction of rate of voltage rise (dv/dt) to earth and between the phases • Reduction of motor noise • Current smoothing		• Longer lifetime of motors • High frequency range • Long motor cables • Omit of the shielded cable possible • Easy connection • Low temperature rise • Very low noise	
Max. motor frequency	650 Hz		60 Hz		60 Hz / 120 Hz	
Pulse frequency	4-16 kHz[1]					
IP55	G120P-../35B	G120P-../35A	G120P-../35B	G120P-../35A	G120P-../35B	G120P-../35A
EN 61800-3 C1 [2]	25 m screened	- - -	150 m screened[3]	- - -	200 m screened	- - -
EN 61800-3 C2	50 m screened[4]	25 m screened		150 m screened[3]		200 m screened
EN 61800-3 C3		50 m screened[4]				
IP20	G120P-../32B	G120P-../32A	G120P-../32B	G120P-../32A	G120P-../32B	G120P-../32A
EN 61800-3 C1 [2]	50 m screened[4]	- - -	150 m screened[3]	- - -	200 m screened	- - -
EN 61800-3 C2		50 m screened[4]		150 m screened[3]		200 m screened
EN 61800-3 C3						
Maximum cable length (no EMC standard complied)	100 m unscreened 50 m screened		150 m unscreened 150 m screened		1000 m unscreened 600 m screened	
Comments			Voltage drop on motor line depends on cable diameter and must be considered. Typical values for voltage drop: - 5 % on motor connections with du/dt filter and 150 m motor cable[5]		Voltage drop on motor line depends on cable diameter and must be considered. Typical values for voltage drop: - 10% on motor connections with sine wave filter and 250 m motor cable[5]	

[1] Compliance with EMC standards is tested with 4kHz for all power sizes
[2] Only conducted emissions
[3] Cable length limited by output filter performance, not by EMC emmissions
[4] Cable length limited by power module, not by EMC emmissions

[5] Voltage drop leads to higher currents if same power must be reached

5.7 Fuses

5.7.1 Where are fuses required?

For fixed installations, a fuse is required for each cross-section reduction. The fuse must always safeguard the smallest cross-section in the electric circuit. Branch lines to fuses, sockets, and energy consumption meters may be dimensioned weaker provided that the line length does not exceed 2 m in control panels (switching panels, control cabinets) or 1 m in other locations. The branch lines must be separated from combustible objects by an incombustible and thermal isolating intermediate layer.

5.7.2 Fuse types

The following fuse types are used:

- D system DIAZED screw-in fuse links (fusible links)
- LV HRC (low-voltage high-rupturing-capacity fuse links) (up to 600 A) (fusible links)
- Miniature circuit breakers (MCB)
- Electromagnetic releases
- Circuit breakers (to bypass a defective variable speed drive yet still safeguard the motor against overloading)
- Thermal overcurrent circuit breakers

D system DIAZED screw-in fuse links

DIAZED (diametral two-step Edison screw) screw-in fuse links (as well as fuse cartridges or fusible links) are divided into 5 frame sizes.

Size	Rated current	Thread
D I	2 A, 4 A, 6 A, 10 A, 16 A	E 16
D II	6 A, 10 A, 16 A, 20 A, 25 A	E 27
D III	35 A, 50 A, 63 A	E 33
D IV	80 A, 100 A	R 1¼"
D V	125 A, 160 A, 200 A	R 2"

Frame sizes D IV and D V are seldom used.

Low-voltage high-rupturing-capacity (LV HRC) fuse links

Low-voltage HRC fuse links are also known as blade-type fuses, blade fuses, and main fuses. These are fusible links, yet they differ in form from screw-in fuse links. They have a larger volume than screw-in fuse links and a massive blade contact at both ends, which allows them to carry and break larger currents.

They are generally used to connect a house to a power supply system, or in electrical power distribution systems for switchgear assemblies according to EN 60439

LV HRC fuses can be used as individual fuses, in which case a fuse handle must be inserted/pulled. 3 fuses can also be mounted in a single box, however, in which case the cover then serves as a fuse holder and all fuses are inserted or removed at the same time (LV HRC fuse isolators).

⚠ WARNING

Arc generation

Removing this type of fuse when under load poses a high risk of an arc being produced. This causes a high current to flow along with high temperatures. The risk is reduced by using fuse isolators.

- LV HRC fuses must only be replaced by specialists with the appropriate tools and necessary protective equipment.
- The protective equipment is not necessarily essential if it is certain that there is no load on the relevant electric circuit, as hazardous arcs only arise when under load.

Miniature circuit breakers (MCBs)

The miniature circuit breaker (automatic circuit breaker) offers the following advantages over a fuse:

- Constant readiness for operation, meaning it is immediately ready to use again after tripping if there is no more overload
- Low space requirements
- The tripping characteristic does not change due to aging
- The line can be utilized better as starting currents do not result in trips when the switch is selected correctly
- They can be used as switches if specially marked as such with a symbol. In special cases where the electric circuit is only switched occasionally, it is also permitted to have switches that do not bear this symbol

Motor starter protectors (MSPs)

Motor starter protectors are used both as protective devices and switching devices for motors. The standard MSP is a three-pole, manually operated switch with thermal overcurrent release. In modern devices, electromagnetic releases are also installed. Auxiliary contacts are often switched, too. Motor starter protectors are built in various sizes with a rated current of up to approximately 200 A. The releases are available in different versions:

- Quick-response releases for if the starting current does not rise too high and last for too long, which is generally the case for no-load starting and motors with low speeds
- Slow releases for when the motor is intended to start-up under load (heavy starting) or for motors with high speeds

5.7.3 Overcurrent protection

Overcurrent protection

The electrical cables must be protected against overcurrent to avoid both electrical and fire hazards as a result of cables overheating. This means that all electric circuits in an installation must be fused against short-circuits and overloads in accordance with national and international regulations.

When taking the measurements, we recommend selecting the next largest standard value above the G120P's respective maximum input current.

Short-circuit protection

The G120P must be protected against short-circuits to prevent electrical hazards or electrical fire hazards. The short-circuit protection must always be in place at the start of the supply. The size of the fuse/miniature circuit breaker is dependent on the maximum input current.

When taking the measurements, we recommend selecting the next largest standard value above the G120P's respective maximum input current.

The fuses must be suitable for use in an electric circuit that can supply a symmetrical current of up to 100,000 A (eff) at a maximum voltage of 480 VAC.

The G120P guarantees full short-circuit protection in the event of a short-circuit at the motor output.

Overload protection

The G120P has internal overload protection which complies with UL508C. I^2t is active for each factory setting. Motor overload protection can also be achieved by using an external motor PTC.

Max. input and output current:

Power (kW)	Frame size	Max. input current (LO)	Max. output current (LO)	Recommended Siemens fuse
0.37	A	1.3 A	1.3 A	3NE1813-0
0.55	A	1.8 A	1.7 A	3NE1813-0
0.75	A	2.3 A	2.2 A	3NE1813-0
1.1	A	3.2 A	3.1 A	3NE1813-0
1.5	A	4.2 A	4.1 A	3NE1813-0
2.2	A	6.1 A	5.9 A	3NE1813-0
3	A	8.0 A	7.7 A	3NE1813-0
4	B	10.5 A	10.2 A	3NE1813-0
5.5	B	13.6 A	13.2 A	3NE1814-0
7.5	B	18.6 A	18.0 A	3NE1815-0
11	C	26.9 A	26.0 A	3NE1803-0
15	C	33.1 A	32.0 A	3NE1817-0
18.5	C	39.2 A	38.0 A	3NE1817-0
22	D	42 A	45 A	3NE1818-0
30	D	56 A	60 A	3NE1820-0
37	E	70 A	75 A	3NE1021-0
45	E	84 A	90 A	3NE1022-0
55	F	102 A	110 A	3NE1224-0
75	F	135 A	145 A	3NE1225-0
90	F	166 A	178 A	3NE1227-0

5.7.4 Operation with a residual current protective device (RCD)

Do not use an RCD

Wherever possible, avoid using RCDs for variable speed drives with EMC filters, as the leakage currents in these devices are higher than in unfiltered devices.

If you require an RCD, use a variable speed drive without EMC filters.

In exceptional circumstances, a variable speed drive with filter A can be used.

If you require an RCD for fire protection, for example, this must meet the following conditions. For further information on RCD switches, read the Siemens "Residual current protective devices" guide (order number: E10003-E38-10T-G3011).

Requirements for RCD switches

In the event of a variable speed drive fault, smooth residual currents or residual currents with slight residual ripple can occur. Pulsating-current-sensitive residual current protective devices cannot detect and disconnect such fault currents. They are also negatively affected in terms of their tripping function. This is why electrical loads that generate such fault currents in the event of faults must not be operated with pulsating-current-sensitive RCDs on the electrical supply network.

As a result, only universal-current-sensitive RCDs (type B) may be used in conjunction with variable speed drives. These are suitable for use in three-phase current systems with 50/60 Hz.

Universal-current-sensitive RCDs (type B) are marked with the  symbol.

When planning and installing electrical installations, it must be noted that electrical consumers, such as variable speed drives, that generate smooth DC fault currents in the event of a fault are assigned their own circuit with a universal-current-sensitive RCD (type B).

It is not permitted to branch electric circuits with these types of electrical consumers to pulsating-current-sensitive RCDs (type B). Consumers that may be the source of smooth DC fault currents in the event of a fault would affect the tripping ability of the pulsating-current-sensitive RCDs (type A).

Operation with residual current operated circuit breakers

When using residual current operated circuit breakers, the G120P functions without unwanted disconnections under the following preconditions:

- A G120P with EMC filter A is used
- A type B residual current operated circuit breaker is used
- The trip limit of the residual current operated circuit breaker is 300 mA
- The neutral conductor of the network is grounded
- Each G120P is supplied by its own residual current operated circuit breaker
- The output cables are shorter than 50 m (shielded) or 100 m (unshielded)

!	*NOTICE*
	Residual current operated circuit breakers in use Residual current operated circuit breakers in use must offer protection against direct-current components in the fault current and be suitable for temporarily discharging peaks in pulse current. • Fuse the variable speed drive separately • Observe the respective country requirements and those of the regional energy supplier

5.8 Service switch

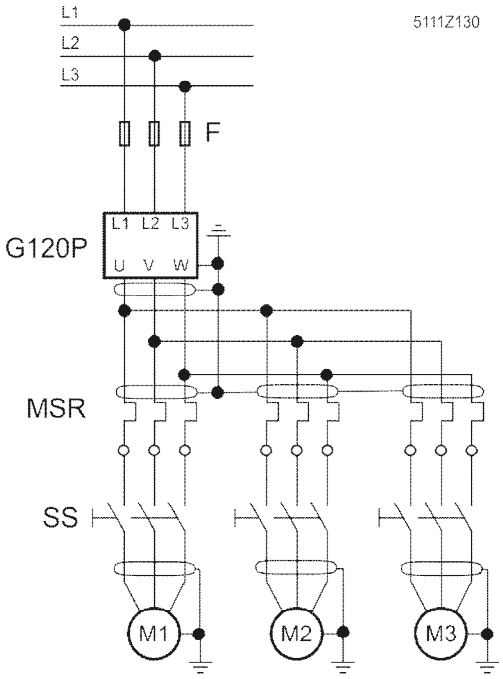
In most countries, the standards and safety regulations prescribe a service switch for service purposes in the motor's supply line, which must be installed between the variable speed drive and the motor.

You can safeguard the variable speed drive against operation faults using a service switch with an additional NO contact. For more information, see recommended settings 2 on the next page.

Breaking a cable at the variable speed drive output when under voltage leads to an overvoltage fault in the variable speed drive due to the induction being reversed. In extreme cases, it can also result in irreparable damage to the variable speed drive's power circuit, particularly if a contactor is used instead of a mechanical switching device.

To perform maintenance, the service technician or customer must first switch off the entire application (including the variable speed drive) before opening a service switch. There are various ways of preventing the power circuit from becoming irreparably damaged or fault messages from arising due to operation faults.

!	*NOTICE*
	Close the service switch or contactor during operation Closing a switch installed between a variable speed drive and a motor while the variable speed drive is in operation results in the motor's current consumption multiplying by six. If this should occur, the variable speed drive switches off due to overcurrent. • Only close the service switch/contactor when the variable speed drive is not in operation.



MPR = Motor protection relays
SS = Service switches
F = Fuses

Types of service switches

Various types of service switches are available, in terms of their design and number of contacts. The most common types, with a large red knob, have 3 NO contacts for the motor supply. However, there are also other service switches available with additional NO contacts or NC contacts, for example the Siemens 3LD2.

Connection in the service switch

It is crucial to connect the motor cable shield correctly in the service switch.

The shield must be drawn through to the motor from the G120P output without interruptions to prevent any EMC problems from occurring.

Recommended settings 1

If using a normal service switch without additional NO or NC contacts, you cannot safeguard the variable speed drive against operation faults directly at the service switch. Attach a warning sign to the switch in order to avoid operation faults.

Recommended settings 2

Use a service switch with an additional NO contact for direct variable speed drive protection against operation faults at the service switch. This requires the switch-on command to be fed via the additional NO contact.

If the motor supply contactor is opened, the variable speed drive's power circuit is isolated from its output terminals.

To isolate the G120P power circuit from the variable speed drive's output terminals, you can use the "Enable operation" digital command. This prevents the reverse induction that results from operating the service switch from affecting the G120P power circuit.

When using the "Enable operation" setting:

- The reverse induction that results from operating the service switch has no effect on the G120P power circuit.

Parameter settings (Enable operation at DI0)

Parameters	Description
p0840[0] = r722.0	Switch-on command at DI0
p0852[0] = r722.0	Enable operation with DI0

- Contact closed -> RUN command can be activated
- Contact open -> the motor runs down to a standstill

Service switch at input of variable speed drive

Technically speaking, you can install the service switch at the input for the variable speed drive. An additional NO contact is not required for the switch-on command.

⚠ WARNING

Dangerous voltage in DC link

The DC link carries dangerous voltages during the electrical discharge period, which can take up to 5 minutes after isolating the variable speed drive from the network.

- Wait until the DC link has fully discharged before making adjustments to the system.

An emergency stop button on the variable speed drive's motor cable or connecting cable must not be used as an "emergency stop mechanism" (see EN 60204, 9.2.5.4). Consult your national standards and safety regulations, as these usually prescribe a lockable service switch.

5.9 Output contactors and motor protection relays

Motor contactors are installed on the output side for many variable speed drive applications.

If one of these contactors interrupts the line between the variable speed drive and the motor during operation, an alarm appears on the G120P's display to warn of no-load at the variable speed drive. If this happens, the variable speed drive continues to run, meaning it still carries voltage at the output. This state does not pose any danger for the variable speed drive.

!	*NOTICE*
	Close the contactor during operation Closing a switch installed between a variable speed drive and a motor while the variable speed drive is in operation results in the motor's current consumption multiplying by six. If this should occur, the variable speed drive switches off due to overcurrent. • Only close the service switch/contactor when the variable speed drive is not in operation • If possible, avoid the use of motor contactors

It only makes sense to use motor contactors for a bypass application. In this case, you must check the controls to ensure that the contactor is not switched on until the variable speed drive is at a standstill (in standby).

You should also ensure that the motor contactor and the variable speed drive's release are not switched on together to prevent the error referred to above from arising.

5.10 Operation on non-grounded networks

It is only possible to operate on non-grounded power supply networks using G120Ps with degree of protection IP20/NEMA 0 and no EMC filters.

Devices with integrated EMC line filters cannot be operated on non-grounded networks.

G120Ps with degree of protection IP55/NEMA 12 cannot be operated on non-grounded power supply networks.

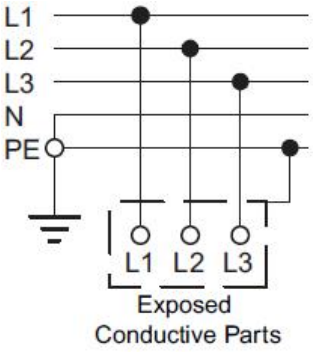
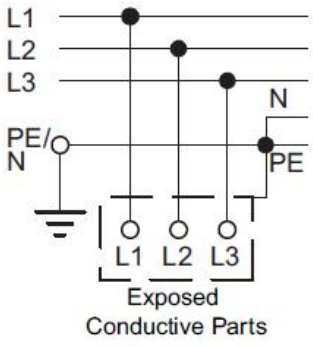
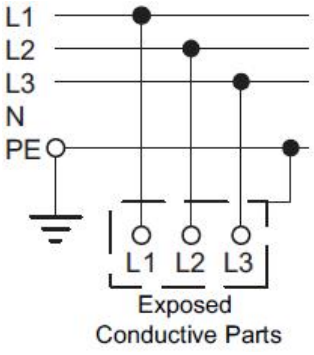
IT systems are also classed as non-grounded networks in this context. For more information, also refer to the following section Current distribution systems [→ 97]

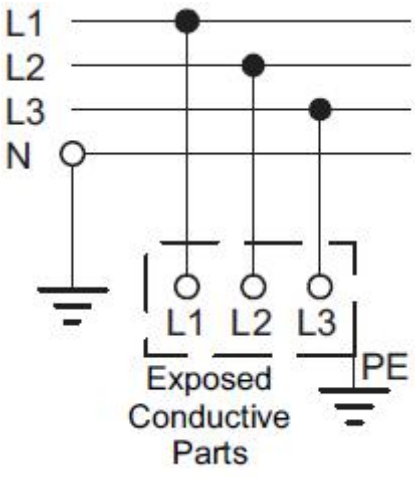
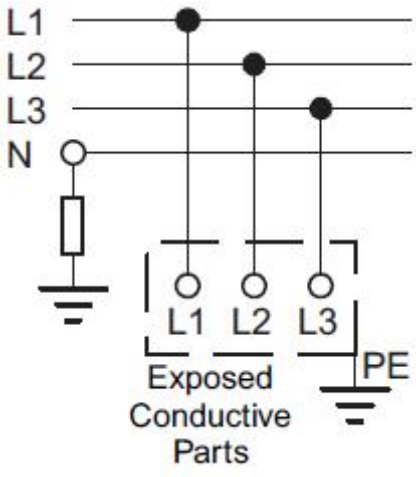
The G120P with degree of protection IP20 functions on non-grounded networks and continues to operate when an input phase is connected to ground. If an output phase has a ground fault, the G120P switches off and displays a corresponding message.

5.11 Current distribution systems

Overview

The current distribution systems described below have been taken into consideration when designing the variable speed drive according to EN 60950. The following diagrams feature three-phase current systems. The three-phase current variable speed drives must be connected to L1, L2, and L3. PE must always be connected. The variable speed drive can be operated in most supply networks. For more information, see also Section Operation on non-grounded networks [➞ 96]. Only G120Ps with degree of protection IP20/Nema 0 and no EMC line filter can be used in IT systems.

TN-S system	TN-C-S system	TN-C system
		
In a TN-S supply network, there are always separate conductors as neutral or grounding protection conductors.	In a TN-C-S system, the functions of the neutral conductor and the grounding protection conductor are combined.	In a TN-C system, the functions of the neutral conductor and the grounding protection conductor are combined in one single cable throughout the complete system.

TT system	IT system
	
In a TT system, one point is directly grounded. The accessible, conductive parts of the plant or system are grounded, so that they are electrically independent of the line supply ground.	An IT line supply does not have any direct connection to ground. Instead of this, the accessible parts of the electrical plant or system are grounded.

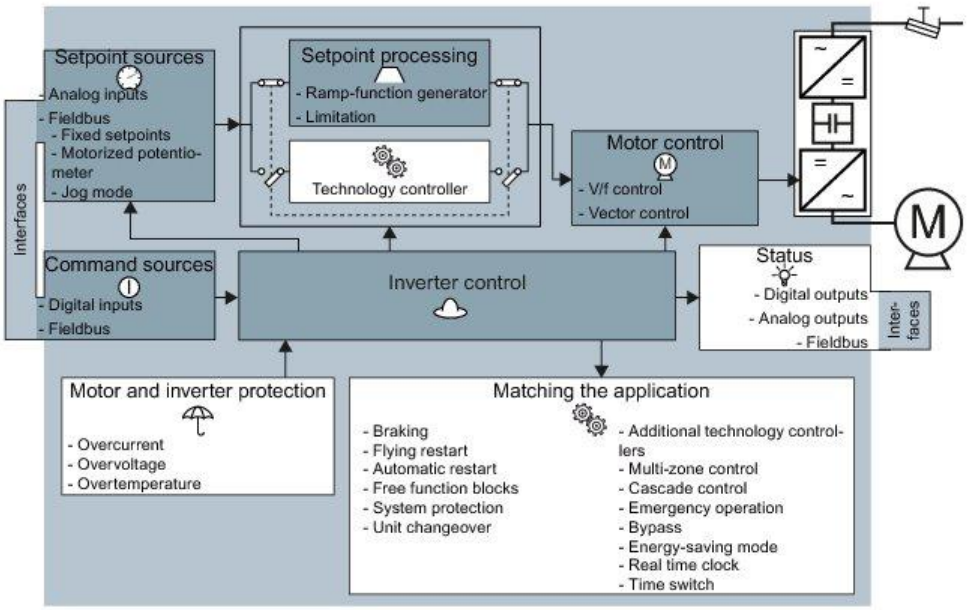
To achieve degree of protection I according to directive EN 61140, input and output power supplies must be grounded.

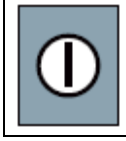
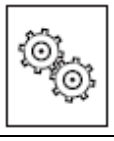
6 Functions

6.1 Overview of the functions

Before you set the variable speed drive functions, you should complete the following commissioning steps:

- Basic commissioning
- If required: adjust the terminal strip
- If required: configure the fieldbus



Functions relevant to all applications		Functions required in special applications only	
The functions that you require in each application are shown in a dark color in the function overview above. In the quick commissioning, the parameters of these functions are assigned an appropriate basic setting, so that in many cases the motor can be operated without having to assign any other parameters.		The functions whose parameters you only need to adapt when actually required are shown in white in the function overview above.	
	**Variable speed drive control** is responsible for all of the other variable speed drive functions. Among other things, it defines how the variable speed drive responds to external control signals.		The **protection functions** avoid overloads and operating states that could cause damage to the motor, variable speed drive, and driven load. The motor temperature monitoring, for example, is set here.
	The **command source** defines where the control signals are received from to switch on the motor, e.g. via digital inputs or a fieldbus.		The **status messages** provide digital and analog signals at the Control Unit outputs or via the fieldbus. Examples include the current speed of the motor or fault message issued by the variable speed drive.
	The **setpoint source** defines how the speed setpoint for the motor is specified, e.g. via an analog input or a fieldbus.		The **functions matching the application** allow you to control a motor holding brake or implement a higher-level pressure or temperature

Functions relevant to all applications		Functions required in special applications only	
	The **setpoint processing** uses a ramp-function generator to prevent speed steps occurring and to limit the speed to a permissible maximum value.		control using the technology controller, for example. The variable speed drive also provides particular solutions for applications relating to pumps, fans, and air-conditioning technology.
	The **motor control** ensures that the motor follows the speed setpoint.		

6.2 Basic functions of the G120P

The following table provides an overview of the basic functions described in this section. The short description allows you to decide whether or not you require the corresponding function as part of the project.

Segment	Short description	Required in the project	
		Yes	No
Inputs and outputs [→ 100]	Number and type of inputs/outputs and internal interconnection		
Digital inputs [→ 101]	Digital inputs and their interconnection with binector inputs		
Digital outputs [→ 102]	Digital outputs and their interconnection with binector outputs		
Analog inputs [→ 103]	Function and settings of the analog inputs and assignment to the connector inputs		
Analog outputs [→ 105]	Function and settings of the analog outputs and assignment to the connector outputs		
Motor identification [→ 107]	The motor identification enables the variable speed drive to be adapted to the motor, resulting in higher motor power		
Switching the motor on and off [→ 108]	The variable speed drive has a switch-on command and 3 different switch-off commands		
Control modes [→ 109]	Function and settings of the V/f control or sensorless vector control (SLVC)		
Braking function [→ 115]	With DC braking, the variable speed drive slows the motor down in the required time and converts the resulting energy into heat.		
Flying restart [→ 119]	The motor is able to turn as soon as the variable speed drive is switched on. With flying restart, the variable speed drive can pick up the motor at the current speed.		
Automatic restart [→ 122]	Following errors or a power failure, the variable speed drive can acknowledge the error and put the motor back into operation		
Data backup and standard commissioning [→ 124]	For the purposes of data backup or series commissioning, the variable speed drive settings can be saved onto a memory card, as a software project, or in an operator panel.		
Write and know-how protection [→ 135]	The write protection prevents settings from being inadvertently adjusted, while know-how protection protects your configuring expertise		
Factory settings [→ 138]	The factory setting facilitates simple		

Segment	Short description	Required in the project	
		Yes	No
	applications or serves as a starting point for configuring complex applications		

6.2.1 Inputs and outputs

Available inputs and outputs

The variable speed drive has the following digital and analog inputs and outputs:

- 6 isolated digital inputs with a separate potential group to prevent potential transfers
- 3 digital outputs
- 4 isolated analog inputs for EMC-compliant installation without the need for additional components
- 2 analog outputs

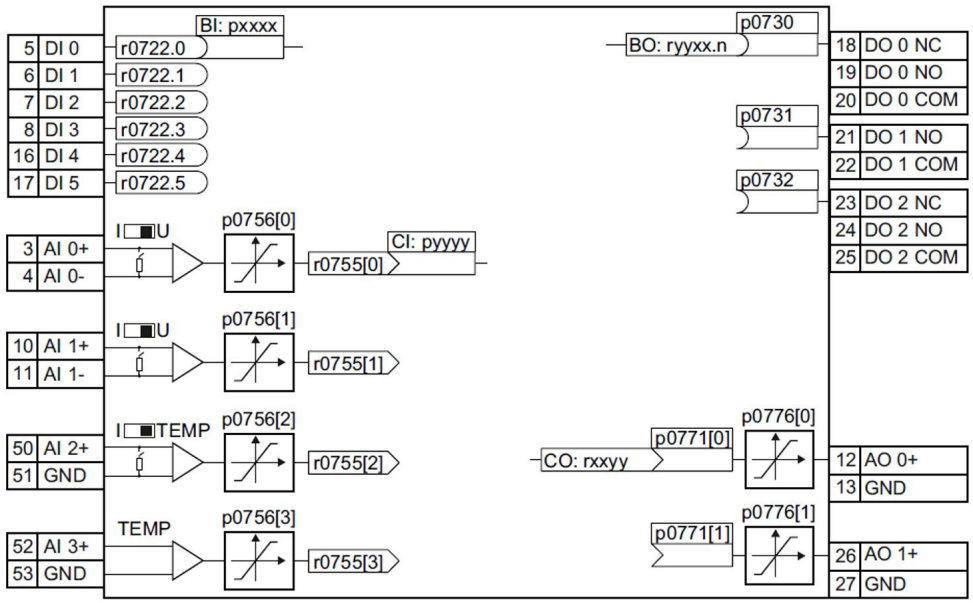
Terminal assignment

The terminal assignment at the CU's terminal strips can be found in Section Terminal strips in the Control Unit [→ 41].:

Permissible wire cross-sections for the terminal connections are: 0.5 to 2.5 mm²

Internal interconnection

The terminals are connected internally as follows:



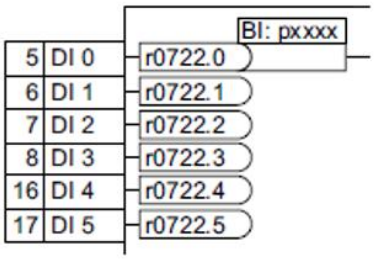
Before you adapt the inputs and outputs of the variable speed drive, you should have completed the basic commissioning.

In the basic commissioning, select an assignment of the variable speed drive interfaces from several predefined configurations. This is done using the MacPar P0015 macro parameter. Section contains the latest HVAC applications and the corresponding macro numbers.

If none of the predefined configurations completely matches your application, then you must adapt the assignment of the individual inputs and outputs. You do this by changing the internal interconnection of an input or output using BICO technology.

6.2.2 Digital inputs

External switch-on and switch-off processes are required for autonomous variable speed drive operation. 6 digital inputs are available, which can be expanded to 8 using the 2 analog inputs.



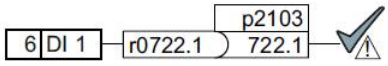
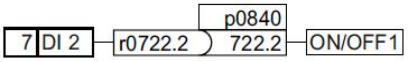
The functions of the digital inputs are freely-programmable, meaning that the status parameter for each digital input can be connected to your choice of binector input (BI).

Binector inputs (BI) of the variable speed drive

BI	Meaning	BI	Meaning
p0810	Command data set selection CDS bit 0	p1036	Motorized potentiometer setpoint lower
p0840	ON/OFF1	p1055	Jog bit 0
p0844	OFF2	p1056	Jog bit 1
p0848	OFF3	p1113	Setpoint inversion
p0852	Enable operation	p1201	Flying restart enable signal source
p0855	Unconditionally open holding brake	p2103	1. Acknowledge faults
p0856	Enable speed controller	p2106	External fault 1
p0858	Unconditionally close holding brake	p2112	External alarm 1
p1020	Fixed speed setpoint selection bit 0	p2200	Technology controller enable
p1021	Fixed speed setpoint selection bit 1		
p1022	Fixed speed setpoint selection bit 2		
p1023	Fixed speed setpoint selection bit 3		
p1035	Motorized potentiometer setpoint higher		

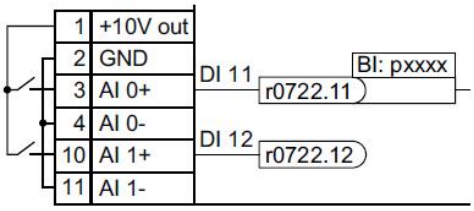
A complete list of the binector inputs is provided in the List Manual.

Example

	With operator panel	In STARTER
Acknowledge fault with digital input 1: 	Set p2103 = 722.1	Go online with STARTER and select "inputs/outputs". Change the input function via the corresponding screen form.
Switch-on motor with digital input 2: 	Set p0840 = 722.2	

Additional digital inputs

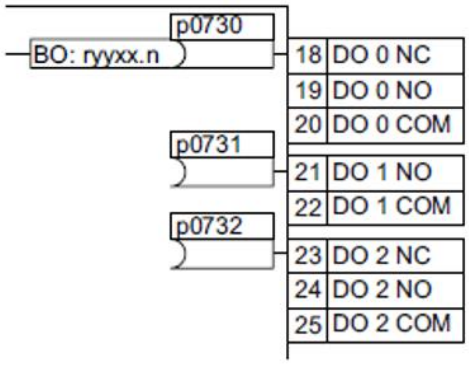
Analog inputs can be used as additional digital inputs as follows:

Terminals of the additional digital inputs	Changing the function of the digital input
	If you use an analog input as a digital input then interconnect the status parameter of the digital input with a binector input of your choice.

If an analog input is configured as a digital input, the following conditions apply:

- Limit value ≤ 1.6 VDC = off
- Limit value ≥ 4.0 VDC = on

6.2.3 Digital outputs

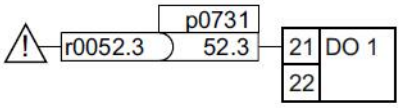
Digital output terminals	Changing the function of the digital output
	Interconnect the digital output with a binector output (BO) of your choice.

Binector outputs (BO) of the variable speed drive

BO	Meaning	BO	Meaning
0	Deactivate digital output	r0052.9	Process data control
r0052.0	Drive ready	r0052.10	f_actual >= p1082 (f_max)
r0052.1	Drive ready for operation	r0052.11	Alarm: Motor current/ torque limitation
r0052.2	Drive running	r0052.12	Brake active
r0052.3	Drive fault active	r0052.13	Motor overload
r0052.4	OFF2 active	r0052.14	Motor CW rotation
r0052.5	OFF3 active	r0052.15	Drive overload
r0052.6	Switching on inhibited active	r0053.0	DC braking active
r0052.7	Drive alarm active	r0053.2	f_actual > p1080 (f_min)
r0052.8	Setpoint/actual value deviation	r0053.6	f_actual ≥ setpoint (f_setpoint)

A complete list of the binectors is provided in the List Manual.

Example

	With operator panel	In STARTER
Signal fault via digital output 1. 	Set p0731 = 52.3	Go online with STARTER and select "inputs/outputs". Change the output function via the corresponding screen form.

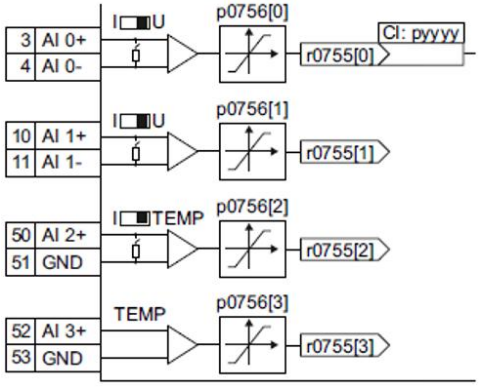
Advanced settings

You can invert the signal of the digital output using parameter p0748.

For more information, see the parameter list and the function diagrams 2230 ff. in the List Manual.

6.2.4 Analog inputs

Setting, control, and feedback signals are fed into the variable speed controller via the analog inputs and converted into digital signals via analog-to-digital converters.

Analog input terminals	Changing the function of the analog input
	1. Define the analog input type using parameter p0756 and the switch on the variable speed drive (e.g. voltage input -10 V to 10 V or current input 4 mA to 20 mA). 2. Connect parameter p0755 using a connector input (CI) of your choice (e.g. as a speed setpoint).

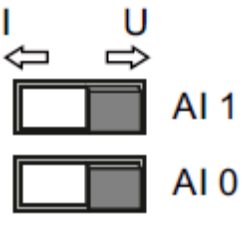
Define the analog input type

The variable speed drive offers a series of default settings, which you can select using parameter p0756:

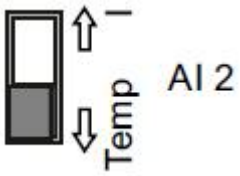
AI 0	Unipolar voltage input	0 V to +10 V	p0756[0] =	0
	Unipolar voltage input monitors:	+2 V to +10 V		1
	Unipolar current input	0 mA to +20 mA		2
	Unipolar current input monitors	+4 mA to +20 mA		3
	Bipolar voltage input (factory setting)	-10 V to +10 V		4
AI 1	Unipolar voltage input	0 V to +10 V	p0756[1] =	0
	Unipolar voltage input monitors:	+2 V to +10 V		1
	Unipolar current input	0 mA to +20 mA		2
	Unipolar current input monitors	+4 mA to +20 mA		3
	Bipolar voltage input (factory setting)	-10 V to +10 V		4
AI 2	Unipolar current input (factory setting)	0 mA to +20 mA	p0756[2] =	2
	Unipolar current input monitors	+4 mA to +20 mA		3
	LG-Ni1000 temperature sensor			6
	Pt1000 temperature sensor			7
	No sensor connected			8
AI 3	LG-Ni1000 temperature sensor		p0756[3] =	6
	Pt1000 temperature sensor			7
	No sensor connected (factory setting)			8

You must also switch on the analog input switch. These switches can be found as follows:

- The DIP switch for AI0 and AI1 (current/voltage) on the Control Unit behind the lower front door



- The DIP switch for AI2 (temperature/current) on the Control Unit behind the upper front door

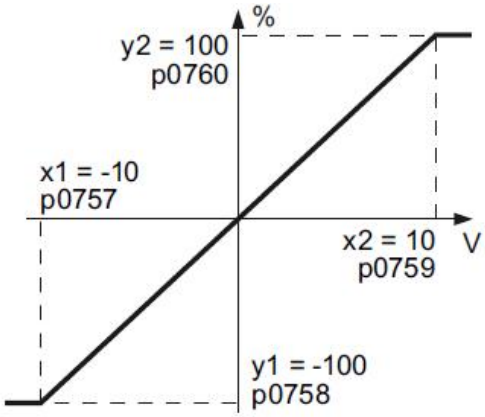


Parameter assignment for the analog inputs

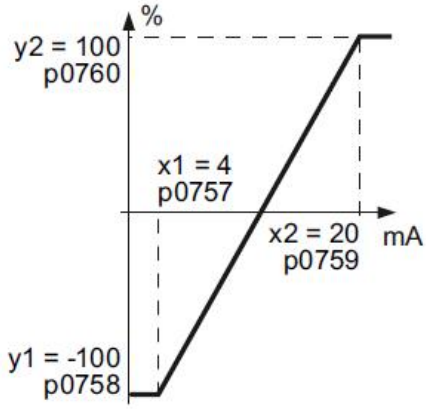
If you change the analog input type using p0756, then the variable speed drive automatically selects the appropriate scaling of the analog input. The linear scaling characteristic is defined using two points (p0757, p0758) and (p0759, p0760). Parameters p0757 to p0760 are assigned to an analog input via their index, e.g. parameters p0757[0] to p0760[0] belong to analog input 0.

Examples for scaling characteristics:

P0756 = 4
Voltage input -10 V to 10 V



P0756 = 3
Current input 4 mA to 20 mA



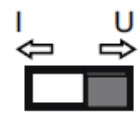
Parameters for the scaling characteristic and wire breakage monitoring:

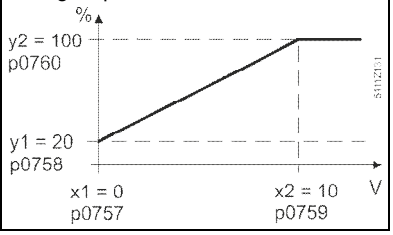
Parameters	Description
p0757	X-coordinate of 1st characteristic point [V or mA]
p0758	Y-coordinate of the 1st characteristic point [% of p200x] p200x are the parameters of the reference variables, e.g. p2000 is the reference speed
p0759	X-coordinate of 2nd characteristic point [V or mA]
p0760	Y-coordinate of 2nd characteristic point [% of p200x]
p0761	Wire breakage monitoring response threshold

You must define your own characteristic if none of the default types match your particular application.

Example

The variable speed drive should convert a 0 V to 10 V signal into the value range -20% to 100% via analog input 0.

Parameters	Description		
p0756[0] = 0	**Analog input type** Define analog input 0 as a unipolar voltage input (0 V to +10 V).	Set DIP switch for AI 0 to voltage input ("U"):	
After changing p0756 to the value 0, the variable speed drive sets the scaling characteristic parameters to the following values: p0757[0] = 0.0; p0758[0] = 0.0; p0759[0] = 10; p0760[0] = 100			

Adapt the characteristic:		
p0757[0] = 0.0 p0758[0] = 20.0	**Analog input characteristic (x1, y1)** 0 V corresponds to 20%	Voltage input, 0 V to 10 V 
p0759[0] = 10.0 p0760[0] = 100.0	**Analog input characteristic (x2, y2)** 10 V corresponds to 100%	

Defining the analog input function

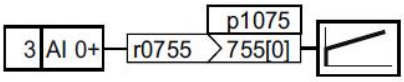
You define the analog input function by interconnecting a connector input of your choice with parameter p0755. Parameter p0755 is assigned to the particular analog input via its index, e.g. parameter p0755[0] is assigned to analog input 0.

Connector inputs (CI) of the variable speed drive (selection):

CI	Meaning	CI	Meaning
p1070	Main setpoint	p1522	Torque limit, upper
p1075	Supplementary setpoint	p2253	Technology controller setpoint 1
p1503	Torque setpoint	p2264	Technology controller actual value
p1511	Supplementary torque 1		

A complete list of the connector inputs is provided in the List Manual.

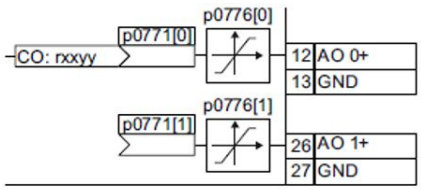
Example

	With operator panel	In STARTER
Analog input 0 is the source for the additional setpoint. 	Set p1075 = 755[0]	Go online with STARTER and select "inputs/outputs". Change the output function via the corresponding screen form.

For more information, see the parameter list and the function diagrams 9566 ff. in the List Manual.

6.2.5 Analog outputs

The purpose of the analog outputs is essentially to present status variables such as output frequency, motor voltage, or current motor current within a scalable area.

Analog output terminals	Changing the function of the analog output
	1. Define the analog output type using parameter p0776, e.g. voltage output -10 V to 10 V or current output 4 mA to 20 mA). 2. Connect parameter p0771 using a connector output of your choice, e.g. the current speed. Connector outputs are marked with "CO" in the parameter list of the List Manual.

Define the analog output type

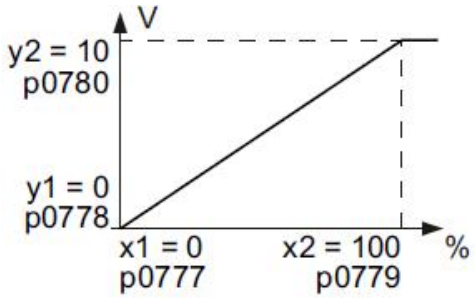
The variable speed drive offers a series of default settings, which you can select using parameter p0776:

AO 0	Current output (factory setting)	0 mA to +20 mA	p0776[0] =	0
	Voltage output	0 V to 10 V		1
	Current output	+4 mA to +20 mA		2

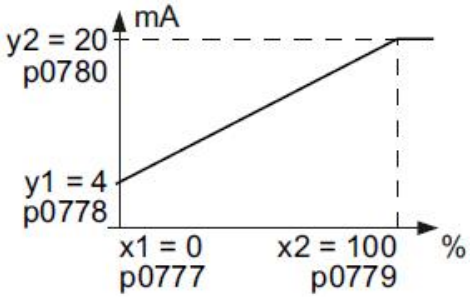
AO 1	Current output (factory setting)	0 mA to +20 mA	p0776[1] =	0
	Voltage output	0 V to +10 V		1
	Current output	+4 mA to +20 mA		2

If you change the analog output type, then the inverter automatically selects the appropriate scaling of the analog output. The linear scaling characteristic is defined using two points (p0777, p0778) and (p0779, p0780).

P0776 = 1
Voltage output 0 V to 10 V



P0776 = 2
Current output 4 mA to 20 mA



Parameters p0777 to p0780 are assigned to an analog output via their index, e.g. parameters p0777[0] to p0770[0] belong to analog output 0.

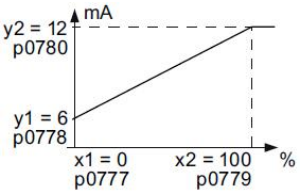
Parameters for the scaling characteristic

Parameters	Description
p0777	**X-coordinate of the 1st characteristic point [% of p200x]** p200x are the parameters of the reference variables, e.g. p2000 is the reference speed.
p0778	**Y coordinate of the 1st characteristic point [V or mA]**
p0779	**X coordinate of the 2nd characteristic point [% of p200x]**
p0780	**Y coordinate of the 2nd characteristic point [V or mA]**

You must define your own characteristic if none of the default types match your particular application.

Example

The variable speed drive should convert a signal in the value range 0% to 100% into a 6 mA to 12 mA output signal via analog output 0.

Parameters	Description	
p0776[0] = 2	**Analog output type** Define analog output 0 as current output.	
After changing p0776 to the value 2, the variable speed drive sets the scaling characteristic parameters to the following values: p0777[0] = 0.0; p0778[0] = 4.0; p0779[0] = 100.0; p0780[0] = 20.0 Adapt the characteristic:		
p0777[0] = 0.0 p0778[0] = -6.0	**Analog output characteristic (x_1, y_1)** 0.0% corresponds to 6 mA	Current output 6 mA to 12 mA 
p0779[0] = 100.0 p0780[0] = 12.0	**Analog output characteristic (x_2, y_2)** 100% corresponds to 12 mA	

Defining the analog output function

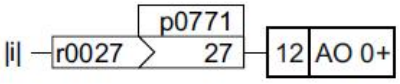
You define the analog output function by interconnecting parameter p0771 with a connector output of your choice. Parameter p0771 is assigned to the particular analog input via its index, e.g. parameter p0771[0] is assigned to analog output 0.

Connector outputs (CO) of the variable speed drive (selection):

CO	Meaning	CO	Meaning
r0021	Actual frequency	r0026	Actual DC-link voltage
r0024	Output actual frequency	r0027	Output current
r0025	Output actual frequency		

A complete list of the connector outputs is provided in the List Manual.

Example

	With Operator Panel	In STARTER
Output the variable speed drive output current via analog output 0. 	Set p0771 = 27	Go online with STARTER and select "inputs/outputs". Change the output function via the corresponding screen form.

For more information, see the parameter list and the function diagrams 9572 ff. in the List Manual.

6.2.6 Motor identification

The motor identification measures the stator resistance. Particularly in the case of the "flying restart" function, or when a Siemens standard motor is not used, motor identification improves the variable speed drive's power rating.

Select the required motor identification type (MOT ID, p1900) during basic commissioning:

0: Disabled

1 STIL ROT Motor data identification at standstill and when the motor is rotating

2: **STILL** Motor data identification at standstill

3: **ROT** Motor data identification when the motor is rotating

We recommend the setting "**STIL ROT**".

If one of the following cases applies, select the setting **STILL**:

- You have set "sensorless vector control" as the control mode but the motor cannot rotate freely.
- You have set "V/f control" as the control mode.

If you select a motor identification during basic commissioning, the A07991 (motor data identification activated) alarm is output once the basic commissioning is complete.

For the motor data identification, the motor must be cold. A motor in its heated operating state does not provide usable measurement results.

⚠ CAUTION

Moving system components and loads

The motor can move by up to a quarter of a revolution during motor data identification, meaning that connected system components and loads may also move as a result. This must not pose a safety hazard.

- Secure hazardous system components and loads before commencing the motor data identification.

Performing the motor identification

▷ Proceed as follows once basic commissioning is complete:

1. Switch the drive from AUTO to MANUAL
2. Switch on the drive

   ⇨ The motor identification is performed
3. Reset the drive from MANUAL back to AUTO

⇨ The drive is ready

The motor identification can be performed using BOP-2, IOP, or STARTER software.

You can perform the motor identification from scratch at any time by starting parameter p1900 and selecting the required setting.

6.2.7 Switching the motor on and off

Activating

After switching on the supply voltage, the variable speed drive normally goes into the "Ready to start" state. In this state, the variable speed drive waits for the command to switch on the motor:

The variable speed drive switches on the motor with the **ON** command. The variable speed drive changes to the "Operation" state.

Switching off

You can stop the motor in various ways: The 3 most important OFF commands are:

- **OFF1**
  After the OFF1 command, the variable speed drive brakes the motor with the ramp-down time of the ramp-function generator (p1120). The variable speed drive switches off the motor once standstill has been reached. The variable speed drive is ready to start again.
  ON and the subsequent OFF1 command can only be programmed together at a single source (for example, at the digital input).
  OFF1 can be combined with DC braking.
- **OFF2**
  The variable speed drive immediately switches off the motor without first braking it. The motor continues to run according to its moment of inertia.
  The OFF2 command can have a maximum of 2 sources, for example, a digital input. The OFF2 command is set by default at the BOP-2 stop button (double-click). This source is even still available when another source is programmed as OFF2, for example, another digital input.
- **OFF3**
  This command means "quick stop". After an OFF3 command, the variable speed drive brakes the motor with the OFF3 ramp-down time. After reaching standstill, the variable speed drive switches off the motor.
  The command is frequently used for exceptional operating situations where it is

necessary to brake the motor especially quickly, e.g. when it involves collision protection.
The OFF3 command can have a maximum of 2 sources, for example, a digital input.

The priority of the 3 commands is: OFF2 – OFF3 – OFF1.

Each switch-on command is automatically assigned to an OFF1 (default). If you would like OFF2 or OFF3, these two commands can also be programmed (at another digital input, for example), and are at a higher level than OFF1 due to their higher priority.

Setting

If you are controlling the variable speed drive using digital inputs, you use macro parameter p0015 during basic commissioning to define how the motor is switched on and off and how it is changed over from clockwise to counter-clockwise rotation.

Five different methods are available for controlling the motor. Three of the five methods require just two control commands (two-wire control). The other two methods require three control commands (three-wire control).

HVAC technology normally uses two-wire control, for which the option of direction reversal is generally not required and is therefore disabled in the G120P's factory settings.

If you enable direction reversal in the G120P, at a default setpoint of 0 (and even at a PID setpoint of 0), the G120P will not start at a minimum speed set in p1080 as the variable speed device is not aware of the required direction of rotation.

Parameters	Description		
p0015 = 12	**Macro drive unit** (factory setting for variable speed drives without PROFIBUS interface)		
	Controlling the motor using the digital inputs of the variable speed device:	DI 0	DI 1
		ON/OFF1	Reversing (This requires the factory-set lock in p1110 to be released)
Advanced setting Interconnecting control commands with digital inputs of your choice (DI x).			
p0840[0 to n] = 722.x	**BI: ON/OFF1**		
p1113[0 to n] = 722.x	**BI: Setpoint inversion** (reversing)		
Example			
p0840 = 722.3	DI 3: ON/OFF1. See also the digital inputs section		

6.2.8 Control modes

For induction motors, there are two different open-loop control or closed-loop control techniques:

- V/f control (calculation of the motor voltage using a characteristic curve)
- Sensorless vector control (also known as speed control, field-oriented control, or SLVC)

Criteria for selecting either V/f control or sensorless vector control (SLVC)

V/f control is suitable for most applications in which the speed of induction motors is to be changed.

When compared to V/f control, sensorless vector control offers the following advantages:

- The speed is more stable for motor load changes
- Shorter ramp times when the setpoint changes
- Larger tolerances for temporary line-side voltage drops or "brown-outs"
- Acceleration and braking are possible with an adjustable maximum torque
- Improved protection of the motor and the driven machine as a result of improvements to the adjustable torque limiting
- The full torque is possible at standstill.

The torque control is no longer applicable in FW version 4.6, although the torque monitoring remains unaffected.

It is not permissible to use sensorless vector control in the following cases:

- If the motor is too small compared to the variable speed drive. The motor's rated power must not be less than a quarter of the variable speed drive's rated power
- If several motors are connected to one variable speed drive
- If a power contactor is used between the variable speed drive and the motor, and is opened when the motor is powered up
- When the maximum motor speed exceeds the following values:

Variable speed drive pulse frequency	4 kHz and higher		
Pole number of the motor	2-pole	4-pole	6-pole
Maximum motor speed [rpm]	14400	7200	4800

Defining the minimum and maximum speed

You are able to define a minimum and maximum speed:

- Minimum speed p1080 – factory setting 0 [rpm]
  The minimum speed is the lowest speed of the motor independent of the speed setpoint. A minimum speed > 0 makes sense in applications, where the motor should be operated with a speed = 0 after it has been switched on. Examples include fans or pumps. For adequate cooling of self-cooling motors, we recommend a minimum speed of at least 20%.
- Maximum speed p1082 – factory setting 1,500 [rpm]
  The variable speed drive limits the motor speed to this value. The value is automatically set to the motor's synchronous speed during basic commissioning.

Ramp-up time and ramp-down time

The ramp-up and ramp-down times define the maximum motor acceleration when the speed setpoint changes. The ramp-up and ramp-down time is the time between motor standstill and the maximum speed, or between the maximum speed and motor standstill.

- Ramp-up time – factory setting 10 s
- Ramp-down time – factory setting 30 s

Recommended ramp times	
0.37 – 3 kW	30 s
4 – 15 kW	60 s
18.5 – 30 kW	90 s
37 – 90 kW	120 s

6.2.8.1 V/f control

The V/f control adapts the motor's power supply depending on the speed setpoint or required output frequency.

The relationship between the speed setpoint and stator voltage is calculated using characteristic curves. The required output frequency is calculated on the basis of the speed setpoint and the number of pole pairs of the motor (f = n * number of pole pairs / 60, in particular: fmax = p1082 * number of pole pairs / 60). The variable speed drive provides the two most important characteristics (linear and square-law). User-defined characteristic curves are also supported.

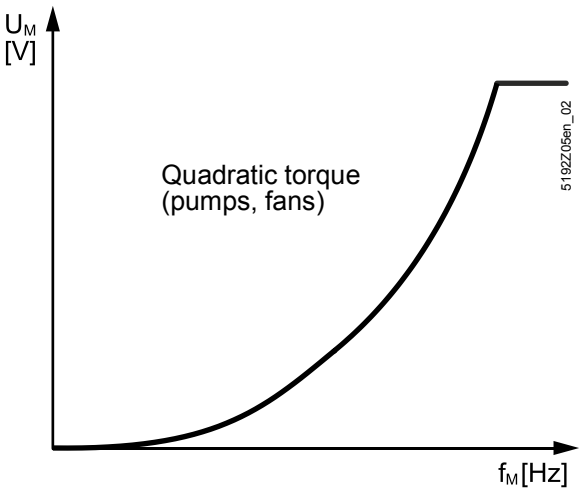
V/f control is not a high-precision method of controlling the speed of the motor. The speed setpoint and the speed of the motor shaft are always slightly different. The deviation depends on the motor load. If the connected motor is loaded with the rated torque, the motor speed is below the speed setpoint by the amount of the rated slip. If the load is driving the motor (i.e. the motor is operating as a generator), the motor speed is above the speed setpoint.

The characteristic is selected during commissioning, using p1300.

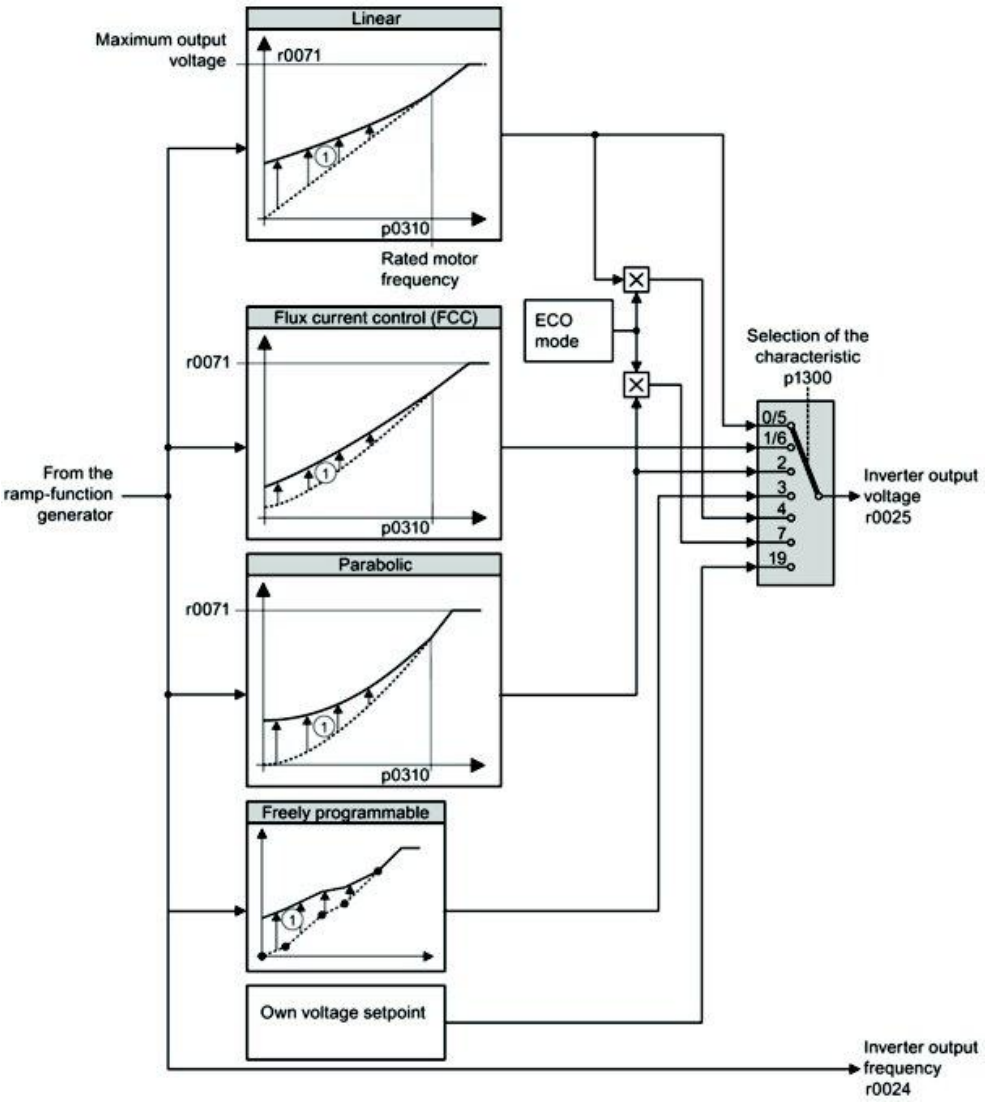
Characteristics of V/f control

Based on the characteristic, as the speed increases the variable speed drive increases its output voltage.

A square-law characteristic is preset at the factory (p1300 = 2). It is generally used for variable torque loads, such as fans and pumps.



The variable speed drive has several V/f characteristics.



The voltage boost (1) is dependent on speed and torque.

The variable speed drive also increases its output voltage above the motor rated speed up to the maximum output voltage. The higher the line voltage, the greater the maximum output voltage of the variable speed drive.
Once the variable speed drive has reached its maximum output voltage, it can only increase the output frequency. From this point onwards, the motor is operated in field weakening; this means that the available torque linearly decreases with increasing speed.

The voltage boost of the characteristic improves motor behavior at low speeds. The G120P is an energy-optimized variable speed drive with a second-generation V/f control. Here, the motor's current is lowered further to the extent permitted by the load while maintaining the speed.

If you would like to reduce the energy consumption further still, you can select the Eco mode or FCC (flux current control) during basic commissioning (p1300).

Selecting the V/f characteristic

Procedure

With operator panel

- Select the suitable characteristic curve and set parameter p1300.

With STARTER:

- Go online with STARTER.
- Select the V/f characteristic curve in one of the screen forms "speed controller" or "V/f control".

Linear and parabolic characteristics

Requirement	Application example	Note	Characteristic	Parameters
The required torque is independent of the speed	Eccentric screw pump, compressor, centrifuge, agitator, mixer	–	Linear	p1300 = 0
		The variable speed drive equalizes the voltage drops across the stator resistance. Recommended for motors with a low power rating. Precondition: You have set the motor data according to the rating plate and have performed the motor identification after the basic commissioning.	Linear with Flux Current Control (FCC)	p1300 = 1
The required torque increases with the speed	Centrifugal pumps, radial fans, axial fans	Lower losses in the motor and variable speed drive than for a linear characteristic.	Parabolic	p1300 = 2

Characteristics for special applications

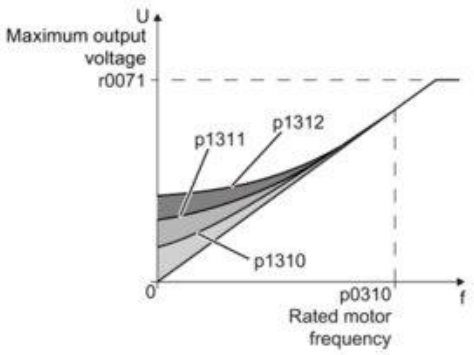
Requirement	Application example	Note	Characteristic	Parameters
Applications with a low dynamic response and constant speed	Centrifugal pumps, radial fans, axial fans	The ECO mode results in additional energy saving when compared to the parabolic characteristic. If the speed setpoint is reached and remains unchanged for 5 seconds, then the variable speed drive again reduces its output voltage.	ECO mode	p1300 = 4 or p1300 = 7

Additional information on V/f characteristics can be found in the parameter list and in the function diagrams 6300 ff of the List Manual.

Voltage boost of the V/f control (boost)

A temporary voltage boost may occur to optimize high break loose torque and short-term overload.

The voltage boost acts on every V/f characteristic. The adjacent diagram shows the voltage boost using a linear characteristic as example.



Parameters	Description
p1310	**Permanent voltage boost** (factory setting 50%) Compensates voltage drops as a result of long motor cables and the ohmic losses in the motor.
p1311	**Voltage boost when accelerating** (factory setting 0%) Provides additional torque when the motor accelerates.
p1312	**Voltage boost when starting** (factory setting 0%) Provides additional torque, however, only when the motor accelerates for the first time after it has been switched on ("break loose torque").

▷ Only increase the voltage boost in small steps. Excessively high values in p1310 to p1312 can cause the motor to overheat and switch off (trip) the variable speed drive due to overcurrent.

1. Switch on the motor with an average speed.
2. Reduce the speed to just a few revolutions per minute.
3. Check whether the motor rotates smoothly.
4. If the motor does not rotate smoothly, or even remains stationary, increase the voltage boost p1310 until you are satisfied with the motor behavior.
5. Accelerate the motor to the maximum speed with maximum load and check as to whether the motor follows the setpoint.
6. If, when accelerating, the motor stalls, increase the voltage boost p1311 until the motor accelerates to the maximum speed without any problems.

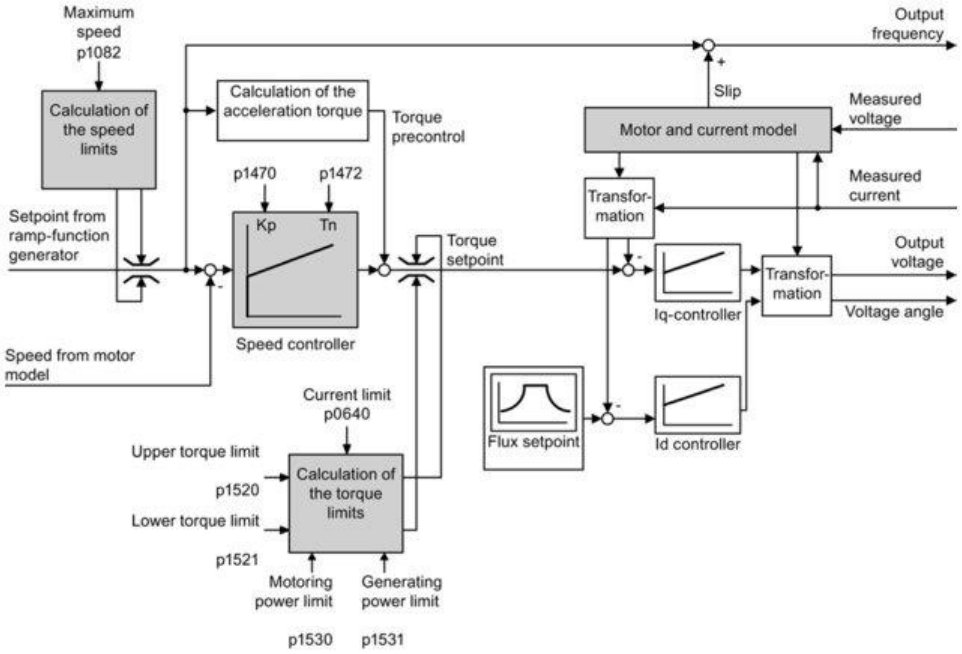
⇨ In most cases, your motor will now behave satisfactorily. You will only have to increase parameter p1312 for applications with a noticeable break loose torque.

You will find more information about this function in the parameter list and in function diagram 6300 of the List Manual.

6.2.8.2 Sensorless vector control (SLVC)

Using a motor model, the sensorless vector control calculates the load and the motor slip. As a result of this calculation, the variable speed drive controls its output voltage and frequency so that the motor speed follows the setpoint, independent of the motor load.

Sensorless vector control is possible without directly measuring the motor speed.



Select sensorless vector control

To achieve a good controller response, you must adapt the elements marked in gray in the figure in the overview diagram above. If you selected sensorless vector control as the control mode in the basic commissioning, you will already have set the following:

- The maximum speed for your application

- The motor and current model: If the motor data in the variable speed drive correspond to the motor data on the rating plate, then the motor and current model in the variable speed drive are correct and the sensorless vector control can operate satisfactorily
- The variable speed drive calculates the torque limits matching the current limit that you have set for the basic commissioning.
  Regardless of it, you can also set additional positive and negative torque limits or limit the power of the motor
- The variable speed drive preset the sensorless vector control during self-optimization (rotating measurement)

If you want to optimize the setting further, follow the additional instructions in this section.

Procedure

With operator panel:

- Set p1300 = 20.

With STARTER:

- Go online with STARTER.
- Select "Speed control without encoder" in the "Speed controller" or "V/f control" screen.

Re-optimizing the speed controller

In the following cases you will need to manually optimize the sensorless vector control:

- Your application does not permit self-optimization because the motor cannot rotate freely.
- You are dissatisfied with the result of the variable speed drive's self-optimization.
- The variable speed drive interrupted the self-optimization with a fault message.

6.2.9 Braking function

If an induction motor electrically brakes the connected load and the mechanical power exceeds the electrical losses, then it operates as a generator. The motor converts mechanical power into electrical power. This may happen in applications with large fans, for example.

The Power Module PM230 offers the option to convert the generated motor power into heat using DC braking.

Principle of operation

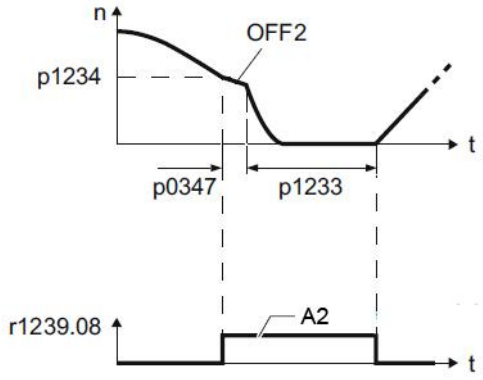
With DC braking, the variable speed drive outputs an internal OFF2 command for the time that it takes to demagnetize the motor – and then impresses the braking current for the duration of the DC braking.

Operating modes

The following operating modes are available for DC braking:

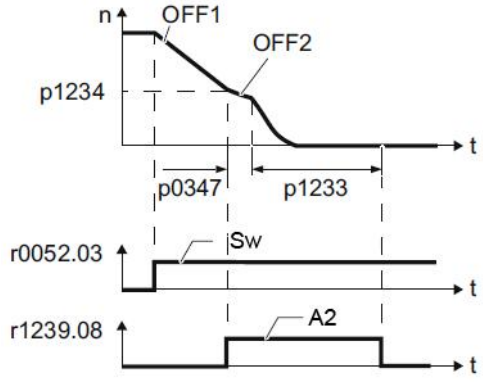
DC braking when the start speed is undershot

DC braking is automatically activated as soon as the motor undershoots the start speed for DC braking. However, the motor speed must have first exceeded the start speed for DC braking. Once the DC braking time is complete, the variable speed drive switches to normal operation. If p1230 is set to 0, DC braking can also be canceled before the time defined in p1233.

Precondition: p1230 = 1 and p1231 = 14

A2 = DC brake active

DC braking in the event of a fault

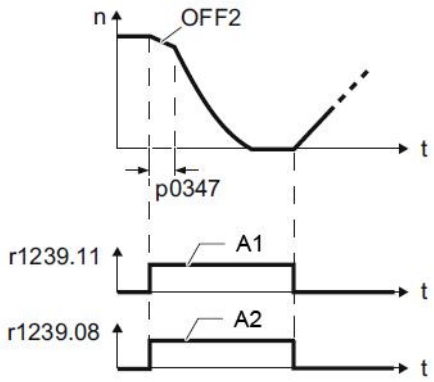
If a fault relating to the DC braking occurs (p2101=6), then the variable speed drive first brakes the motor along the down ramp until the start speed for DC braking is reached, and then starts DC braking.

Precondition: Fault number and fault response are assigned using p2100 and p2101=6

Sw = Fault present A2 = DC brake active

Activating DC braking via a control command regardless of the speed

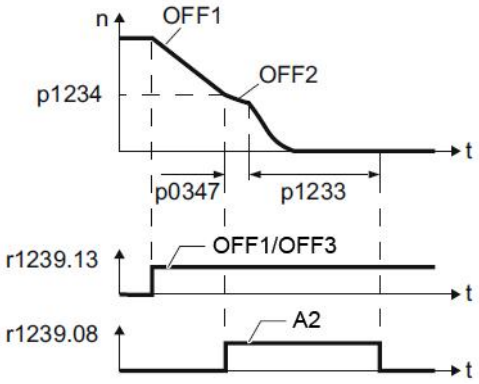
DC braking starts regardless of the motor speed s soon as the control command for braking (e.g. via DI3: p1230 = 722.3) is issued. If the braking command is revoked, the variable speed drive returns to normal operation and the motor accelerates to its setpoint.

The value of p1230 is displayed in r1239.11.

Precondition: p1231 = 4

A1 = DC brake enabled A2 = DC brake active

DC braking when the motor is switched off

If the motor is switched off with OFF1 or OFF3, the variable speed drive first brakes the motor along the down ramp until the start speed for DC braking is reached, and then starts DC braking. The motor is then switched into a torque-free condition (OFF2).

Precondition: p1231 = 5 or p1230 = 1 and p1231 = 14

A2 = DC brake active

Continuously turning motor

In the following operating modes, the motor continues to turn after DC braking is complete.

- DC braking when the start speed for DC braking is undershot
- Activating DC braking independent of the speed using a control command
- DC braking when the motor is switched off

The "flying restart" function must therefore be activated in these operating modes. See the Chapter Flying restart [→ 119].

The DC braking function can only be set for induction motors.

!	*NOTICE*
	Heat generation DC braking converts some of the kinetic energy of the motor and load into heat in the motor (temperature rise). The motor will overheat and can be damaged if the braking operation lasts too long or the motor is braked too often. • Avoid braking operations that are too frequent and too long by setting the parameters accordingly.

Settings

Parameters	Description
p1230	**Activating DC braking (BICO parameter)** The value for this parameter (0 or 1) can be either entered directly or specified by means of an interconnection with a control command.
p1231	**Configuring DC braking** p1231 = 0, no DC braking p1231 = 4, general enabling of DC braking p1231 = 5, DC braking for OFF1/3, independent of p1230 p1231 = 14, enables DC braking for the case that the motor speed undershoots the start speed for DC braking

Configuring DC braking when faults occur

Parameters	Description
p2100	**Setting fault number for fault response** (factory setting: 0) Enter the fault number for which DC braking should be activated, e.g.: p2100[3] = 7860 (external fault 1).
p2101 = 6	**Fault response setting** (factory setting: 0) Assigning the fault response: p2101[3] = 6.
The fault is assigned an index of p2100. The associated fault response must be assigned the same index in p2101. In the List Manual of the variable speed drive – in the "Faults and alarms" list – possible fault responses are listed for every fault. The entry "DCBRAKE" means that for this particular fault, DC braking can be set as fault response.	

Additional parameters for setting DC braking

Parameters	Description
p1232	**DC braking, braking current** (factory setting: 0 A) Setting the braking current for the DC braking.
p1233	**DC braking duration** (factory setting: 1 s)
p1234	**DC braking start speed** (factory setting: 210,000 rpm) DC braking starts – assuming that it has been correspondingly parameterized (p1230/p1231) – as soon as the actual speed falls below this threshold.
p0347	**Motor de-excitation time** The parameter is calculated via p0340 = 1, 3. The inverter can trip due to an overcurrent during DC braking if the de-excitation time is too short.

6.2.10 Flying restart

If a variable speed drive is switched on "normally", the motor does not move and the variable speed drive accelerates the motor from a standstill to the setpoint speed.

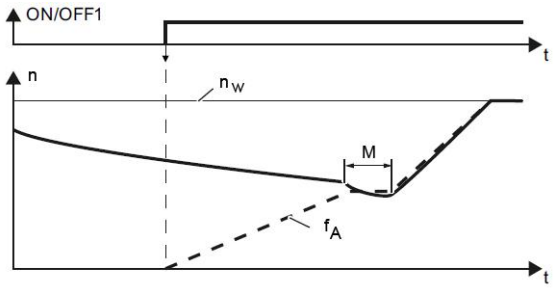
In many cases, however, the motor rotates at any speed and in any direction, even when it is not driven, for example, in the following situations:

- The motor rotates after a brief line interruption
- A flow of air turns the fan impeller
- A load with a high moment of inertia drives the motor
- A high dynamic pressure allows a pump to run backwards

The "flying restart" function (p1200) permits the variable speed drive to connect to an unintentionally rotating motor and then captures the motor at its current speed without it having to start at zero speed.

When starting with a rotating motor, variable speed drives without a flying restart function automatically switch off due to overcurrent or cause an excessive mechanical load on the system. This is because they try to bring the rotating motor to zero speed before they accelerate it to the required setpoint.

After the ON command, the "flying restart" function initially synchronizes the variable speed drive output frequency to the motor speed and then accelerates the motor up to the setpoint with normal ramp time.



n = speed
n_w = speed setpoint
f_A = variable speed drive output frequency
M = magnetizing motor

Method of operation

The variable speed drive first performs a "standstill check", which means that direct current (I DC) is applied for approx. 1 s. This establishes whether the motor is at a standstill or rotating at a speed of more than approx. 10% of the rated speed. If a standstill state is detected, the speed then ramps up as normal.

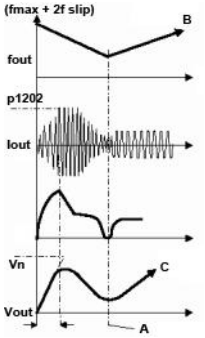
If the motor is rotating, the variable speed drive activates the "flying restart" function and applies a search current (p1202). The frequency initially increases to F_{max} + 2fslip and the "search" for the actual motor speed begins.

Fmax = calculated using the value of p1082.

2fslip = uses an internal calculation that shows the difference between a motor's synchronous speed (e.g. 1,500 rpm for a 4-pole motor) and its actual rated speed (defined in p0311, e.g. 1,480 rpm). In this example, the slip would be 1.3%.

The "search speed" is defined by the value defined in p1203. If the output frequency (f_{off}) drops, the G120P determines that it has found the actual motor speed when it detects a reduction in the motor magnet field, i.e. when the motor voltage increases (V_{off}). The G120P then returns to a standard V/f characteristic and controls the motor speed back to the setpoint.

If the motor speed is not found due to the motor rotating in the opposite direction, the search sequence is repeated in the other direction, although the p1200 must be set to the value of 1 for this. Setting 4 only searches in the direction of the variable speed drive's setpoint (forwards or backwards). If the motor is programmed so that it only searches in one direction and there is a possibility that the motor is rotating in both directions, the variable speed drive can respond to a sudden overcurrent. The G120P may display the A07409 alarm (current limit) or even switch off due to fault F07801 (overcurrent).



Settings

Parameters	Description
p1200	**Flying restart operating mode** (factory setting: 0)
	0 Flying restart is disabled 1 Flying restart is enabled, motor search performed in both directions, startup in direction of setpoint 4 Flying restart is enabled, search performed in direction of setpoint only
p1201	**Flying restart enable signal source** (factory setting: 1) Defines a control command, e.g. a digital input, through which the flying restart function is enabled.
p1201	**Flying restart search current** (factory setting: 90 %) Defines the search current with respect to the motor magnetizing current (r0331), which flows in the motor while the flying restart function is being used.
p1203	**Flying restart search speed factor** (factory setting: 150 %) The value influences the speed with which the output frequency is changed during the flying restart. A higher value leads to a longer search time. If the variable speed drive does not find the motor, reduce the search speed (increase p1203).

Setting up the "flying restart" function

▷ To activate the "flying restart" function, simply set the p1200 parameter to a value other than 0.
Determine the required setting for p1200 using the following questions:

1. Decide whether the flying restart is necessary. Is it possible for the motor to rotate before the G120P operation is activated? If yes, the "flying restart" function should be activated.
2. Is it possible for the motor to rotate in both directions? If yes, p1200 should be set to 1. Although this generally applies to fans, a pump with a high delivery head in a system without non-return valves could rotate in the opposite direction before starting the variable speed drive.
3. If the "automatic restart" function (p1210) has been activated, the "flying restart" function should also be activated. In the event of a power failure or disconnection when the automatic restart is active, it is possible for the G120P to start back up while the motor is still running down. If this should occur, activate p1200 with setting 1. The p1200=1 setting means that the G120P activates the "flying restart" function if the previous stop command was OFF1

(normal braking to a standstill) or a shutdown, fault state, OFF2 (run down to standstill), or OFF3.

4. The p1200=4 setting corresponds to the value 1, although the search is only performed in one direction.

After you have determined the required setting for p1200, you may have to adapt the parameters p1202 and p1203 to ensure that the G120P captures the rotating motor without the mechanical load on the drive mechanics being too high.

The standard setting for p1202 is 90%, p1203 is set to 150%. In certain applications, this can mean that loads are too high for the G120P. In certain applications, leaving the factory settings as they are can result in the G120P shutting down due to overcurrent. If a fault or warning is displayed during startup with an activated "flying restart" function, the p1202/p1203 parameters may have to be adapted.

▷ All applications are different and the inertia of every load varies. The following information is for orientation purposes only.
Before you begin, first set p1200 to the correct setting for your application.

1. Check the behavior of the "flying restart" function (i.e. ensure that it does not cause excessive loads) by activating the restart at approx. 60% of the full speed.
2. Without a speed counter, it can be difficult to establish the actual motor speed. A simple way to check is to accelerate the motor to full speed then activate a run down to standstill, measuring the time it takes for the motor to come to a stop. If the motor requires 30 s to come to a standstill, for example, it runs at approx. 60% of the speed after 12 s.
3. You can activate the run down to standstill as follows: This function can be programmed for one of the reserve digital inputs if it is not already available in your system. To do this, program the "Run down to standstill" function at one of the digital inputs (digital input 3 [terminal 8], for example, would be p0844 = r722.3) and establish a connection between terminal 9 and this digital input (terminal 8 in this example).
Before the restart can take place, the "Run down to standstill" switch must be closed to allow the RUN signal to be sent.

▷ A simple sequence could be as follows:

1. Accelerate the motor to maximum speed.
2. Activate a run down to standstill.
   - For this, open 9-8 in the example described.
   - Close the switch again between 9-8.
   - Activate the RUN signal after 12 s via (usually) terminals 5-9.
3. After the RUN signal has been applied, the output frequency increases rapidly and the current increases. Ensure that the current does not increase too much during this restart period. If the warning A07409 is displayed then p1202 is set to a value that is too high.
4. The simplest method is to set the BOP-2 (basic operator panel) to current monitoring. You can then see how the ampere value changes during the flying restart. If you reduce p1202 by 90% (we recommend steps of 10% to a minimum of 50%), the current drops with every check. If the current drops too

significantly, this can affect the "flying restart duration", which in turn affects the effectivity of the flying restart.

5. In larger motors (>30 kW) and motors with high efficiency, the motor slip decreases. For these motors, it is sometimes advisable to increase the search time (p1203) (in steps of 10% again).
6. By completing these two processes step-by-step and checking the effects after every change, you should be able to make optimal adjustments to the flying restart, i.e. a lower current demand yet with the motor speed reached quickly.

If the variable speed drive simultaneously drives several motors, then you must only use the "flying restart" function if all motors run at the same speed (group drive with a mechanical coupling).

Systems with a moment of inertia

For systems with large moments of inertia, the default settings for the "flying restart" function can lead to disconnections due to overcurrent. You can rectify this by changing flying restart parameters p1202 (search current) and p1203 (search speed).

6.2.11 Automatic restart

⚠ WARNING

Automatic restart

When the automatic restart function is active (p1210 > 1), the motor automatically starts after a power failure. Particularly after longer power failures, the restart may take place unexpectedly for a person on-site.

- Reduce the risk of accidents due to unexpected restarts in your machine or system by applying suitable measures, e.g. protective doors or covers.

The automatic restart includes two different functions:

- The variable speed drive automatically acknowledges faults.
- After a fault occurs or after a power failure, the variable speed drive automatically switches on the motor again.

This automatic restart function is primarily used in applications where the motor is controlled locally via the variable speed drive's inputs. In applications with a connection to a fieldbus, the central control should evaluate the feedback signals of the drives, specifically acknowledge faults or switch on the motor.

The variable speed drive interprets the following events as power failure:

- The variable speed drive signals fault F30003 (DC-link undervoltage), as the line supply voltage of the variable speed drive has briefly failed.
- The variable speed drive power supply has failed for such a long time that the variable speed drive has been switched off.

Setting the automatic restart

- If it is possible that the motor is still rotating for a longer period of time after a power failure or after a fault, then you must also activate the "flying restart" function.
- Using p1210, select the automatic restart mode that best suits your application. We recommend setting 26 for HVAC systems.

⚠ WARNING

Automatic restart in the event of no communication with the fieldbus

When connecting the variable speed drive to a fieldbus and setting p1210 = 6, the motor restarts – even if the communication to the fieldbus is interrupted. The motor cannot be stopped via the interrupted fieldbus.

- Prevent unwanted restarts in the event of missing bus communication by entering the fault code for the communication error into parameter p1206. Example: A communication failure via USS, Modbus, or BACnet MS/TP is signaled using fault code F01910. You should therefore set p1206[n] = 1910 (n = 0 to 9).

Parameters	Description	
p1210	**Automatic restart mode** (factory setting: 0)	
	0	Disables automatic restart
	1	Acknowledges all faults without restarting
	4	Automatic restart after line supply failure, without additional startup attempts
	6	Restart after fault, with additional startup attempts
	14	Restart after line supply failure, after manual acknowledgement
	16	Restart after fault, after manual acknowledgement
	26	Acknowledges all faults and restarts for an ON command (recommended setting for HVAC systems)
p1211	**Automatic restart start attempts** (factory setting: 3) This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26. Define the maximum number of start attempts using p1211. After each successful fault acknowledgement, the variable speed drive decrements its internal counter of start attempts by 1. For p1211 = n, up to n + 1 start attempts are made. Fault F07320 is output after n + 1 unsuccessful start attempts. The variable speed drive sets the start attempt counter back again to the value of p1211 if one of the following conditions is fulfilled: ● After a successful start attempt, the time in p1213[1] has expired. ● After fault F07320, withdraw the ON command and acknowledge the fault. ● You change the start value p1211 or the mode p1210.	
p1212	**Automatic restart wait time start attempt** (factory setting: 1 s) This parameter is only effective for the settings p1210 = 4, 6, 26. Examples for setting this parameter: ● After a power failure, a certain time must elapse before the motor can be switched on, e.g. because other machine components are not immediately ready. In this case, set p1212 longer than the time after which all of the fault causes have been removed. ● In operation, the variable speed drive develops a fault condition. The lower you select p1212, then the sooner the variable speed drive attempts to switch on the motor again.	
p1213[0]	**Automatic restart monitoring time for restart** (factory setting: 60 s) This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26. With this monitoring function, you limit the time in which the variable speed drive may attempt to automatically switch on the motor again. The monitoring function starts when a fault is identified and ends with a successful start attempt. If the motor has not successfully started after the monitoring time has expired, fault F07320 is signaled. Set the monitoring time longer than the sum of the following times: + p1212 + Time that the variable speed drive requires to start the motor on the fly.	

Parameters	Description
	+ Motor magnetizing time (p0346) + 1 s You deactivate the monitoring function with p1213 = 0.
p1213[1]	**Automatic restart monitoring time to reset the fault counter** (factory setting: 0 s) This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26. Using this monitoring time, you prevent faults, which continually occur within a certain time period, from being automatically acknowledged each time. The monitoring function starts with a successful start attempt and ends after the monitoring time has expired. If the variable speed drive has made more than (p1211 + 1) successful start attempts within monitoring time p1213[1], it cancels the automatic restart function and signals fault F07320. In order to switch on the motor again, you must acknowledge the fault and issue a new ON command.

Advanced settings

If you wish to suppress the automatic restart function for certain faults, then you must enter the appropriate fault numbers in p1206[0 to 9].

Example: p1206[0] = 07331 ⇒ No restart for fault F07331.

Suppressing the automatic restart only functions for the setting p1210 = 6, 16 or 26.

6.2.12 Data backup and standard commissioning

External data backup

After commissioning and copying the data into the variable speed drive's ROM (EEprom), your settings are saved in the variable speed drive and protected against power failure.

!	*NOTICE*
	Defects in the variable speed drive In the case of a defect in the variable speed drive, your settings may be lost. • In addition, you should also save the parameters on a storage medium outside the variable speed drive.

The following storage media are available for your settings:

- Memory card
- PC/PG (via STARTER software)
- Operator panel

Series commissioning

▷ Series commissioning is the commissioning of several identical drives. After commissioning of the first drive, you must do the following:

1. Back up the settings of the first variable speed drive to an external storage medium.
2. Transfer the settings of the first variable speed drive to another one via the storage medium.

The Control Unit to which the parameters are transferred must have the same order number and the same or a higher firmware version as the source Control Unit.

6.2.12.1 Backing up and transferring settings using a memory card

Recommended memory cards

We recommend that you use one of the memory cards with the following order number:

- MMC (order number 6SL3254-0AM00-0AA0)

Alternatively, you can also use MMC or standard SD cards up to 2 GB. SDHC, SDXC, or other special types of SD cards are not supported.

Other memory cards

If you use SD or MMC memory cards from other manufacturers, then you must format the memory card as follows:

▷ MMC: Format FAT 16

1. Insert the card into your PC's card reader.
2. Command to format the card:
   format x: /fs:fat (x: Drive code of the memory card on your PC)

▷ SD: Format FAT 32

1. Insert the card into your PC's card reader.
2. Command to format the card:
   format x: /fs:fat32 (x: Drive code of the memory card on your PC)

Memory cards from third-party manufacturers do not support all functions, e.g. for downloading. The use of memory cards from other manufacturers is at your own risk.

6.2.12.1.1 Saving setting on a memory card

We recommend that you insert the memory card before switching on the variable speed drive.

Ensure that your variable speed drive is not connected to the computer via USB, otherwise the memory card will be recognized by Windows as a USB mass storage drive and locked for use by the variable speed drive.

The variable speed drive always also backs up its settings on an inserted card.

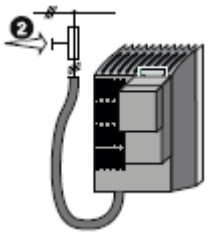
If you wish to backup the variable speed drive settings on a memory card, you have two options:

Automatic backup

▷ The variable speed drive power supply is switched off.

1. Insert an empty memory card into the variable speed drive.
2. Then switch on the variable speed drive power supply.

⇨ After it has been switched on, the variable speed drive copies its settings to the memory card.

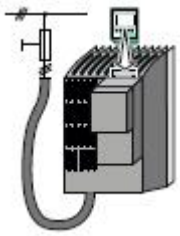


!	*NOTICE*
	If the memory card is not empty, then the variable speed drive accepts the data from the memory card. The previous setting in the variable speed drive will be deleted and will not be able to be restored. ● Only use empty memory cards for automatic data backup.

Overwriting data on a memory card

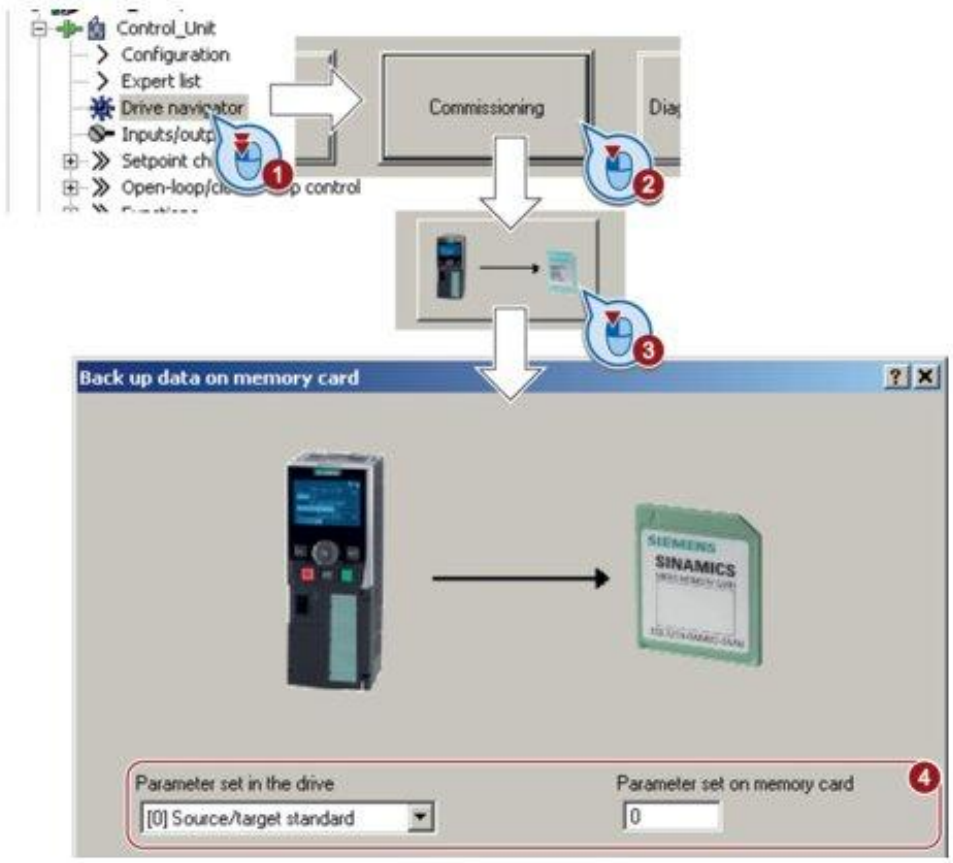
▷ The variable speed drive power supply is switched on.

● Insert a memory card into the variable speed drive.



Procedure using STARTER

▷ STARTER must be online.



1. In your drive, select "Drive Navigator".
2. Select the "Commissioning" button.
3. Select the button to transfer the settings to the memory card.
4. Select the settings as shown in the diagram and start the data backup.

Procedure with the BOP-2

- Start data transfer in the menu "OPTIONS" – "TO CRD".

Procedure with IOP

1. Choose the **Menu** option using the rotary knob and confirm with **OK**.
2. Select the **Up/Download** setting and confirm with **OK**.
3. Select **From drive to memory card** and confirm with **OK**.
   ⇨ "Select parameter set on memory card" appears on the display.
4. Select the required number for the parameter set and confirm with **OK**.
   ⇨ "The parameter up/download will take some time and cannot be cancelled" appears on the display.
5. Select **Continue** and confirm with **OK** (the option to cancel is also available).

⇨ "Upload/Download in progress. Please wait..." appears on the display.

⇨ Once this has successfully completed, "Upload completed successfully" appears.

6.2.12.1.2 Transferring the setting from the memory card

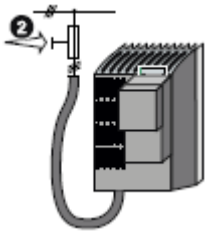
Accepting data automatically

▷ The variable speed drive power supply is switched off.

1. Insert the memory card into the variable speed drive.
2. Then switch on the variable speed drive power supply.

⇨ If there is valid parameter data on the memory card, then the variable speed drive accepts the data from the memory card.

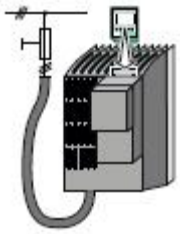
- 

- 

Accepting data manually

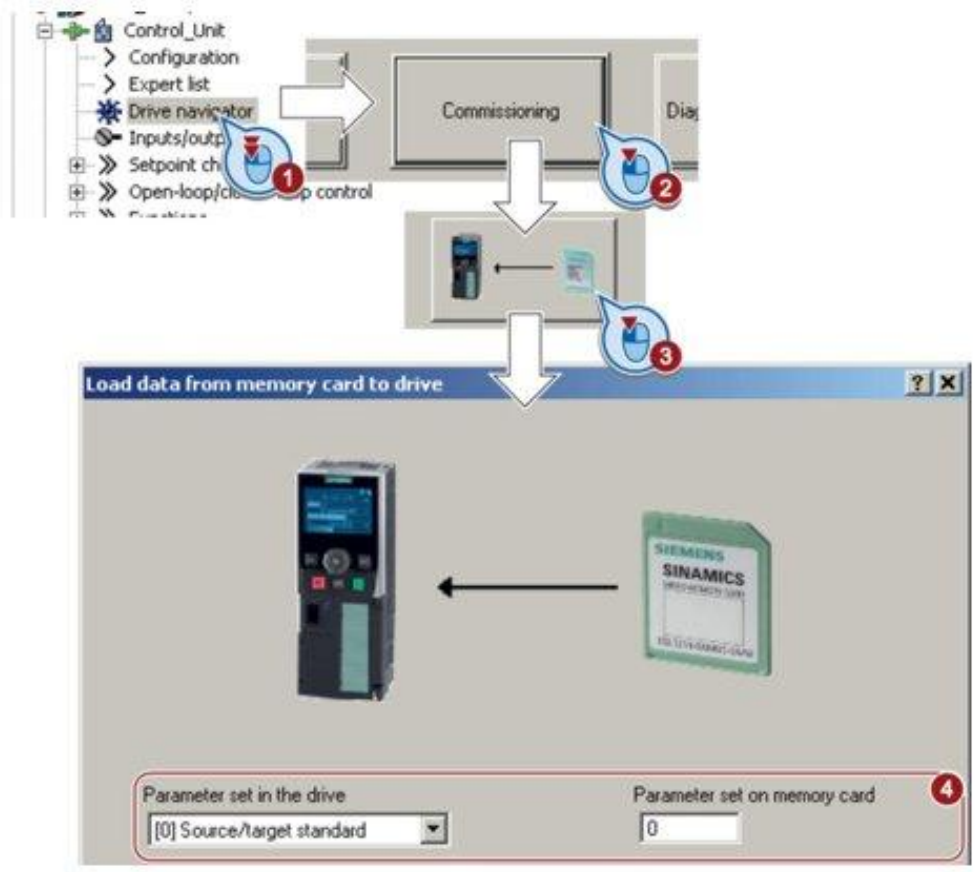
▷ The variable speed drive power supply is switched on.

- Insert a memory card into the variable speed drive.



Procedure using STARTER

▷ STARTER must be online.



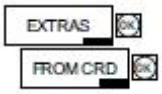
1. In your drive, select "Drive Navigator".
2. Select the "Commissioning" button.
3. Select the button to transfer the data from the memory card to the variable speed drive.
4. Select the settings as shown in the diagram and start the data backup.
5. Close the screen forms.
6. Go offline with STARTER.
7. Switch off the variable speed drive's supply voltage.
8. Wait until all LEDs on the variable speed drive go dark.
9. Now switch on the variable speed drive power supply again.

⇨ Your settings only become effective after this power-on reset.

Procedure with the BOP-2

1. Start data transfer in the menu "OPTIONS" – "TO CRD".
2. Switch off the variable speed drive's supply voltage.
3. Wait until all LEDs on the variable speed drive go dark.
4. Now switch on the variable speed drive power supply again.

⇨ Your settings only become effective after this power-on reset.



Procedure with IOP

1. Choose the **Menu** option using the rotary knob and confirm with **OK**.
2. Select the **Up/Download** setting and confirm with **OK**.
3. Select **From memory card to drive** and confirm with **OK**.
   ⇨ "Select parameter set on memory card" appears on the display.
4. Select the number for the required parameter set and confirm with **OK**.
   ⇨ "The parameter up/download will take some time and cannot be cancelled" appears on the display.
5. Select **Continue** and confirm with **OK** (the option to cancel is also available).
   ⇨ "Upload/Download in progress. Please wait..." appears on the display.

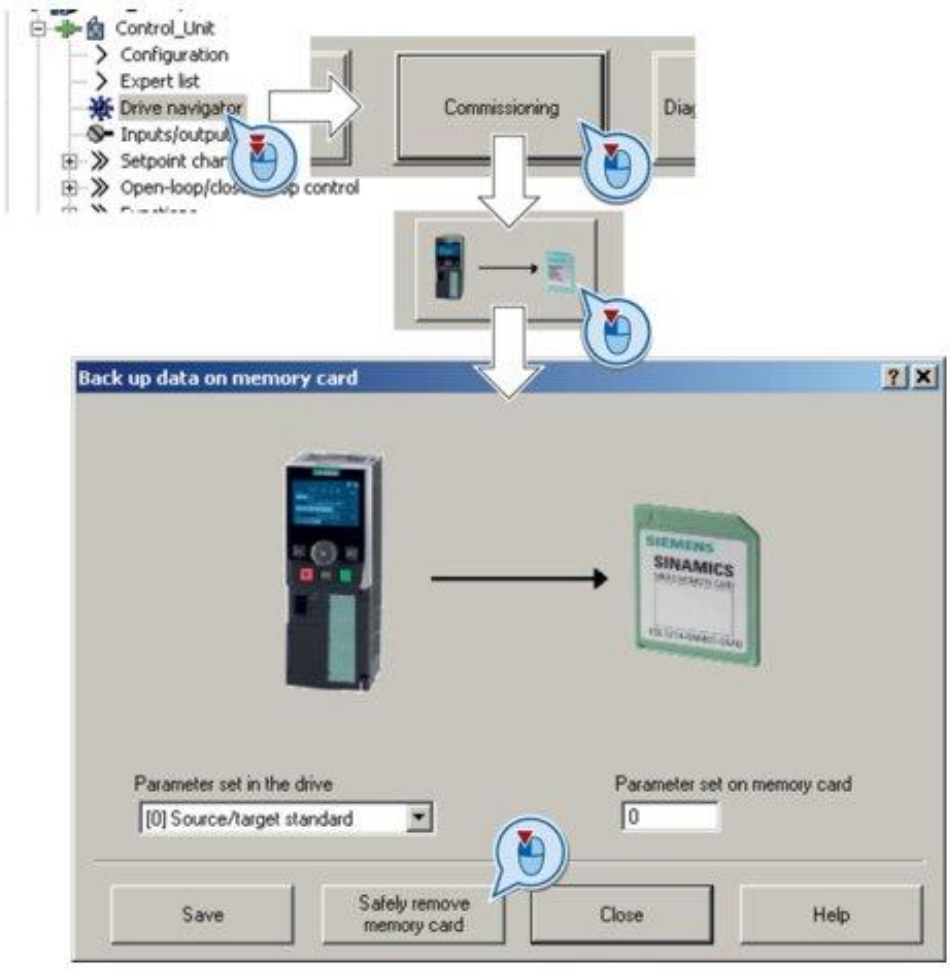
⇨ Once this has successfully completed, "Download completed successfully. Remove the memory card and reboot the drive" appears.

6.2.12.1.3 Safely removing the memory card

!	*NOTICE*
	Removing the memory card incorrectly The file system on the memory card can be destroyed if the memory card is removed while the variable speed drive is switched on without first requesting and confirming this using the "remove safely" function. The memory card will then no longer function. • Always select "remove safely" before removing the memory card.

Procedure using STARTER

1. In the Drive Navigator, select the following screen form:



2. Click on the button to safely remove the memory card.
3. You may remove the memory card from the variable speed drive after the appropriate message has been output.

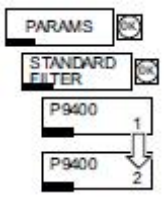
Procedure with the BOP-2

1. Go to parameter p9400. If a memory card is correctly inserted, then p9400=1.
2. Set 9400 = 2. BOP-2 shows "BUSY" for a few seconds and then jumps either to p9400 = 3 or p9400 = 100.

⇨ You may remove the memory card when p9400 = 3.

You must not remove the memory card when p9400 = 100.

- In this case try again by setting p9400 = 2.



Procedure with IOP

1. Choose the **Menu** option using the rotary knob and confirm with **OK**.
2. Select the **Parameters** setting and confirm with **OK**.
3. Select the **Search by number** setting and confirm with **OK**.
4. Set number 9400 and confirm with **OK**.
   ⇨ "1 mem_card inserted" appears on the display under p9400.

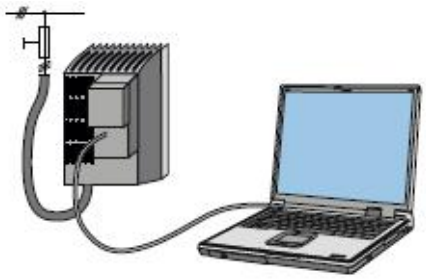
⇨ Select p9400 confirm with **OK**.

- Select option **2: Mem_card rem req** and confirm with **OK**.
  ⇨ Either "3: Rem poss" or "100: Rem n poss acc" appears on the display under p9400.

⇨ In the case of "3: Rem poss", you may remove the card. In the case of "100: Rem n poss acc", you must not remove the card. In this case try again by setting p9400 = 2.

6.2.12.2 Backing up and transferring settings using STARTER

With the supply voltage switched on, you can transfer the variable speed drive settings to a PG/PC, or the data from a PG/PC to the variable speed drive.
This requires you to have installed the STARTER commissioning tool on your PG/PC.



Variable speed drive → PC/PG

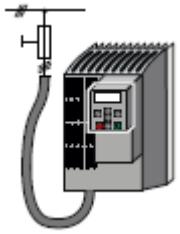
1. Go online with STARTER: 
2. Select the button "Download project to PG": 
3. To save the data in the PG, select the button: 
4. Go offline with STARTER: 

PC/PG → variable speed drive

1. Go online with STARTER: 
2. Select the button "Download project to target system": 
3. To save the data in the variable speed drive, select the "Copy RAM to ROM" button: 
4. Go offline with STARTER: 

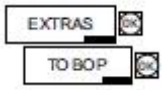
6.2.12.3 Backing up and transferring settings using an operator panel

When the power supply is switched on, you can transfer the settings of the variable speed drive to the BOP-2 or vice versa.



Procedure for variable speed drive → BOP-2

- Start data transfer in the menu "OPTIONS" – "TO BOP".



Procedure for BOP-2 → variable speed drive

1. Start data transfer in the menu "OPTIONS" – "FROM BOP".
   ⇨ In FW version 4.6, this completes the transfer. In FW versions < 4.6, you must also complete the following steps:
2. Switch off the variable speed drive's supply voltage.
3. Wait until all LEDs on the variable speed drive go dark.
4. Now switch on the variable speed drive power supply again.

⇨ Your settings only become effective after this power-on reset.

Procedure for variable speed drive → IOP

1. Choose the **Menu** option using the rotary knob and confirm with **OK**.
2. Select the **Up/Download** setting and confirm with **OK**.
3. Select **Upload from drive** and confirm with **OK**.
   ⇨ The list of panel parameter sets 0-15 appears on the display.
4. Select the number of the panel parameter set to which you want to save the data and confirm with **OK**.
   ⇨ "Running" appears on the display and a bar shows the progress. You can cancel this using "ESC".

⇨ Once this has successfully completed, "Upload complete" appears.

Procedure for IOP → variable speed drive

1. Choose the **Menu** option using the rotary knob and confirm with **OK**.
2. Select the **Up/Download** setting and confirm with **OK**.
3. Select **Download to drive** and confirm with **OK**.
   ⇨ A list of the available panel parameter sets appears on the display.
4. Select the number of the panel parameter set that you want to save to the variable speed drive and confirm with **OK**.

⇨ "The parameter up/download will take some time and cannot be cancelled" appears on the display.

5. Select **Continue** and confirm with **OK** (the option to cancel is also available).

⇨ "Running" appears on the display and a bar shows the progress. The process cannot be stopped.

⇨ Once this has successfully completed, "Download completed successfully. Reboot the drive" appears

1. Switch off the variable speed drive's supply voltage.
2. Wait until all LEDs on the variable speed drive go dark. Now switch on the variable speed drive power supply again.

⇨ Your settings only become effective after this power-on reset.

6.2.12.4 Other ways to back up settings

In addition to the default setting, the variable speed drive has an internal memory for backing up three other settings.

On the memory card, you can back up 99 other settings in addition to the default setting.

You will find further information on the Internet under storage options at: http://support.automation.siemens.com/WW/view/en/43512514.

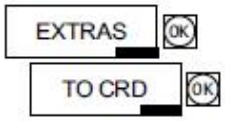
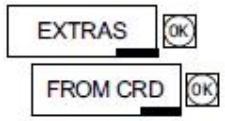
Backing up settings in the variable speed drive

Parameters	Description
p0970	**Reset drive parameters** Load the back-up setting (number 10, 11 or 12). You overwrite your actual parameter setting when loading.
p0971	**Save parameters** Back up the setting (10, 11 or 12).

Backing up additional settings on the memory card

Parameters	Description
p0802	**Data transfer with memory card as source/target** (factory setting: 0) Default setting: p802 = 0 Further settings: p802 = 1 to 99
p0803	**Data transfer with device memory as source/target** (factory setting: 0) Default setting: p803 = 0 Further settings: p803 = 10, 11, or 12

Operation on the BOP-2

Menu	Description
	The variable speed drive writes its setting 0, 10, 11, or 12 to the memory card in accordance with p0802. The file on the memory card is assigned the number according to p0802.
	The variable speed drive loads the setting with the number according to p0802 from the memory card and thus overwrites its setting 0, 10, 11, or 12.

6.2.13 Write and know-how protection

The variable speed drive offers the option to protect configured settings from being changed or copied.

Write protection and know-how protection are available for this purpose.

Write protection – overview

Write protection prevents variable speed drive settings from being inadvertently changed. No password is required for write protection. There is no encryption.

The following functions are excluded from the write protection:

- Activating/deactivating write protection (p7761)
- Changing the access level (p0003)
- Saving parameters (p0971)
- Safely removing the memory card (p9400)
- Access to service parameters (p3950) – only for service personnel, a password is required
- Restoring the factory setting
- Upload
- Acknowledging alarms and faults
- Switching over to the control panel
- Trace
- Function generator
- Measuring functions
- Reading out diagnostic buffer

The individual parameters that are excluded from the write protection, can be found in the List Manual in Chapter "Parameters for write protection and protection of know-how".

Setting the write protection

▷ To allow you to set write protection, your variable speed drive must be connected online with STARTER.

1. Select the variable speed drive in your STARTER project with the left mouse button.
2. Open the shortcut menu by right-clicking.
3. Activate write protection.

Deactivation is executed in analog.

To make this setting permanent, you need to copy the settings from RAM to ROM. Otherwise, your settings will be lost when the variable speed drive is switched off.

Know-how protection – overview

The know-how protection is used, for example, so that a machine manufacturer can encrypt his configuration know-how and protect it against changes or copying.

The know-how protection is available in the following versions:

- **Know-how protection without copy protection** (possible with or without memory card)
- **Know-how protection with copy protection** (possible only with Siemens memory card)

A password is required for the know-how protection.

In case of active know-how protection, the STARTER dialog screens are locked. You can, however, read the values of the display parameters from the expert list. The values of the adjustment parameters are not displayed and cannot be changed.

Actions that are also possible during active know-how protection

- Restoring factory settings
- Acknowledging messages
- Displaying messages
- Displaying the alarm history
- Reading out diagnostic buffer
- Switching to the control panel (complete control panel functionality: Fetching master control, all buttons and setting parameters)
- Upload (only parameters that are accessible even though know-how protection is active)

Actions that are not possible during active know-how protection

- Download
- Export/import
- Trace
- Function generator
- Measuring functions
- Automatic controller setting
- Stationary/rotating measurement
- Deleting the alarm history

The parameters that are excluded from the know-how protection can be found in the List Manual in Chapter "Parameters for write protection and protection of know-how".

Creating an exception list for the know-how protection

Using the exception list, you as a machine manufacturer may make individual adjustable parameters accessible to end customers although know-how protection is active. You may define the exception list via parameters p7763 and p7764 in the expert list. Specify the number of parameters for the selection list in p7763. Assign the individual indexes to the parameter numbers of the selection list in p7764.

Factory setting for the exception list:

- p7763 = 1 (selection list contains precisely one parameter)
- p7764[0] = 7766 (parameter number for entering the password)

!	*NOTICE*
	Removing p7766 from the exception list If you remove p7766 from the exception list, you can no longer enter a password and therefore no longer de-activate know-how protection. You have to restore the factory settings for the variable speed drive in order to regain access to the parameters. • Take special care when creating the exception list.

Activating know-how protection

1. Select the variable speed drive in the STARTER project, and then select "Know-how protection drive unit/activate ..." in the shortcut menu.

   ⇨ The screen form below then opens:

2. Enter your password in this screen form and confirm with OK. The password must consist of at least one character and can be no longer than 30 characters. All characters are permissible.

In this screen form "Copy RAM to ROM" has been selected in the factory. This will ensure that your settings are permanently stored.

If "Copy RAM to ROM" is not selected, then your know-how protection settings are only saved in the volatile memory, and will no longer be available the next time the system is switched on.

Backing up parameter settings on the memory card

▷ When the know-how protection is activated, you may save the parameter settings via p0971 on the memory card.

- To do this, set p0971 = 1. The data is encrypted before being written to the memory card. After saving, p0971 is reset to 0.

Deactivate know-how protection, delete password

1. Select the variable speed drive in the STARTER project, and right-click to open the dialog box "Know-how protection drive unit/deactivate …".
2. There, select the desired option.

3. Enter the password and exit the screen form with OK.

Deactivating know-how protection temporarily

Temporarily deactivating the know-how protection means that you can change the settings in the variable speed drive until you switch the variable speed drive off and on again, or until you reactivate the know-how protection.

Permanently deactivating know-how protection (deleting password)

Permanently deactivating the know-how protection means that you delete the password:

- Immediately and finally, if you select "Copy RAM to ROM"
- Until the next OFF/ON if you do not select "Copy RAM to ROM"

Changing the password

Select the variable speed drive in the STARTER project and open the dialog box via the shortcut menu "Know-how protection drive unit/change password …".

6.2.14 Factory settings

6.2.14.1 Using the factory settings

▷ You only have to do the following if the factory settings of the variable speed drive match your motor and your application.

- Connect the variable speed drive in accordance with the wiring example.

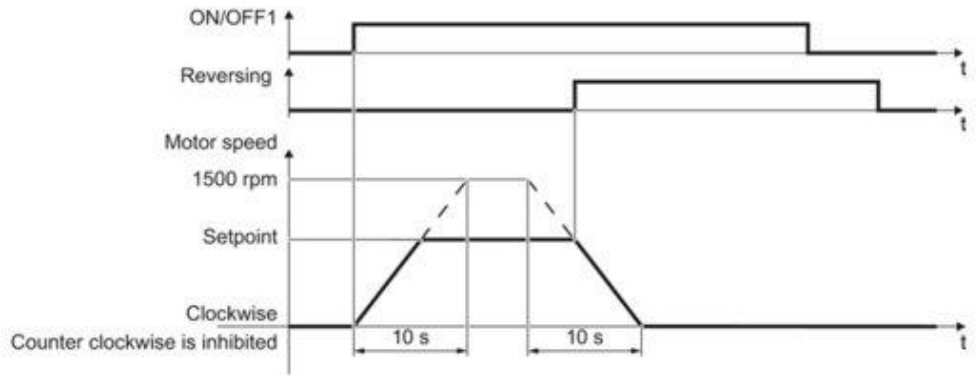
▷ If you operate the drive on a fieldbus, you have to do the following:

1. Configure your central controller according to the settings of the variable speed drive.
2. If required by the fieldbus, set the bus address on the variable speed drive.

6.2.14.2 Factory setting of the variable speed drive control

Switching the motor on and off

The variable speed drives are set in the factory so that after it has been switched on, the motor accelerates in 10 s (based on 1,500 rpm) up to its speed setpoint. After it has been switched off, the motor brakes with a ramp-down time of 30 seconds. See also AC motors [➙ 20] and Motor selection [➙ 44].



Open-loop/closed-loop control operating mode

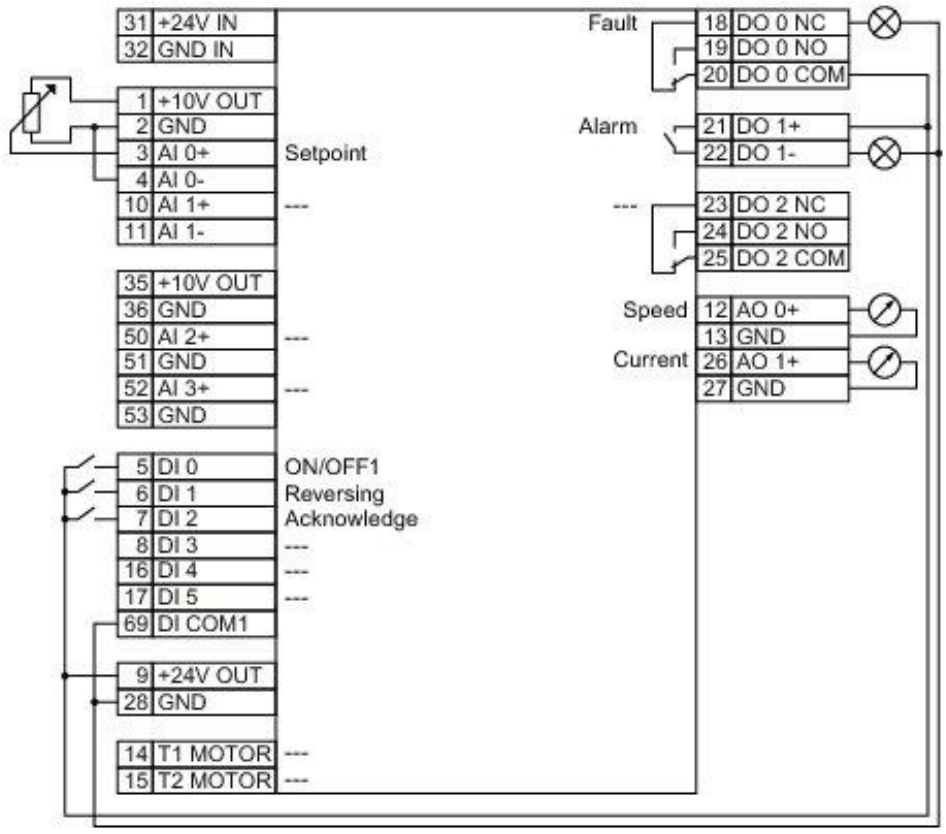
You can set the required open-loop/closed-loop operating mode in control bar p1300. The **V/f control with parabolic characteristic** is set as standard (setting 2). See V/f control [➞ 111].

6.2.14.3 Pre-assignment of the control terminals

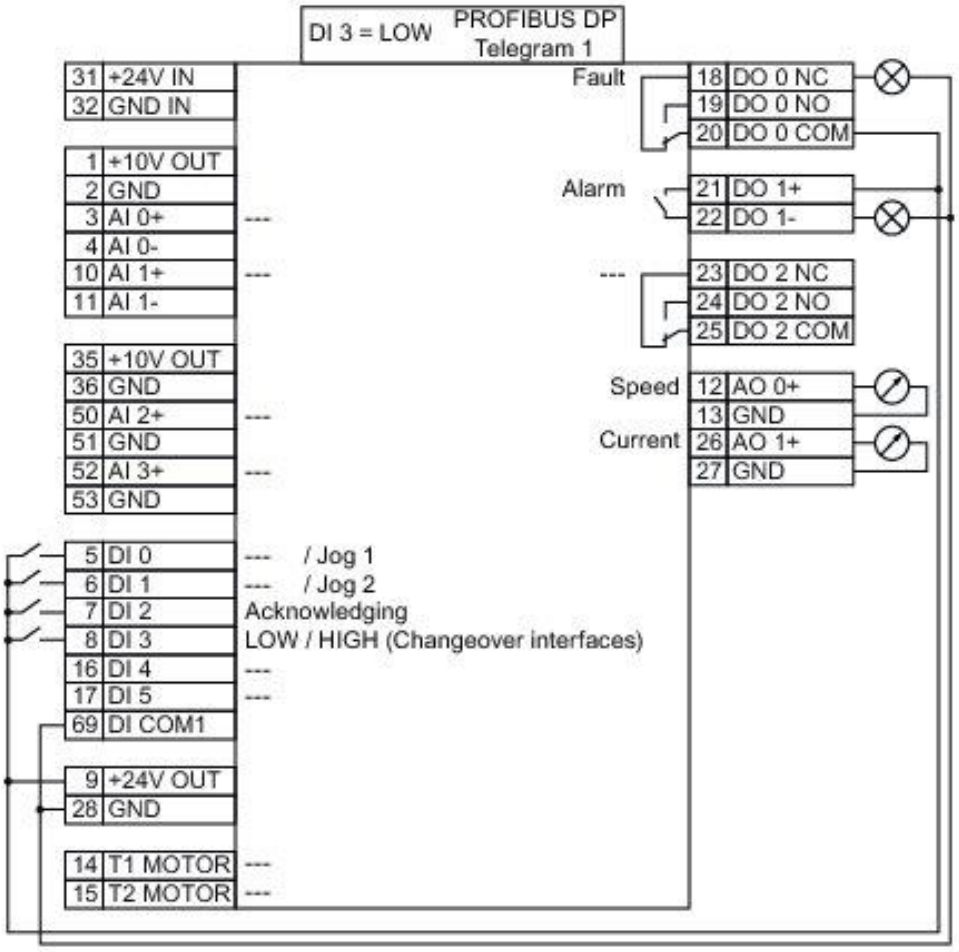
Many applications already function using the factory settings.

The following wiring can be used for Control Units which receive their commands and setpoints via control terminals (CU230P-2 BT and CU230P-2 CAN) to use the factory setting.

CU230P-2 BT and CU230P-2 CAN (CANopen)



CU230P-2 DP (Profibus)



6.2.14.4 Resetting to factory settings

The following faults can arise during commissioning:

- The line voltage was interrupted during commissioning and you were not able to complete commissioning.
- You made a mistake when setting the parameters and you can no longer understand the individual settings that you made.
- You do not know whether the variable speed drive was already operational.

In cases such as these, reset the variable speed drive to the factory settings.

This function resets the settings in the variable speed drive to the factory settings.

The communication settings and the settings of the motor standard (IEC/NEMA) are retained even after restoring the factory setting.

STARTER	BOP-2
• Go online with STARTER • Click on the button in STARTER	• In the "Options" menu, select the "DRVRESET" entry • Confirm the reset using the OK key

6.3 HVAC functions of the G120P

The following table provides an overview of the HVAC functions described in this section. The short description allows you to decide whether or not you require the corresponding function as part of the project.

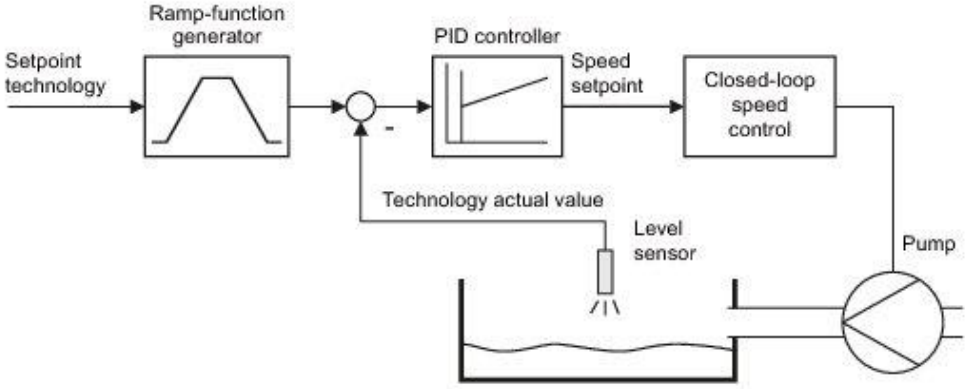
Segment	Short description	Required in the project	
		Yes	No
PID controller [→ 141]	PID controller functions and settings for controlling the speed using HVAC-specific process variables		
Real time clock (RTC) [→ 143]	The real time clock sets time stamps for events in the controller, such as fault messages, alarms, or a reminder for the motor/fan service		
Time switch (DTC) [→ 144]	The time switch is for time-related open loop/closed loop control of the speed for day/night or weekday/weekend, for example		
Connection for temperature sensors [→ 145]	Permissible temperature sensors, connection to the analog inputs and their settings		
Cascading pumps or fans [→ 146]	Several graded pumps/fans that can be switched on and off to cover wide mass/volume flows or pressure ranges		
Connecting several motors [→ 149]	Conditions for connecting several motors operated in parallel		
Multi-zone control [→ 150]	Minimum, maximum, or mean value control of several setpoint or actual values from various zones		
Energy-saving mode (hibernation mode) [→ 153]	Switches the motor off by means of several criteria to save energy as soon as a definable lower limit is reached		
Bypass (bypassing the variable speed drive) [→ 156]	Variable speed drive behavior in definable framework conditions, for example at maximum motor power or if the variable speed drive should fail		
Torque monitoring [→ 181]	Constant torque monitoring to detect deviations, for example due to a lack of flow, a torn V-belt, or faulty ball bearings		
Essential Service Mode (fire/emergency operation) [→ 183]	Operating mode to maintain emergency functions for as long as possible, for example stairwell ventilation in the event of a fire		

6.3.1 PID controller

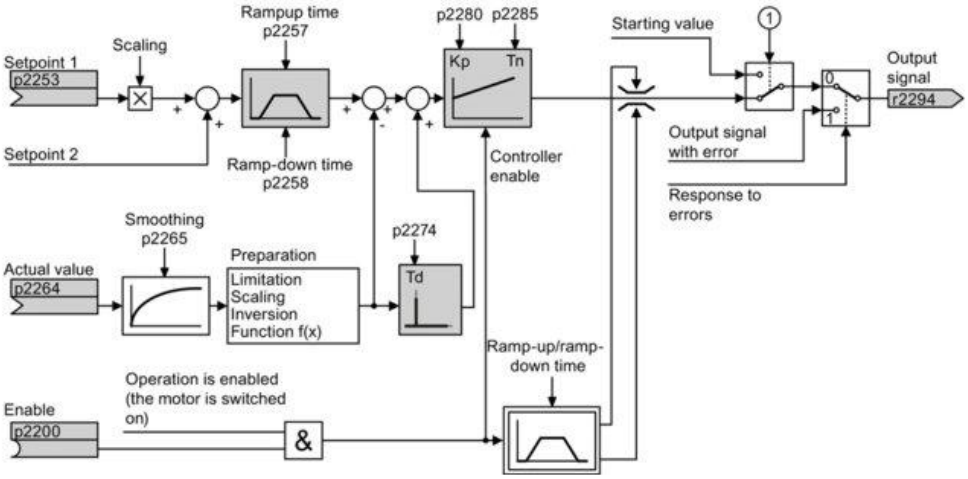
The G120P has an integrated PID technology controller for controlling the speed using HVAC-specific process variables such as pressure, temperature, level, or flow.

This enables you to establish independent application control without additional controllers.

Example: Technology controller as a level controller



Thanks to its diverse range of setting options, the controller is very flexible in terms of adapting it to the required application.



Parameters

If the PID controller is activated, the set ramp times are bypassed in p1120 and p1121.

Therefore, define the following settings for smoothing times, ramp times, and controller.

Parameters	Note
p2200 = 1	Setting of the signal source for switching the technology controller on/off.
p2253 = r2224	Define the setpoint for the technology controller. The variable speed drive interconnects the fixed setpoint p2201 with the setpoint of the technology controller. r755.0 analog setpoint (AI0) r2224 technology controller fixed setpoint r2050.1 fieldbus setpoint
p2257 = 30 s *	Define technology controller setpoint ramp-up time
p2258 = 30 s *	Define technology controller setpoint ramp-down time
p2264 = r755.1	Define actual value for technology controller For 755[1], analog input 1 is the source for the actual value
p2265 = 10 s *	Technology controller actual value filter time constant
p2267 = 120%	Technology controller upper limit actual value
p2268 = -20%	Technology controller lower limit actual value
p2280 = 1	Technology controller proportional gain
p2285 = 30 s *	Technology controller integral time

Parameters	Note
p2293 = 30 s *	Technology controller ramp-up/ramp-down time
p2306 = 0	Technology controller fault-signal inversion (heating or cooling)

* The time settings, such as "Technology controller integral time", are dependent on the frame size used. For information on the recommended ramp times, see Control modes [➞ 109].

The recommended PID controller settings can be parameterized via a macro:

- P0010 = 1
- P0015 = 120 "PID settings for pumps or fans (only for optimization)"
- P0010 = 0

You can find additional information in function diagram 7958 of the List Manual.

Additional technology controllers

You can assign parameters to additional technology controllers using the following parameter ranges:

- p11000 to p11099: Free technology controller 0
- p11100 to p11199: Free technology controller 1
- p11200 to p11299: Free technology controller 2

These can be used in an HVAC standalone solution with the G120P, for example to control additional components.

Refer to the parameter descriptions and function diagram 7970 of the List Manual for additional details.

Example

Refer also to the application example "Pump pressure control" in Section .

6.3.2 Real time clock (RTC)

The real time clock is the basis for time-dependent process controls, e.g.:

- Operating hours counter with reminders for the motor/fan service
- Time stamp for fault messages and alarms

Format and commissioning

The real time clock starts as soon as the Control Unit power supply is switched on for the first time. The real time clock comprises the time in a 24 hour format and the date in the "day, month, year" format.

After a Control Unit power supply interruption, the real time clock continues to run for approx. five days.

If you wish to use the real time clock, you must set the time and date once when commissioning. If you restore the variable speed drive's factory setting, the real time clock parameters are not reset.

Parameters	Real time clock (RTC)
p8400[0]	RTC time, **hour** (0 to 23)
p8400[1]	RTC time, **minute** (0 to 59)
p8400[2]	RTC time, **second** (0 to 59)
p8401[0]	RTC date, **day** (1 to 31)
p8401[1]	RTC date, **month** (1 to 12)
p8401[2]	RTC date, **year** (1 to 9999)
r8404	RTC **Weekday** 1: Monday 2: Tuesday 3: Wednesday 4: Thursday 5: Friday

Parameters	Real time clock (RTC)
	6: Saturday 7: Sunday
p8405	Activate/deactivate RTC **alarm** A01098 Sets whether the real time clock issues an alarm if the time is not running in synchronism (e.g. after a longer power supply interruption). 0: Alarm A01098 deactivated 1: Alarm A01098 activated

Accepting the real time clock in the alarm and fault buffer

Using the real time clock, you can track the sequence of alarms and faults over time. In the event of a message appearing, it is stored along with the date and time and displayed in the corresponding IOP and STARTER dialog boxes.

No times are displayed in the BOP-2.

6.3.3 Time switch (DTC)

The "time switch" (DTC) function, along with the real time clock in the variable speed drive, offers the option of controlling when signals are switched on and off.

Examples:

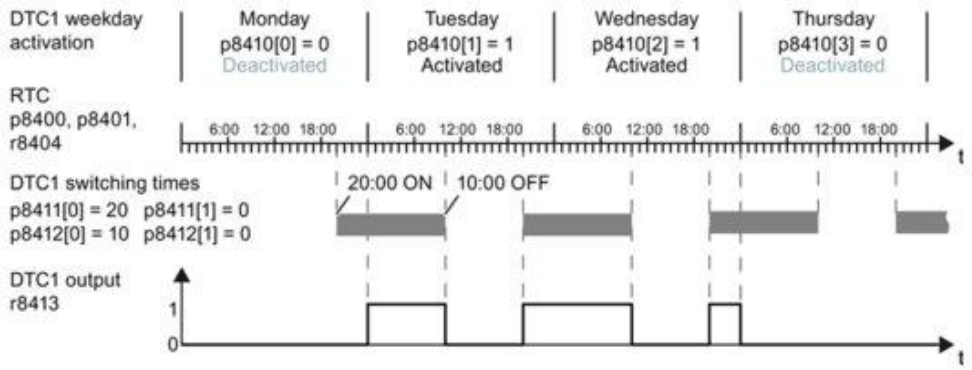
- Day/night switching of a temperature control
- Switching a process control from weekday to weekend

Principle of operation of the time switch (DTC)

The variable speed drive has three independent parameterizable time switches.

Using BICO technology, the time switch output can be interconnected with every binector of your variable speed drive, e.g. a digital output or a technology controller's enable signal.

Example using DTC1



Assigning parameters for the time switch

- Enable parameter assignment of the DTC: p8409 = 0.
  As long as DTC parameter assignment is enabled, the variable speed drive keeps the output of all three DTCs (r84x3, x = 1, 2, 3) at LOW.
- Assign parameters for the activation of the weekdays, and the switching on and off times.
- Enable the setting: p8409 = 1.
  The variable speed drive enables the DTC output once more.

Additional information is provided in the parameter list of the List Manual.

6.3.4 Connection for temperature sensors

Analog input AI 2

Analog input AI 2 can be used as a current input or resistance input for a temperature sensor. Both the DIP switch and parameter p0756.2 must be set accordingly for this purpose.

- p0756.2 = 2: Unipolar current input (0 mA to +20 mA)
- p0756.2 = 3: Monitored unipolar current input (+4 mA to +20 mA)
- p0756.2 = 6: LG-Ni1000 temperature sensor
- p0756.2 = 7: Pt1000 temperature sensor
- p0756.2 = 8: No sensor connected

Analog input AI 3

Analog input AI 3 is designed as a resistance input for a temperature sensor.

Setting options:

- p0756.3 = 6: LG-Ni1000 temperature sensor
- p0756.3 = 7: Pt1000 temperature sensor
- p0756.3 = 8: No sensor connected

Permissible temperature sensors

The temperature-dependent Pt1000 or LG-Ni1000 resistors can be used as sensors. The values of these sensors are supplied via analog input AI 2 or AI 3 (p2264 = 756.2 or 756.3) as actual values for the technology controller.

The connection is established at AI 2 (terminals 50, 51) or AI 3 (terminals 52, 53).

Measuring ranges and alarm thresholds for LG-Ni1000

The measuring range of the LG-Ni1000 sensor extends from -88 ℃ to 165 °C. For values outside this range, the variable speed drive outputs alarm A03520 "Temperature sensor fault".

The fault type is displayed in r2124.

Measuring ranges and alarm thresholds for Pt1000

The measuring range of the Pt1000 sensor extends from -88 ℃ to 240 °C. For values outside this range, the variable speed drive outputs alarm A03520 "Temperature sensor fault".

The fault type is displayed in r2124.

Fault values for temperature sensing via AI 2

- r2124 = 33: Wire break or sensor not connected
- r2124 = 34: Short-circuit

Fault values for temperature sensing via AI 3

- r2124 = 49: Wire break or sensor not connected
- r2124 = 50: Short-circuit

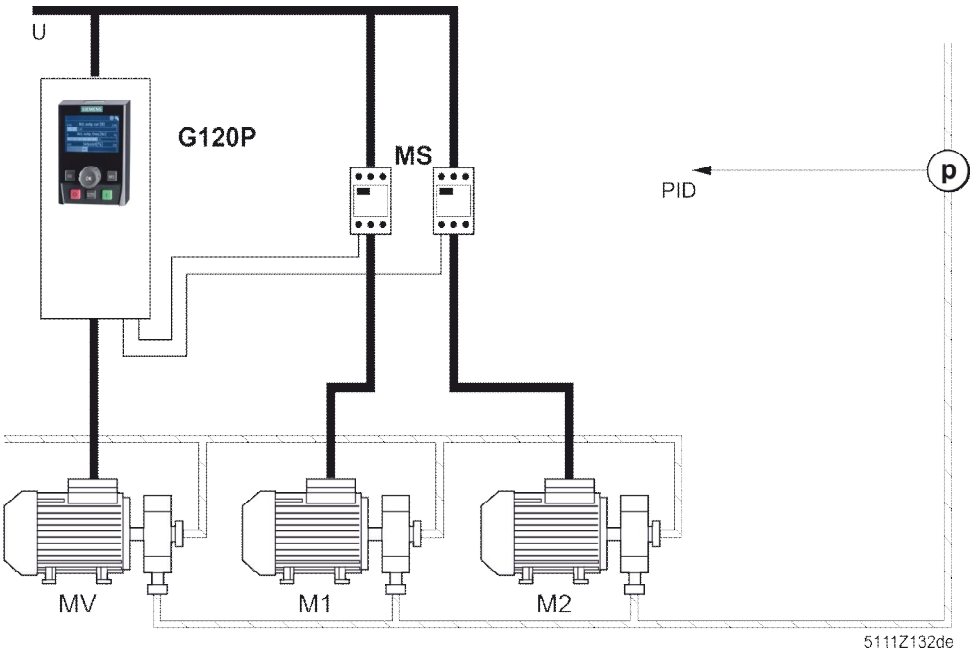
If a temperature sensor is used as an input for the PID controller, the scaling of the analog input must be adjusted.

– Scaling example for LG-Ni1000:
0 °C (p0757) = 0% (p0758); 100 °C (p0759) = 100% (p0760)

– Scaling example for Pt1000:
0 °C (p0757) = 0% (p0758); 100 °C (p0759) = 80% (p0760)

6.3.5 Cascading pumps or fans

The cascade control function is used in applications that require between one and four motors to be run at the same time depending on load, so that e.g. highly variable pressure ratios or flow volumes can be corrected.



U = power supply
p = pressure sensor
MS = motor starter
PID = signal to PID technology controller

Cascade control consists of the speed-controlled main drive and up to three other drives that are switched-on or switched-off via contactors or motor starters, either in a fixed arrangement or dependent on the operating hours.

The PID deviation serves as the input signal for activating the other motors. The contactors or motor starters are switched by the variable speed drive's digital outputs.

For cascade control, the main setpoint must be entered via the technology controller (p2251 = 0, p2200 = 1).

Activating external motors

If the main drive is run at maximum speed and the deviation on the technology controller input continues to increase, the control also switches an external motor to the line. At the same time, the main drive is ramped down to the switch-on/switch-off speed (p2378) to keep the total output power as constant as possible. The technology controller is deactivated while ramping down to the switch-on/switch-off speed.

The required total output power can then continue to increase until the main drive achieves the maximum speed again. If the deviation on the technology controller input then continues to increase, the control also switches the next external motor to the line. The main drive is then ramped down to the switch-on/switch-off speed (p2378).

The process for activating a third motor is exactly the same.

A maximum of three external motors can be activated.

Deactivating external motors

If the main drive is running at minimum speed and the deviation on the technology controller input continues to decrease, the control switches an external motor between M1 and M3 off the line. The main drive is simultaneously ramped-up to the switch-on/switch-off speed to keep the total output power as constant as possible.

The required total output power can then continue to decrease until the main drive achieves the minimum speed again. If the deviation on the technology controller input then continues to decrease, the control switches the next external motor to the line. The main drive is then ramped up to the switch-on/switch-off speed (p2378).

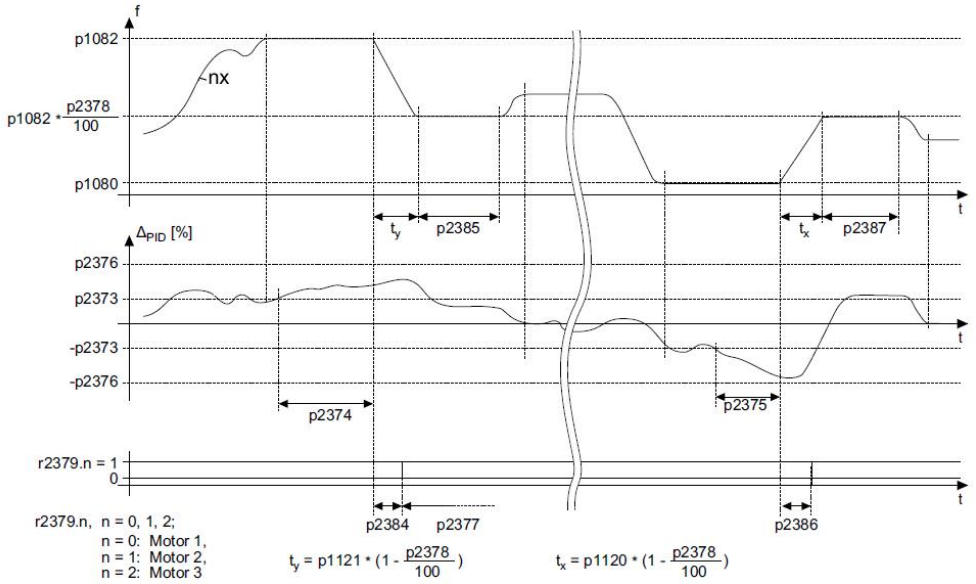
The process for deactivating a third motor is exactly the same.

Avoiding frequent activation and deactivation

To avoid frequent activation/deactivation of the uncontrolled motors, a time can be specified in p2377 which must have elapsed before a further motor can be activated/deactivated. After the time set in p2377 has elapsed, a further motor will be activated immediately if the PID deviation is greater than the value set in p2376. If, after p2377 has elapsed, the PID deviation is smaller than p2376 but greater than 2373, the timer p2374 is started before the uncontrolled motor is activated.

The motors are deactivated in the same way.

The following diagram shows the conditions for activating/deactivating an uncontrolled motor



n_x = actual speed value
Δ_{PID} = PID deviation

Controlling the activation/deactivation of motors

Use p2371 to determine the activation/deactivation sequence for the individual external motors.

Activation sequence

p2371	Meaning	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
0	Cascade control deactivated	---					
1	One motor can be activated	M1					
2	Two motors can be activated	M1	M1+M2				
3	Two motors can be activated	M1	M2	M1+M2			

p2371	Meaning	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
4	Three motors can be activated	M1	M1+M2	M1+M2+ M3			
5	Three motors can be activated	M1	M3	M1+M3	M1+M2+ M3		
6	Three motors can be activated	M1	M2	M1+M2	M2+M3	M1+M2+ M3	
7	Three motors can be activated	M1	M1+M2	M3	M1+M3	M1+M2+ M3	
8	Three motors can be activated	M1	M2	M3	M1+M3	M2+M3	M1+M2+ M3

Deactivation sequence

p2371	Activated motors	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
1	M1	M1					
2	M1+M2	M1+M2	M1				
3	M1+M2	M1+M2	M2	M1			
4	M1+M2+M3	M1+M2+ M3	M1+M2	M1			
5	M1+M2+M3	M1+M2+ M3	M3+M1	M3	M1		
6	M1+M2+M3	M1+M2+ M3	M3+M2	M2+M1	M2	M1	
7	M1+M2+M3	M1+M2+ M3	M3+M1	M3	M2+M1	M1	
8	M1+M2+M3	M1+M2+ M3	M3+M2	M3+M1	M3	M2	M1

If you are using motors of the same power rating, you can use p2372 to define whether the motors are to be activated/deactivated following the setting specified in p2371 (p2372 = 0) or based on the operating hours (p2372 = 1, 2 ,3. For details, see parameter list).

Setting and activating the cascade control

p0730 = r2379.0	**Signal source for digital output 0** Control external motor 1 via DO 0
p0731 = r2379.1	**Signal source for digital output 1** Control external motor 2 via DO 1
p0732 = r2379.2	**Signal source for digital output 2** Control external motor 3 via DO 2
p2200 = 1	**Technology controller enable** Activate technology controller
p2251 = 0	**Technology controller mode** Technology controller as main speed setpoint
p2370	**Cascade control – enable** Signal source for staging on/off
p2371	**Cascade control – configuration** Activate staging and define activation sequence
p2372	**Cascade control – motor selection mode** Define automatic motor activation
p2373	**Cascade control – activation threshold** Define activation threshold
p2374	**Cascade control – activation delay** Define delay time

p2375	**Cascade control deactivation delay** Define delay time for destaging
p2376	**Cascade control – overcontrol threshold** Define overcontrol threshold
p2377	**Cascade control – interlock time** Define interlock time
p2378	**Cascade control – switch-on/switch-off speed** Defining the speed for the main drive after activating/deactivating a motor
r2379	**Cascade control – status word**
p2380	**Cascade control – operating hours**
p2381	**Cascade control – maximum time for continuous operation**
p2382	**Cascade control – absolute operating time limit**
p2383	**Cascade control – deactivation sequence** Define deactivation sequence for an OFF command
p2384	**Cascade control – motor ON delay** Define motor ON delay
p2385	**Cascade control – activation speed hold time** Define speed hold time after activating an external motor
p2386	**Cascade control – motor OFF delay** Define motor OFF delay
p2387	**Cascade control – deactivation speed hold time** Define speed hold time after deactivating an external motor

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

6.3.6 Connecting several motors

Several motors can be connected in parallel at the G120P's output. All connected motors start and stop at the same time.

Provided all connected motors have the same number of poles, they all turn at the same speed.

The maximum required output current according to the following formula plays a decisive role in dimensioning the variable speed drive correctly.

$$I_{VSD} \geq (I_{Motor\ 1} + I_{Motor\ 2} + ... + I_{Motor\ n}) \cdot 1.1$$

The factor 1.1 is for safety purposes in the event that one or more motors are overloaded.

When connecting several motors, the rated currents – not the rated powers – of the individual motors must be added together to dimension the variable speed drive correctly.

Please note the following points when connecting several motors:

- The sum of the lengths of all motor connection cables must not exceed the permitted cable length.
  The permitted cable lengths for unfiltered devices can be found under Cable lengths [→ 86] and those for devices with filters under Filter Overview [→ 89].
- To protect the motors, use individual motor protection relays, PTC resistors, or circuit breakers, as the p0610 protection function "Motor-overtemperature response" does not function during multi-motor operation.
- Motor data identification must not take place during commissioning.
- Where possible, avoid using contactors or service switches between variable speed drives and the individual motors. Details can be found in Section Output contactors and motor protection relays [→ 96].

!	*NOTICE*
	Several motors on one variable speed drive In the case of several motors on one variable speed drive, sensorless vector control must not be used. Torque monitoring is not available either. The variable speed drive can only apply the motor model to an individual motor. • Use the V/f control mode in this case.

You will find additional information in the Section Control modes [→ 109].

!	*NOTICE*
	Flying restart with several motors The "flying restart" function only functions if all motors are running at the same speed. • Use a mechanical motor group coupling or avoid using the flying restart function.

You will find additional information in the Section Flying restart [→ 119].

6.3.7 Multi-zone control

Multi-zone control is used to control quantities such as pressure or temperature via the technology setpoint deviation. The setpoints and actual values are fed in via the analog inputs as current (0 to 20 mA) or voltage (0 to 10 V) or as a percentage via temperature-dependent resistances (LG-Ni1000/Pt1000, 0 °C = 0%; 100 °C = 100%).

Control variants for multi-zone control

There are three control variants for multi-zone control, which are selected via p31021:

- One setpoint and 1, 2, or 3 actual values
  The actual value for the control can be calculated as a mean value, a maximum value, or a minimum value. You can find all of the setting options in the parameter list in parameter p31022.
  - Mean value: The deviation from the setpoint of the mean value of two or three actual values is controlled.
  - Minimum value: The deviation from the setpoint of the smallest actual value is controlled.
  - Maximum value: The deviation from the setpoint of the highest actual value is controlled.
- Two pairs of setpoints/actual values as a maximum value control (cooling)
  The maximum value control compares two pairs of setpoints/actual values and controls the actual value that has the largest deviation upwards from its associated setpoint. No control takes place when both actual values are below their setpoints.
  In order to avoid frequent changeover, the variable speed drive only switches over if the deviation of the controlled setpoint/actual value pair is more than two percent lower than the deviation of the uncontrolled value pair.
- Two pairs of setpoints/actual values as a minimum value control (heating)
  The minimum value control compares two pairs of setpoints/actual values and controls the actual value that has the largest deviation downwards from its associated setpoint. No control takes place when both actual values are above

their setpoints.
In order to avoid frequent changeover, the variable speed drive only switches over if the deviation of the controlled setpoint/actual value pair is more than two percent lower than the deviation of the uncontrolled value pair.

Day and night switching

Using a day/night changeover, other setpoints can be entered for specific times. The day/night changeover control can be realized e.g. using an external signal via DI4 or using free blocks and the real time clock via p31025.

When the multi-zone control is activated, the analog inputs are newly interconnected as sources for the setpoint and actual value of the technology controller (see table).

Parameters

Parameters	Description	
p2200 = …	**Technology controller enable**	
p2251	**Set technology controller as main setpoint**	
p31020 = …	**Multi-zone control interconnection** (factory setting = 0) A subsequent parameterization is performed by activating or deactivating the multi-zone control.	
	Subsequent connection for p31020 = 1 (activate multi-zone control)	Subsequent connection for p31020 = 0 (deactivate multi-zone control)
	p31023[0] = 0755.0 (AI0) p31023[2] = 0755.1 (AI1) p31026[0] = 0755.2 (AI2) p31026[1] = 0755.3 (AI3) p2253 = 31024 (setpoint output, technology controller) p2264 = 31027 (actual value output, technology controller)	p31023[0] = 0 p31023[2] = 0 p31026[0] = 0 p31026[1] = 0 p2253 = 0 p2264 = 0
p31021 = …	**Multi-zone control configuration** 0 = setpoint 1 or several actual values (factory setting) 1 = two zones or maximum value setting 2 = two zones or lowest value setting	
p31022 = …	**Processing of actual values for multi-zone control** (only for p31021 = 0) Possible values: 0 to 11 (factory setting = 0)	
p31023[0 … 3] = …	**Setpoints for multi-zone control** Parameters for selecting the source for setpoints in multi-zone control (factory setting = 0)	
r31024 = …	**Multi-zone control setpoint output for technology controller** CO parameters	
p31025 = …	**Day/night changeover for multi-zone control** Parameter for selecting the source for day/night changeover of the multi-zone control (factory setting = 0)	
p31026[0 to 2] = …	**Actual values for multi-zone control** Parameters for selecting the source for actual values of the multi-zone control (factory setting = 0)	
r31027 = …	**Multi-zone control actual value output for technology controller** CO parameters	

Please note that when multi-zone control is activated, any BICO interconnections present for analog inputs and for the technology controller's setpoint and actual value are cancelled and interconnected with the links defined in the factory.

When you deactivate multi-zone control, the associated BICO interconnections are cancelled.

Example

The temperature in a large office is measured at three points and transferred to the variable speed drive using analog inputs. LG-Ni1000 temperature sensors are used as actual value sensors. The setpoint temperature is specified via the analog input 0 and can be set in the range from 8 °C to 30 °C by a controller. Overnight, the average temperature should be 16 °C.

Parameter settings

Parameters	Description
p2200.0 = 1	Technology controller enable
p2251 = 0	Set technology controller as main setpoint
p2900.0 = 16	Temperature setpoint overnight as a fixed percentage value
p31020 = 1	Activate multi-zone control
p31021 = 0	Select multi-zone control with one setpoint and three actual values
p31022 = 7	Three actual values, one setpoint. The average value of the three actual values is used for the control.
p31023.0 = 755.0	Temperature setpoint via analog input 0
p0756.0 = 0	Select analog input type (voltage input 0 to 10 V)
p0757.0 = 0 / p0758.0 = 8	Set the lower value to 8 °C (0 V ≙ 8 °C)
p0759.0 = 10 / p0760.0 = 30	Set the upper value to 30 °C (10 V ≙ 30 °C)
p31023.1 = 2900.0	Supply p31023.1 with the value written in p2900 to reduce the temperature overnight
p31026.0 = 755.2	Temperature actual value 1 via analog input 2 as a percentage value
p0756.2 = 6	Select analog input type (temperature sensor LG-Ni1000)
p0757.2 = 0 / p0758.2 = 0	Set lower value of the scaling characteristic
p0759.2 = 100 / p0760.2 = 100	Set upper value of the scaling characteristic
p31026.1 = 755.3	Temperature actual value 2 via analog input 3 as a percentage value
p0756.3 = 6	Select analog input type (temperature sensor LG-Ni1000)
p0757.3 = 0 / p0758.3 = 0	Set lower value of the scaling characteristic
p0759.3 = 100 / p0760.3 = 100	Set upper value of the scaling characteristic
p31026.2 = 755.1	Temperature actual value 3 via temperature sensor with current output (0 mA to 20 mA) via analog input 1
p0756.1 = 2	Select analog input type (current input 0 to 20 mA)
p0757.1 = 0 / p0758.1 = 0	Set lower value of the scaling characteristic (0 mA ≙ 0 °C)
p0759.1 = 20 / p0760.1 = 100	Set upper value of the scaling characteristic (20 mA ≙ 100%)
p31025 = 722.4	Changeover from day to night via digital input 4

You will find more information about this multi-zone control in the parameter list and in function diagram 7972 of the List Manual.

6.3.8 Energy-saving mode (hibernation mode)

The energy-saving mode is mainly used for pumps and fans. Typical applications include pressure and temperature controls.

In the energy-saving mode, the variable speed drive stops and starts the motor depending on the system conditions. The energy-saving mode can be activated via the technology controller (without external commands via terminals or bus interface) and via an external setpoint input.

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

In the energy-saving mode, if the setpoint is to be entered from the motorized potentiometer or from the motorized potentiometer of the technology controller, you must set p1030.4 or p2230.4 = 1.

After the variable speed drive has been powered up, the motor goes into the energy-saving mode if the energy-saving mode start speed has still not been reached after the highest value from p1120 (ramp-up time), p2391 (energy-saving mode delay time) and 20 s have expired.

Operating principle

The energy-saving mode starts as soon as the motor speed drops below the energy-saving mode start speed. However, the motor is only switched off after an adjustable time has expired. If, during this time, the speed setpoint increases above the energy-saving mode start speed due to pressure or temperature changes, the energy-saving mode is exited and the variable speed drive goes into normal operation.

In the energy-saving mode, the motor is shut down; however, the speed setpoint and/or the technology controller deviation are/is monitored.

- **For an external setpoint input (without technology controller) the speed setpoint is monitored** and the motor is switched-on again as soon as the setpoint increases above the restart speed. The restart speed is calculated as follows: Restart speed = p1080 + p2390 + p2393.
  The positive speed setpoint is monitored in the factory settings, meaning that the motor is switched on as soon as the setpoint exceeds the restart speed.
  If the negative speed setpoint is also to be monitored, the setpoint amount must be monitored. This can be set with p1110 = 0.
  Additional setting options are described in the parameter list, in function diagrams 3030 and 3040, as well as in the associated parameter descriptions.
- **For a setpoint input via the technology controller, the technology controller deviation (r2273) is monitored** and the motor is switched back on when this deviation is larger than the energy-saving mode restart value (p2392).
  Only the positive technology controller deviation is monitored in the factory settings, meaning that the motor is switched on as soon as this deviation is larger than the energy-saving mode restart value (p2392).
  If the motor is to be switched back on even in the event of negative technology controller deviation, the amount of this deviation must be monitored.
  For this, p2298 = 2292 must be set. The percentage value for the minimum limit can be entered in p2292.
  Additional setting options are provided in the parameter list in function diagram 7958 and in the associated parameter descriptions.

Boost functions

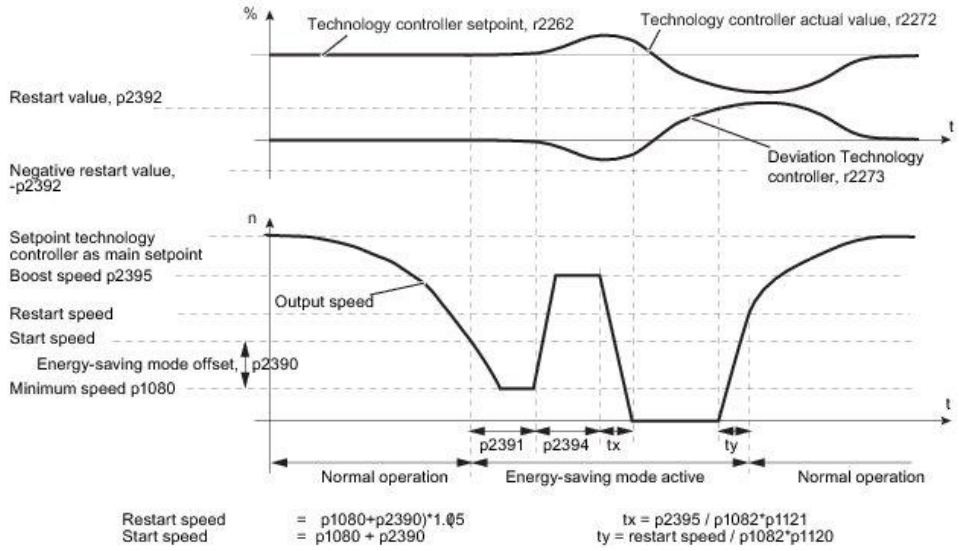
In order to prevent frequent starts and stops, the speed may be boosted for a short time before shutdown (boost). This function can be disabled by setting the boost time (p2394) to 0.

After an adjustable time (p2396) has expired, the energy-saving mode can be ended and switched to normal mode, particularly to avoid tank deposits in the case of liquids.

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

Energy-saving mode with setpoint input using the internal technology controller

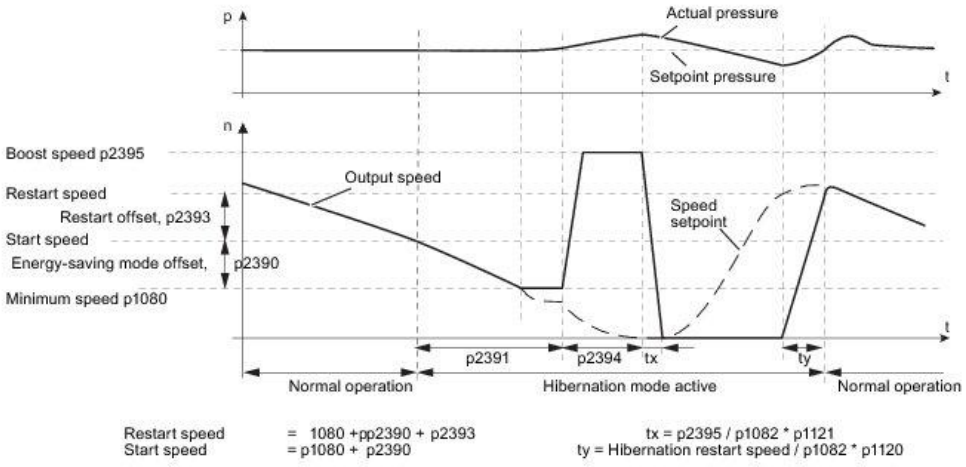
In this operating mode, the technology controller must be activated as the setpoint source (p2200) and used as the main setpoint (p2251). The function can be operated both with and without boost.



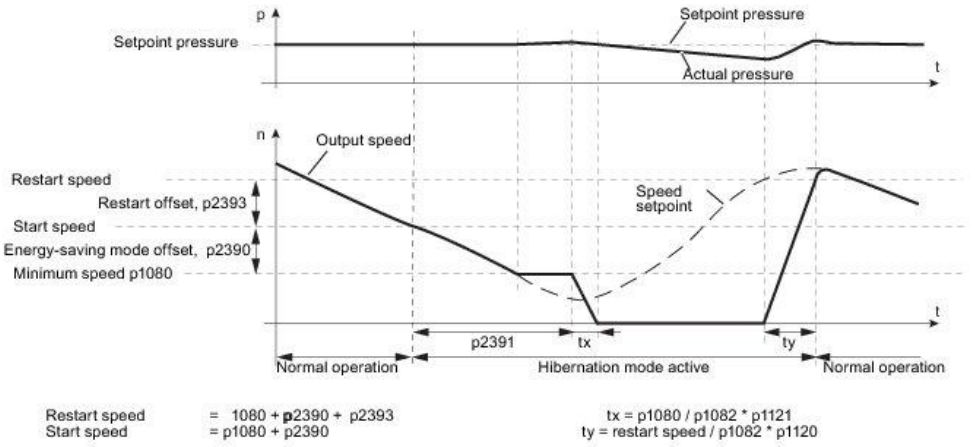
Energy-saving mode with external setpoint input

The setpoint is provided via an external source (e.g. a temperature sensor) in this operating mode. The technology setpoint can be used as a supplementary setpoint for this.

Energy-saving mode using an external setpoint with boost



Energy-saving mode using an external setpoint without boost



Adjustable parameters

Parameters	Description		Via tech. setpoint	Via ext. setpoint
p1080 = …	**Minimum speed**		x	x
	0	(factory setting) … 19,500 rpm. Lower limit of the motor speed is dependent on the speed setpoint.		
p1110 = …	**Block negative direction** Parameter to block the negative direction		-	x
p2200 = …	**Enable technology controller**		x	-
	0	Technology controller deactivated (factory setting)		
	1	Technology controller activated		
p2251 = 1	**Technology controller mode**		x	-
	0	Technology controller as main setpoint (factory setting)		
	1	Technology controller as supplementary setpoint		
p2298 = …	**Technology controller minimum limiting** Parameter for the minimum limiting of the technology controller		x	-
p2398 = …	**Energy-saving operating mode**		x	x
	0	Energy-saving mode disabled (factory setting)		
	1	Energy-saving mode enabled		
p2390 = …	**Energy-saving mode start speed** 0 (factory setting) … 21,000 rpm. As soon as this speed is undershot, the energy-saving mode delay time starts and switches off the motor once it expires. The energy-saving mode start speed is calculated as follows: Start speed = p1080 + p2390 p1080 = minimum speed p2390 = energy-saving mode start speed.		x	x
p2391 = …	**Energy-saving mode delay time** 0 to 3,599 s (factory setting 120). The energy-saving mode delay time starts as soon as the output frequency of the variable speed drive drops below the energy-saving mode start speed p2390. If the output frequency increases above this threshold during the delay time, the energy-saving mode delay time is interrupted. Otherwise, the motor is switched off after the delay time has expired (if necessary, after a short boost).		x	x
p2392 = …	**Energy-saving mode restart value (in %)** Required if the technology controller is used as the main setpoint. As soon as the technology controller deviation (r2273) exceeds the energy-saving mode restart value, the variable		x	-

Parameters	Description	Via tech. setpoint	Via ext. setpoint
	speed drive switches to normal operation and the motor starts with a setpoint of 1.05 * (p1080 + p2390). As soon as this value is reached, the motor continues to operate with the setpoint of the technology controller (r2260).		
p2393 = …	**Energy-saving mode restart speed (rpm)** Required for external setpoint setting. The motor starts as soon as the setpoint exceeds the restart speed. The restart speed is calculated as follows: Restart speed = p1080 + p2390 + p2393 p1080 = minimum speed p2390 = energy-saving mode start speed p2393 = energy-saving mode restart speed	-	x
p2394 = …	**Energy-saving mode boost duration** 0 (factory setting) to 3,599 s. Before the variable speed drive switches over into the energy-saving 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.	x	x
p2395 = …	**Energy-saving mode boost speed** 0 (factory setting) to 21,000 rpm. Before the variable speed drive switches over into the energy-saving 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 boost cannot cause any overpressure or overflow conditions.	x	x
p2396 = …	**Maximum energy-saving mode shutdown time** 0 (factory setting) to 863,999 s. At the latest when this time expires, the variable speed drive switches to normal operation and is accelerated up to the start speed (p1080 + p2390). If the variable speed drive switches to normal operation before this, the shutdown time is reset to the value set in this parameter. The automatic switch over to normal operation is deactivated after a specific time via p2396 = 0.	x	x

Monitoring parameters

Parameters	Description	
r2273	**Display of the setpoint/actual value deviation of the technology controller**	
r2397	**Actual energy-saving mode output speed** Actual boost speed before the pulses are inhibited or the actual start speed after restart.	
r2399	**Energy-saving mode status word**	
	00	Energy-saving mode enabled (p2398 <>0)
	01	Energy saving mode active
	02	Energy-saving mode delay time active
	03	Energy-saving mode boost active
	04	Energy-saving mode motor switched off
	05	Energy-saving mode motor switched off, cyclical restart active
	06	Energy-saving mode motor starts back up.
	07	Energy-saving mode supplies ramp-function generator's total setpoint
	08	Energy-saving mode bypasses the ramp-function generator in the setpoint channel

6.3.9 Bypass (bypassing the variable speed drive)

The integrated bypass function is used in the following cases:

- If an application is intended to run for a longer period of time with maximum motor power
- If an application requires a variable speed drive bypass system for safety reasons

The bypass function uses a digital output to control the bypass and variable speed drive relays. If both digital outputs are already being used for other functions, it is possible to use an external bypass.

In the bypass function, the motor is either operated by the variable speed drive or directly on the line.

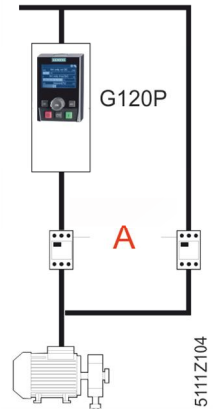
The bypass is controlled as follows:

- Depending on the speed via the variable speed drive
- Independently of the speed
- Via a signal from the variable speed drive
- Via a higher-level control

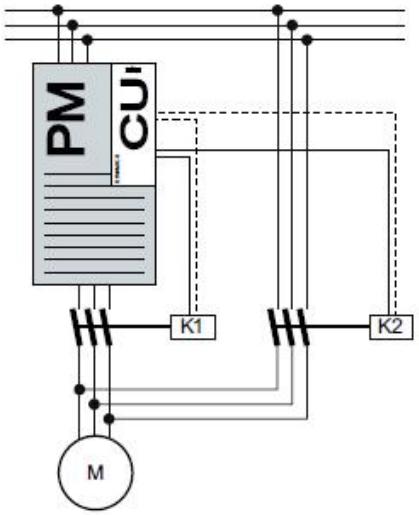
If the bypass is controlled by a higher-level control, the control must lock the contactors so they cannot switch on at the same time.

If controlled by the variable speed drive, the digital outputs are used to activate two contactors via which the motor is powered. The variable speed drive is provided with contactor position feedback via the digital inputs. This is evaluated. If using direct connection logic (high level = ON), both contactors should be NO contacts.

Bypass circuit for control using the variable speed drive



A = Motor starter (mechanical interlocking)



----- Control via digital output
- - - - Feedback via digital input
K1 contactor for variable speed drive operation
K2 contactor for bypass operation

Changeover operation between line and variable speed drive operation

At changeover to line operation, contactor K1 is opened (after the variable speed drive pulses have been inhibited). The system then waits for the motor de-excitation time to elapse, after which contactor K2 is closed, connecting the motor directly to the line supply.

When the motor is switched to the line supply, an equalizing current flows that must be taken into account when the protective equipment is selected and dimensioned.

When changing over to variable speed drive operation, initially contactor K2 must be opened and after the de-excitation time, contactor K1 is closed. The variable

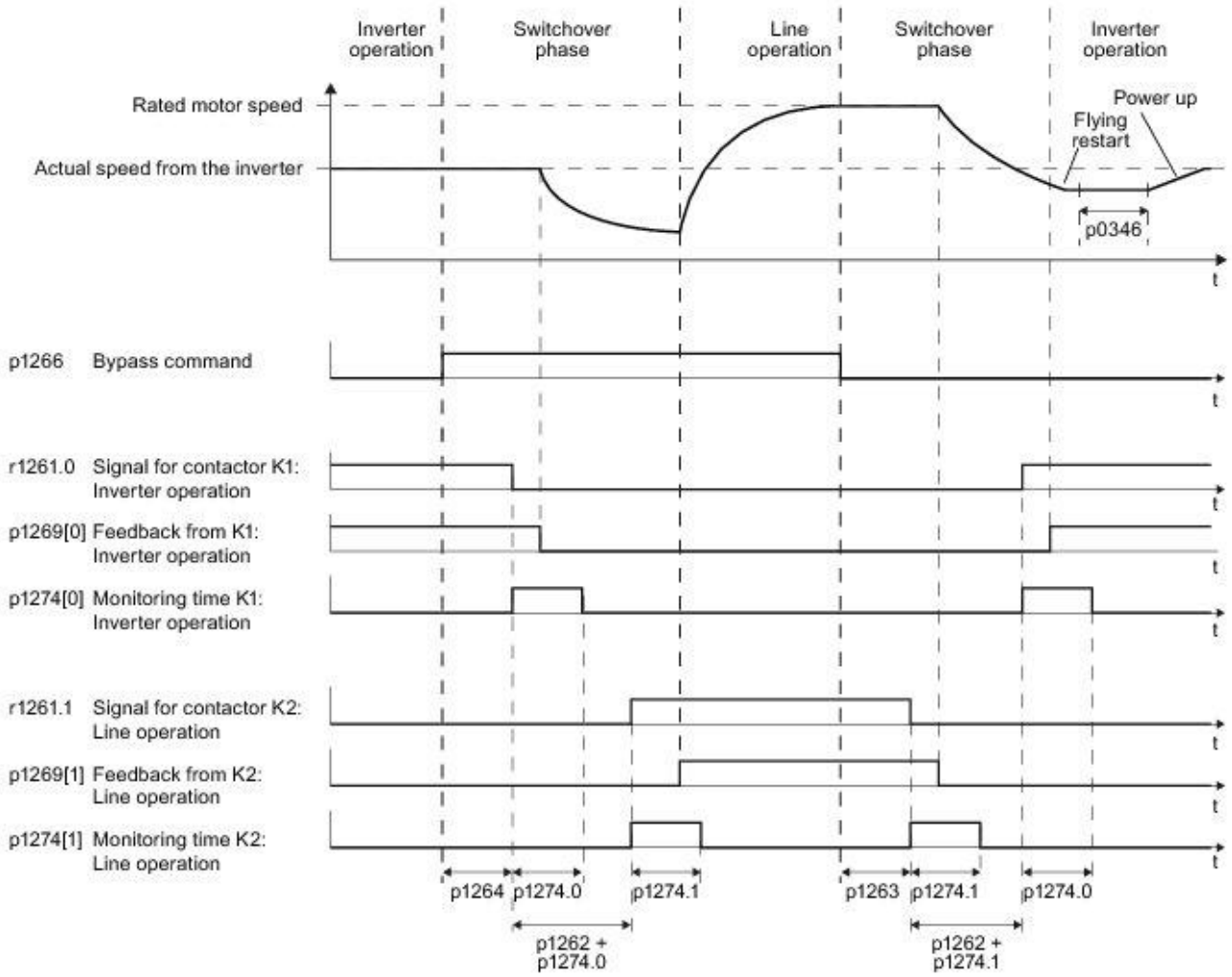
speed drive then captures the rotating motor and the motor is operated on the variable speed drive.

Flying restart (p1200=1)

The "flying restart" function is required for bypass functions. Otherwise, the variable speed drive cannot capture the rotating motor while it is switching from the bypass to the G120P. If the function is not activated, this can lead to fault F30002.

Bypass function when activating via a control signal (p1267.0 = 1)

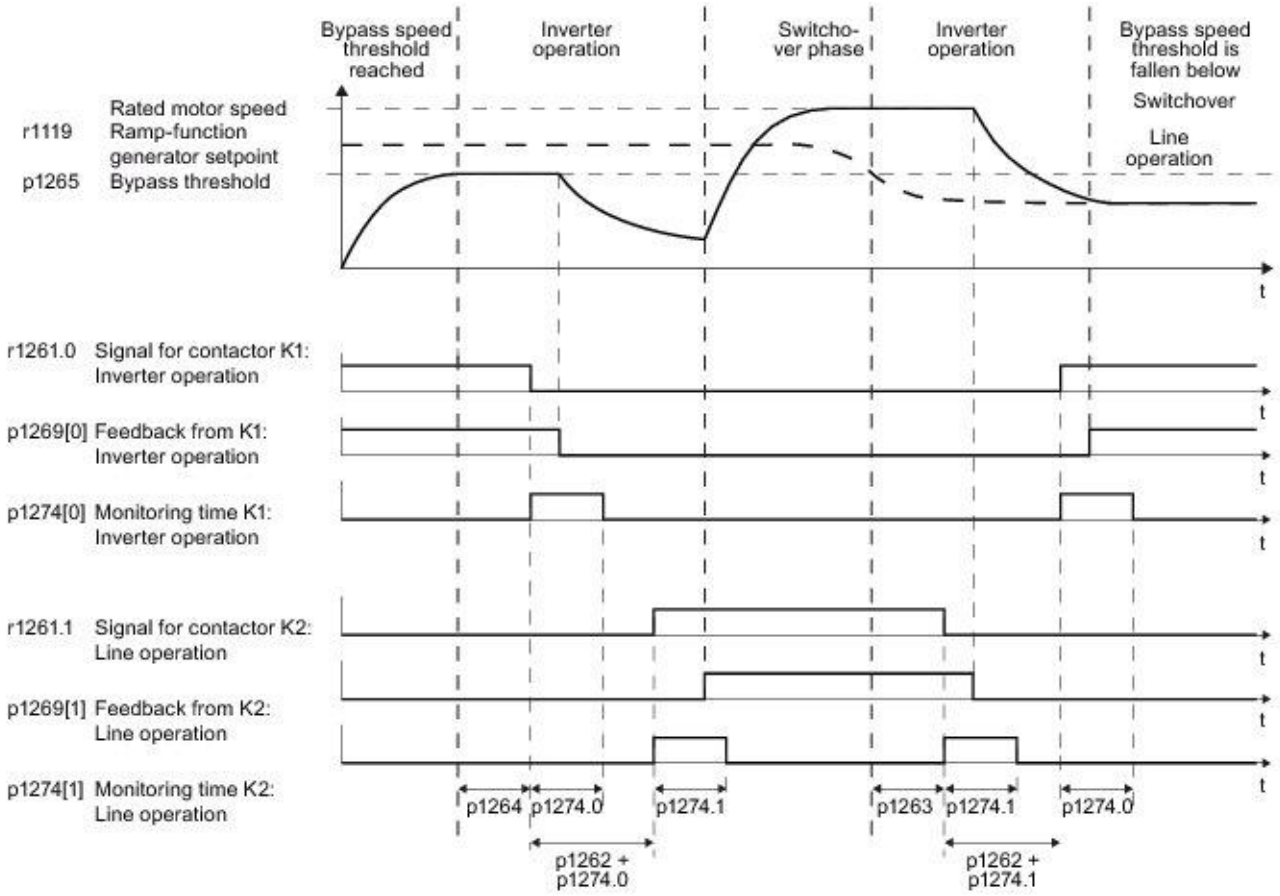
The state of the bypass contactors is evaluated when the variable speed drive is switched on. If the automatic restart function is active (p1210 = 4) and an ON command (r0054.0 = 1) as well as the bypass signal (p1266 = 1) are still present at power up, then after power up, the variable speed drive goes into the "ready and bypass" state (r899.0 = 1 and r0046.25 = 1) and the motor continues to run directly connected to the line supply.



Bypass function is dependent on the speed (p1267.1 = 1)

With this function, changeover to line operation is realized corresponding to the following diagram if the setpoint lies above the bypass threshold.

If the setpoint falls below the bypass threshold, the variable speed drive captures the motor and the motor is fed from the variable speed drive.



General properties of the bypass function

- The two motor contactors must be designed for switching under load.
- Contactor K2 must be designed for switching an inductive load.
- Contactors K1 and K2 must be mutually interlocked so that they cannot close at the same time.

Motor starting current

A motor that is started directly has a start or inrush current of 600% of the rated motor current. You can reduce the starting current for motors with I_{rated} > 2 A using the following methods.

- Star-delta (wye-delta) start (200% I_{rated})
- Soft starter (100% I_{rated})
- G120P (100% I_{rated})

Recommended motor-start methods for bypass application:

- Direct switch-on (for small motors with I_{rated} < 2 A only)
- Star-delta (wye-delta) start
- Soft starter

Details on the Siemens soft starter can be found in the documentation for the 3RW3 soft starter.

Shutdown behavior in bypass mode

- If the motor is running in bypass mode, it cannot be shut down with OFF1. The motor runs down to a stop after an OFF2 or OFF3.
- If the motor is running in bypass mode and the variable speed drive is isolated from the network, even the bypass contactor does not receive any control signals from the variable speed drive and the motor runs to a stop.
  If the motor is still to be operated after shutting down the variable speed drive, the signal for the bypass contactor must therefore come from the higher-level control.

Temperature monitoring and overload protection in bypass mode

- If the motor is running in bypass mode, while the variable speed drive is in the "ready and bypass" state (r899.0 = 1 and r0046.25 = 1), then the motor temperature monitoring via the temperature sensor is active.
- If the motor is running in bypass mode, while the variable speed drive is in the "ready and bypass" state (r899.0 = 1 and r0046.25 = 1), then the overload protection for the motor must be realized on the plant or system side.

High-availability, Essential Service Mode (ESM), and bypass

In high-availability systems or if the ESM function is required, we recommend an external bypass solution with an additional network bypass fuse. The external bypass with supplementary mains fuse provides the system redundancy that is required in such applications.
See schematic diagram: "External bypass with direct switch-on, troubleshooting – example with supplementary fuse".

Parameters for setting the bypass function

Parameters	Description
p1260	**Bypass configuration** Activating the bypass function
r1261	**Bypass control/status word** Control and feedback signals for the bypass function.
p1262	**Bypass dead time** Changeover time for contactors. This should be longer than the motor's demagnetizing time.
p1263	**Debypass delay time** Delay time for switching back to variable speed drive operation.
p1264	**Bypass delay time** Delay time for switching to bypass mode.
p1265	**Bypass speed threshold** Speed threshold for switching to bypass mode.
p1266	**Bypass control command** Signal source for switching to bypass mode.
p1267	**Bypass changeover source configuration** Switch to bypass mode using speed threshold or control signal.
p1269	**Bypass switch feedback signal** Signal source for contactor feedback for bypass mode.
p1274	**Bypass switch monitoring time** Monitoring time setting for bypass contactors.

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

Automatic restart after failure

Depending on the bypass setting (p1260), even disconnections can activate the bypass. If the automatic restart is not activated, the motor is driven by the bypass until the site maintenance technician manually resets and restarts the G120P.

You can, however, automatically acknowledge the disconnection and restart the G120P with the automatic restart. In this case, the drive automatically resets the disconnection (depending on the settings for the automatic reset) and switches back from the bypass to the drive.

Automatic reset and time delay for fault signals

There may also be an additional advantage for sites where temporary problems can arise, for example voltage peaks at the G120P inputs lead to shutdown due to overvoltage.

Example:

You do not want to monitor every fault message caused by a temporary problem, particularly if the G120P cannot reset and restart itself.

If the "automatic restart" function is activated in connection with an external bypass (p1210=4 or 6), every power system fault is acknowledged by the G120P within the restart time delay (p1212) and restart time increase (p1213). If there was only a

temporary problem with the power supply that was rectified after the restart time delay (p1212 and p1213), the drive switches from bypass back to drive and starts back up. In such cases, the fault message on the DDC module does not have to be monitored, as the implemented bypass keeps the motor running until the drive tries to restart.

For applications such as these, it makes sense to configure a time delay for displaying G120P fault messages in the DDC system.

T_t = p1212 + (p1213 x p1211)

Within this time delay, the drive can try to rectify temporary problems in the power supply itself using the automatic restart before the fault message is output on the DDC module.

If the drive cannot start back up after three attempts (or p1211), the G120P sends the fault message to the DDC module.

In this case, only "hard shutdowns" that the G120P cannot reset itself result in the DDC module outputting a fault message. Temporary faults, such as voltage peaks at the inputs, are ignored by the DDC system, so the fault messages that the G120P can process itself can also be ignored.

p1211 prescribes a defined number of restart attempts for the drive before a fault message is sent to the DDC module.

How to generate a time delay

To generate a time delay, you can use the free PDE drive control block (ON delay).

Example:

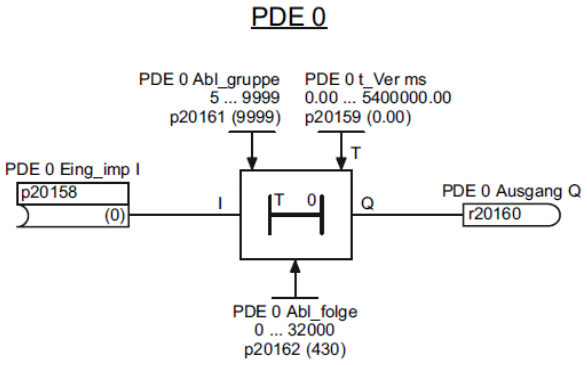
p2080[3] = r20160

p20158 = r2139[3]

p20159 = 60,000 ms

p20161 = 5

This delays the fault display on the fieldbus by 60 s.



6.3.9.1 Integrated bypass function for the G120P

The G120P has an integrated bypass function. Further detailed information on the G120P's integrated bypass function can be found in the operating instructions for the CU230P-2 (A5E02430659B).

Advantages and disadvantages of the G120P's integrated bypass function

Advantages	Disadvantages
● The troubleshooting and mains power failure are included in this function without the need for additional hardware. ● Includes the bypass dead time, bypass time, and bypass-to-G120P changeover time. ● No additional OFF2 settings required.	● The G120P cannot be replaced in bypass mode without shutting down the system. (A solution with 3 contactors is not possible.) ● No system redundancy. System redundancy is crucial for ESM and high availability applications.

● No additional time delay relay required.	

Parameter settings for the G120P integrated bypass function

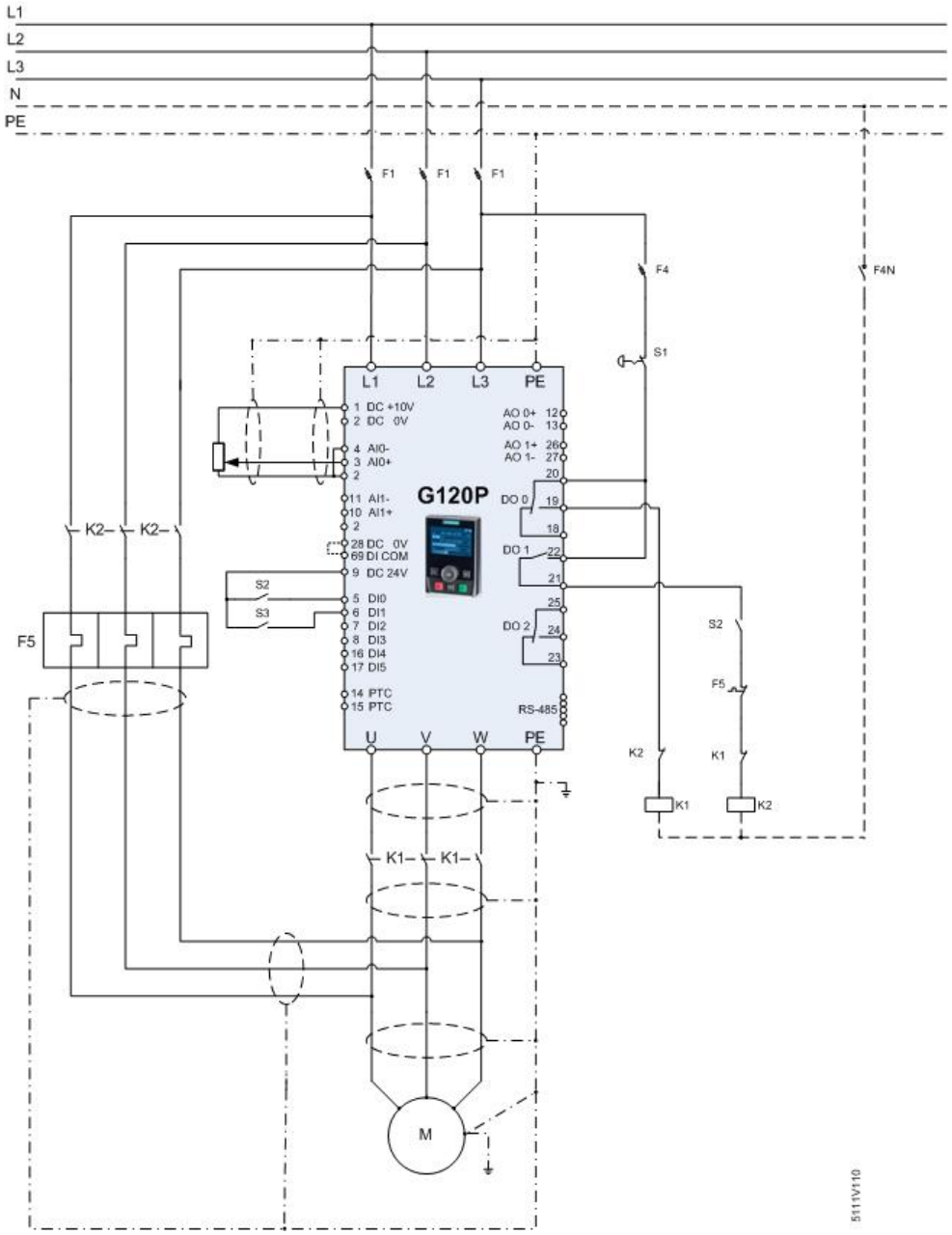
Bypass command to DO0.

P No.	Value	Description
P0730	1261.0	DO0 VSD output relay
P0731	1261.1	DO1 power supply relay
p1260	3	Bypass activated
p1262	s	Bypass dead time (should be > p0347)
p1263	s	De-bypass time
p1264	s	Bypass time
p1266	r0722.5	Bypass control command: DI5
p1267	01	Bypass via signal
p1200	1	Flying restart
p1210	26	Automatic restart
p1212	s	Time until the first restart
p1213	s	Restart time increase

Setting up the bypass function for the G120P

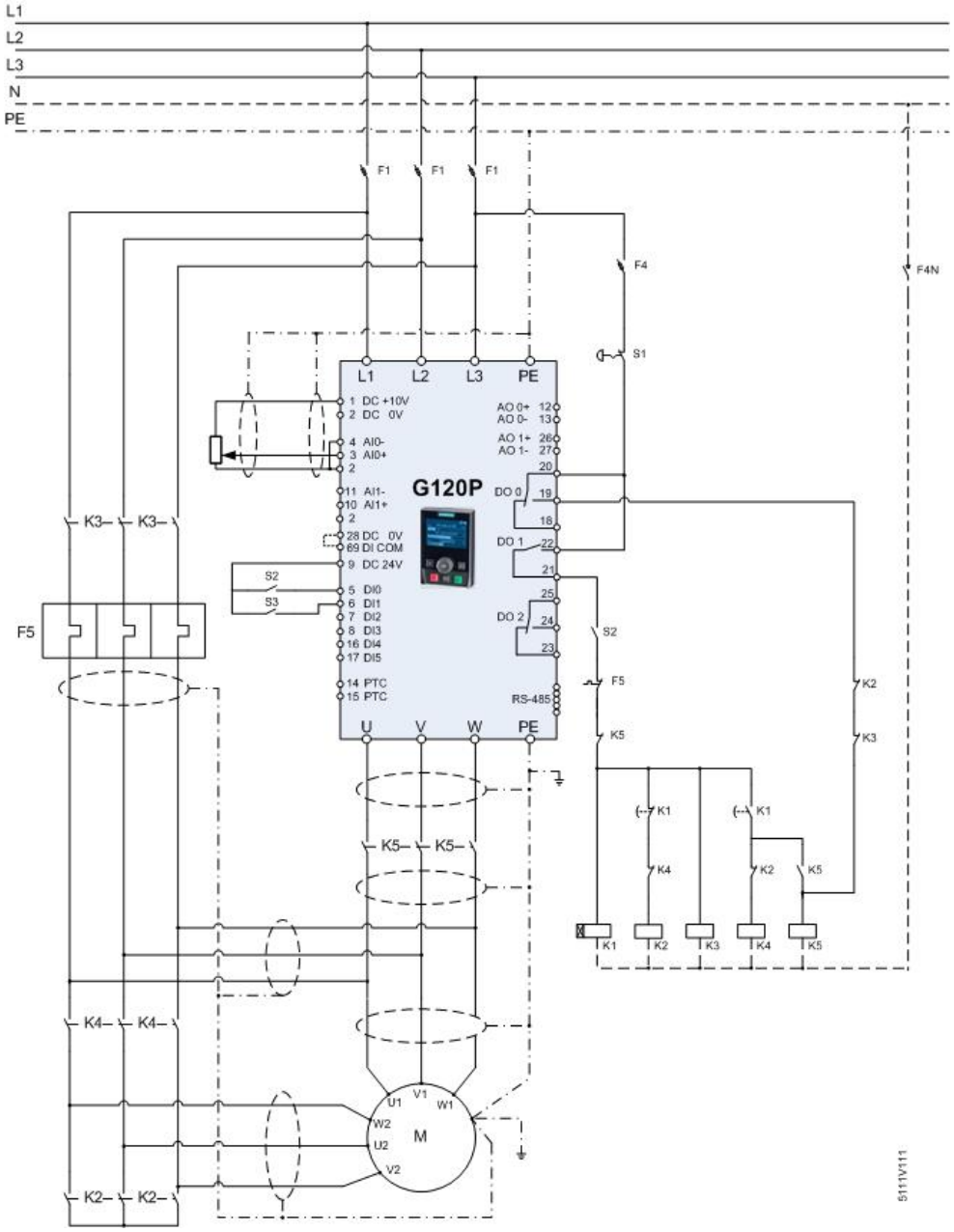
The three following circuit diagrams display the possible configurations for the G120P's integrated bypass function. The difference between the three configurations is the method of starting the motor. The first example uses direct switch-on, the second circuit diagram displays a star-delta (wye-delta) start, and the final example uses a soft starter.

Internal bypass function with direct switch-on



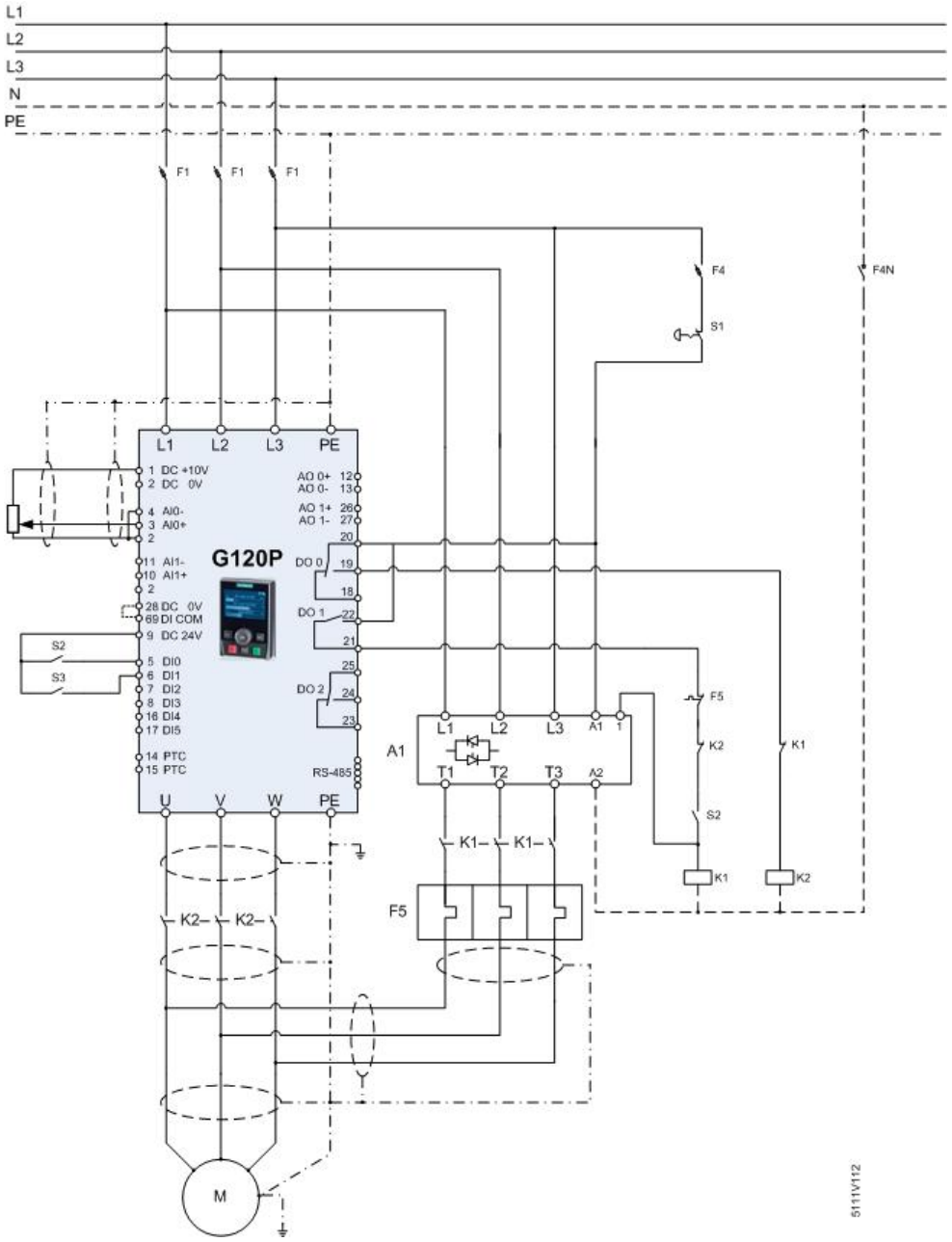
Legend	
K1 VSD contactor	S1 EMERGENCY STOP
K2 Bypass contactor	S2 G120P ON/OFF command
F1 Fuse (power supply)	S3 Bypass command
F4 Fuse (control circuit)	
F4N F4 Neutral isolator	
F5 Thermal relay	

Internal bypass function, direct star-delta (wye-delta)



Legend	
K1 ON delay contactor (star-delta (wye-delta) start)	F1 Fuse (power supply)
K2 Star (wye) contactor	F4 Fuse (control circuit)
K3 Bypass contactor	F4N F4 Neutral isolator
K4 Delta contactor	F5 Thermal relay
K5 VSD contactor	S1 EMERGENCY STOP
	S2 G120P ON/OFF command
	S3 Bypass command

Internal bypass function, direct soft starter



Legend	
K1 Bypass contactor	S1 EMERGENCY STOP
K2 VSD contactor	S2 G120P ON/OFF command
F1 Fuse (power supply)	S3 Bypass command
F4 Fuse (control circuit)	A1 Siemens Sirius soft starter
F4N F4 Neutral isolator	
F5 Thermal relay	

6.3.9.2 External bypass function

Depending on the application requirements, additional settings and components are required for the external bypass solution in order to establish compatibility with the G120P's internal bypass function.

For high-availability applications, you can only achieve the required system redundancy via the external bypass. The logic for the external bypass can even be implemented in the DDC system.

"Operation deactivated" command for avoiding disconnections

The G120P is normally switched off using an OFF1 command. Stopping with OFF1 means that the variable speed drive stops the motor with the programmed ramp-down time. In the case of an external bypass, however, the bypass signal starts the ramp-down time and immediately opens the output contactor to the G120P. Opening the contactor to the motor while current is flowing can cause irreparable damage to the G120P's power circuit.

A practical solution to this problem is to stop the variable speed drive using the "Operation deactivated" command instead of an OFF1 command (ramp-down). "Operation deactivated" means that the G120P Power Module and its outputs are immediately separated. The motor runs down to a standstill without ramp-down time.

Set the following parameters to DI0 for this command:

P No.	Index	Value	Description
P0840	0	722.0	BICO connection from DI0 and ON command
P0852	0	722.0	BICO connection from DI0 and "Operation activated" command

Time delay for ON command

In common VSD applications, the VSD ON signal not only starts the drive, but also closes the contactor at the VSD output. This leads to disconnections, as the bouncing contactor changes the VSD output resistance.

To ensure a soft and appropriate start, the VSD output contactor must be closed before the ON command is output at the DI

The contactor must not switch or bounce when the ON signal is applied.

Avoid this problem by establishing a time delay for the ON command using the delay contactor. The VSD contactor should first be closed, then the G120P should start with a short time delay of 3 to 5 seconds via DI.

Applications with a contactor at the VSD output (solution with 3 contactors) do not require a time delay for the ON signal. If the contactor at the input and output is closed, the G120P requires a few seconds to power up and get ready for operation. Once powered up, the G120P is ready. The input and output contactors are closed properly and no shutdown takes place.

Troubleshooting

Two questions should be asked as part of the troubleshooting process:

- What happens if the G120P shuts down?
- What happens if the G120P's external power supply or internal DC power supply fail?

In a standard configuration with an external bypass, the G120P is shut down, although the bypass is not activated. This means that a special configuration is required to cover these fault states.

Using one of the G120P's digital outputs, you can set up an application that activates the bypass in the following ways:

- External signal (DI)
- G120P fault or shutdown
- Power supply failure or internal DC power supply for the G120P

This means that all fault states are covered and the G120P application reaches a high level of reliability.

Three contactors

With an additional contactor at the G120P input, the VSD is completely isolated from the power supply in bypass mode and can be replaced with ease. This can provide significant added value for applications that require a high level of reliability.

Advantages and disadvantages of the external bypass

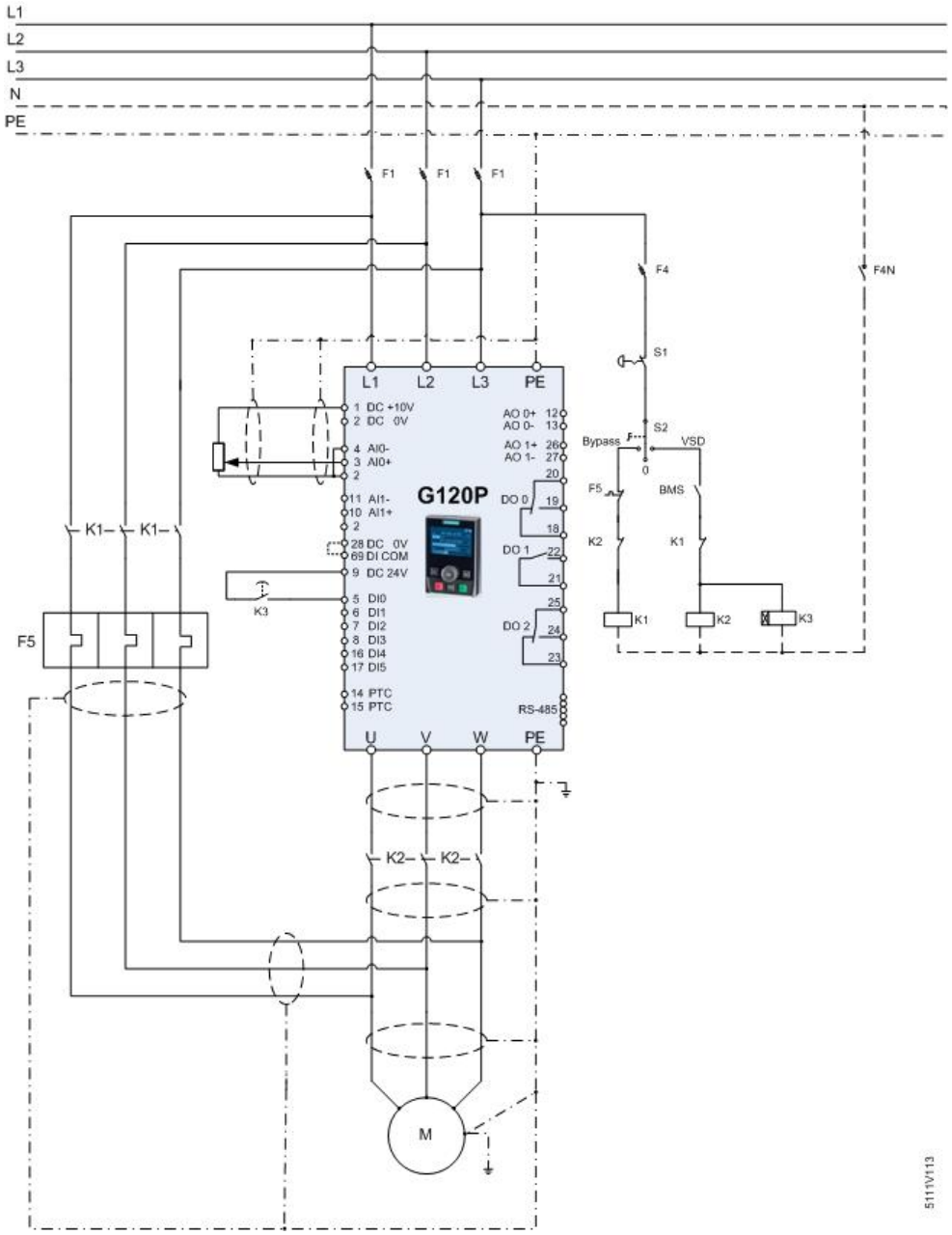
Advantages	Disadvantages
● Three free digital outputs for other functions if no troubleshooting is required ● System redundancy: crucial for ESM and high availability applications	● No bypass and de-bypass time or bypass dead time ● The troubleshooting only covers one digital output. Only two digital outputs remain for other functions ● ON-command time delay required for configuration without a contactor at the G120P input.

Setting up the external bypass

The following diagrams provide a practical overview of the common external bypass applications. Based on the three motor start configurations (direct switch-on, star-delta (wye-delta), soft starter), options are available with:

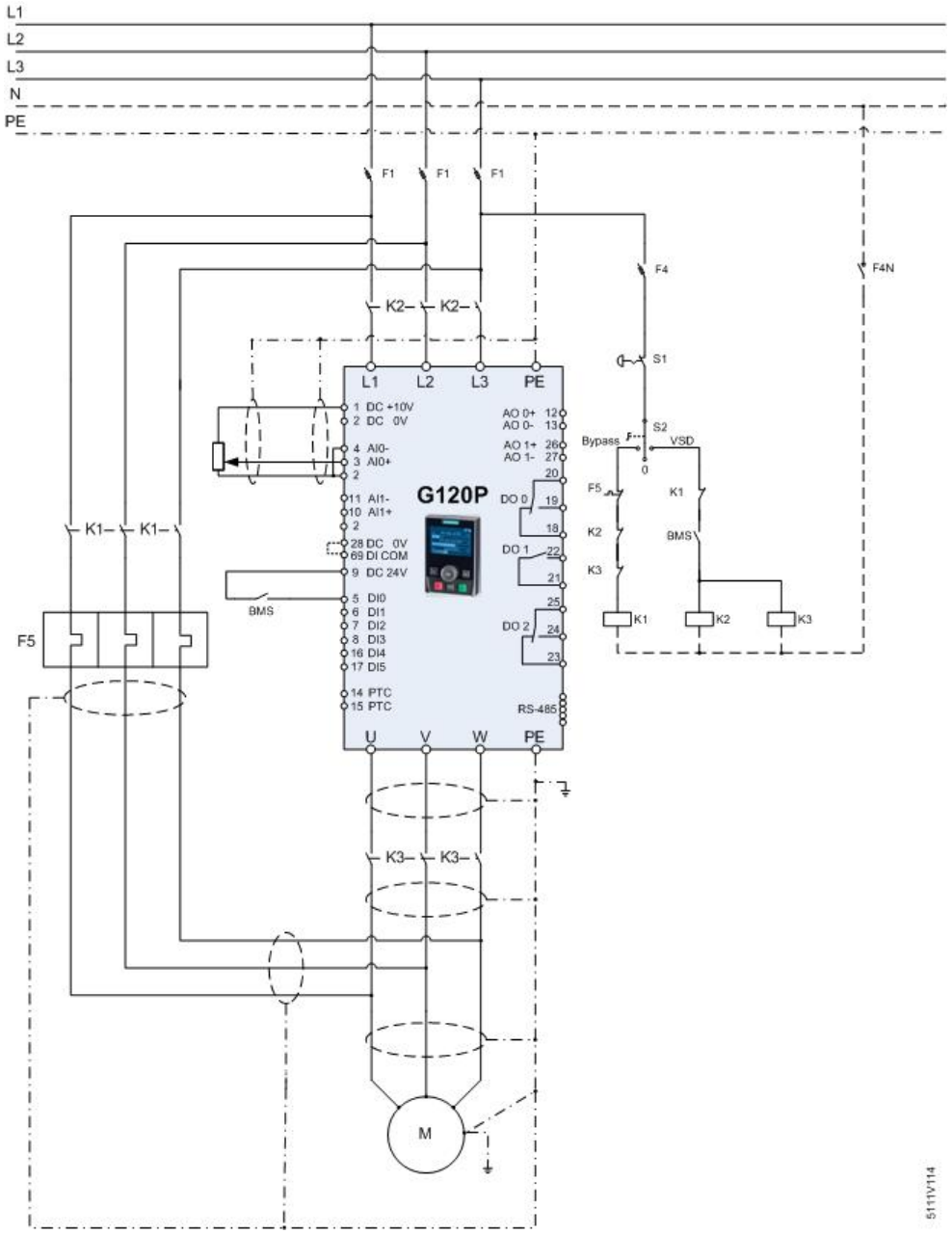
- Contactors
- Troubleshooting
- Contactor and troubleshooting

External bypass with direct switch-on



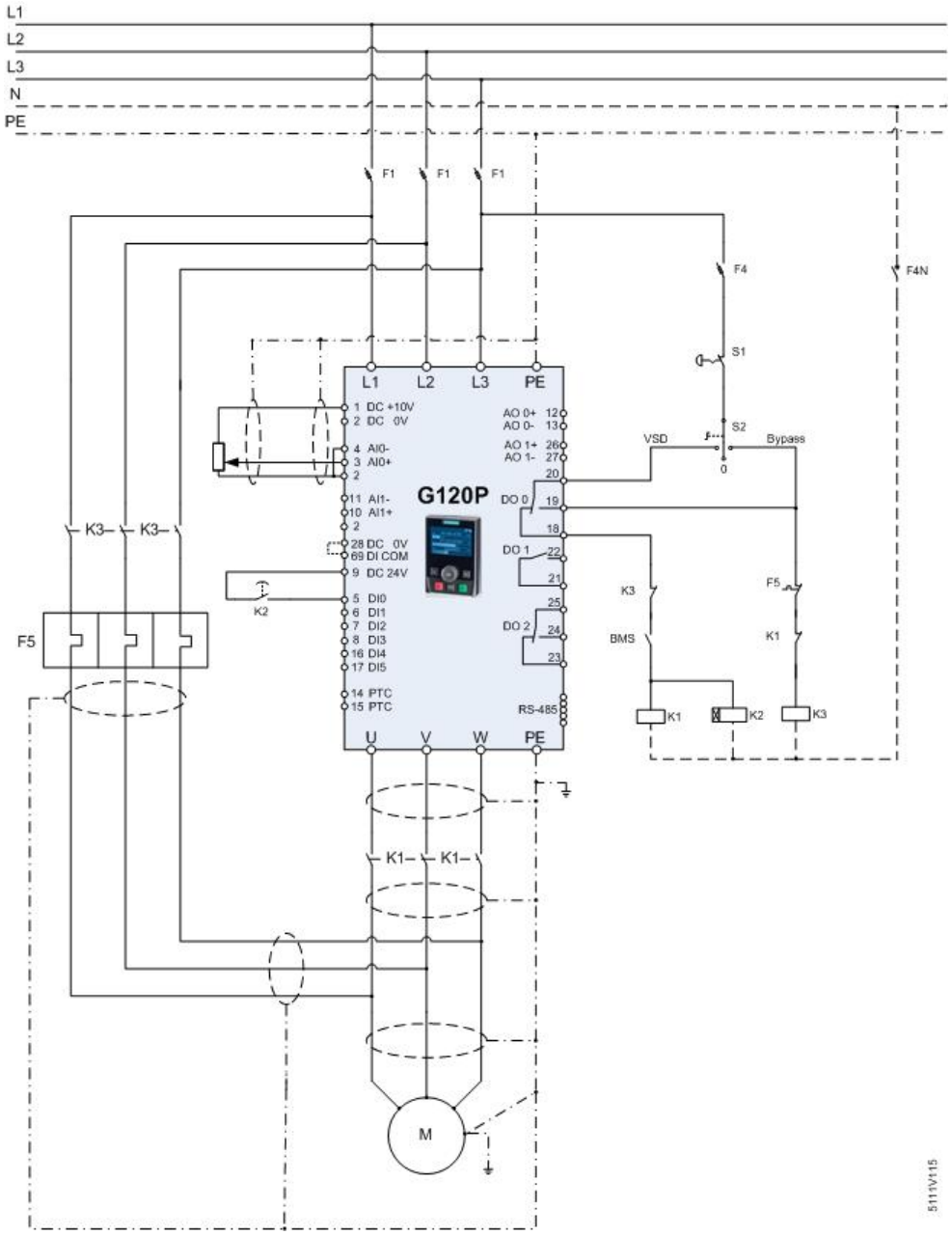
Legend	
K1 Bypass contactor	F4N F4 Neutral isolator
K2 VSD contactor	F5 Thermal relay
K3 ON delay contactor (VSD ON/OFF command)	S1 EMERGENCY STOP
F1 Fuse (power supply)	S2 Switch (bypass/VSD/OFF)
F4 Fuse (control circuit)	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with direct switch-on, 3 contactors



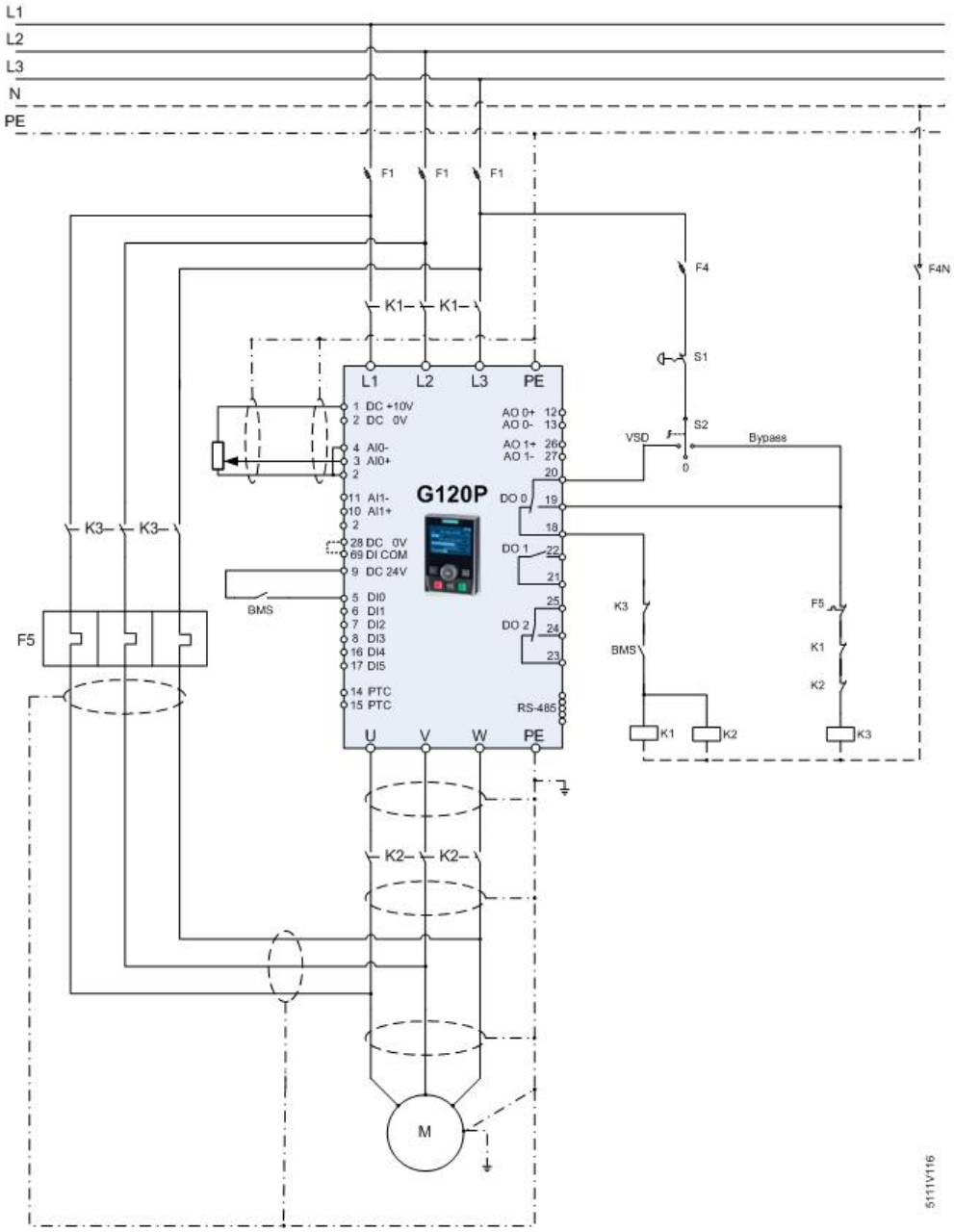
Legend	
K1 Bypass contactor	F4N F4 Neutral isolator
K2 VSD input contactor	F5 Thermal relay
K3 VSD output contactor	S1 EMERGENCY STOP
F1 Fuse (power supply)	S2 Switch (bypass/VSD/OFF)
F4 Fuse (control circuit)	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with direct switch-on, troubleshooting



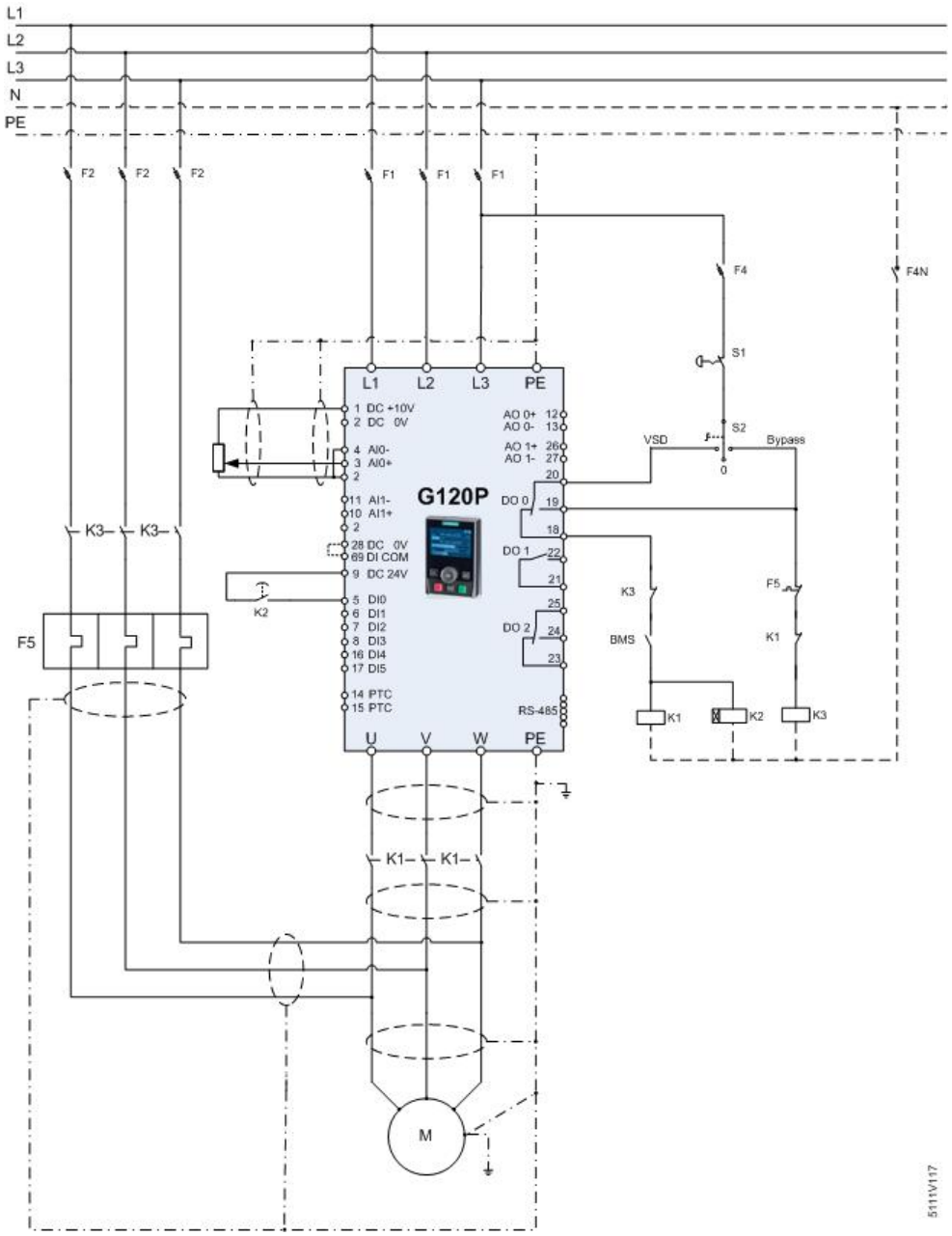
Legend	
K1 VSD contactor	F4N F4 Neutral isolator
K2 ON delay contactor (VSD ON/OFF command)	F5 Thermal relay
K3 Bypass contactor	S1 EMERGENCY STOP
F1 Fuse (power supply)	S2 Switch (bypass/VSD/OFF)
F4 Fuse (control circuit)	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with direct switch-on, troubleshooting, 3 contactors



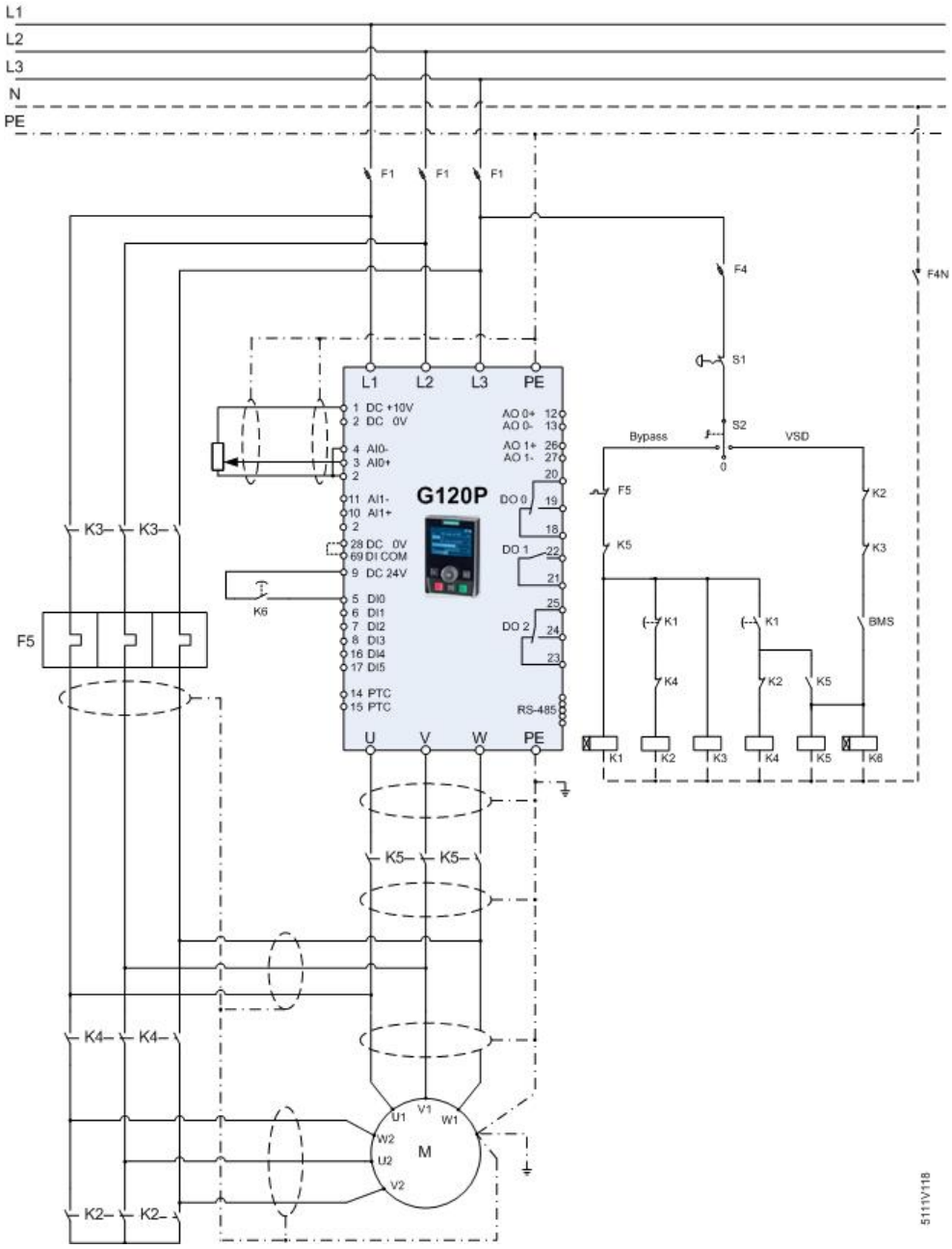
Legend	
K1 VSD input contactor	F4N F4 Neutral isolator
K2 VSD output contactor	F5 Thermal relay
K3 Bypass contactor	S1 EMERGENCY STOP
F1 Fuse (power supply)	S2 Switch (bypass/VSD/OFF)
F4 Fuse (control circuit)	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with direct switch-on, troubleshooting – example with supplementary fuse



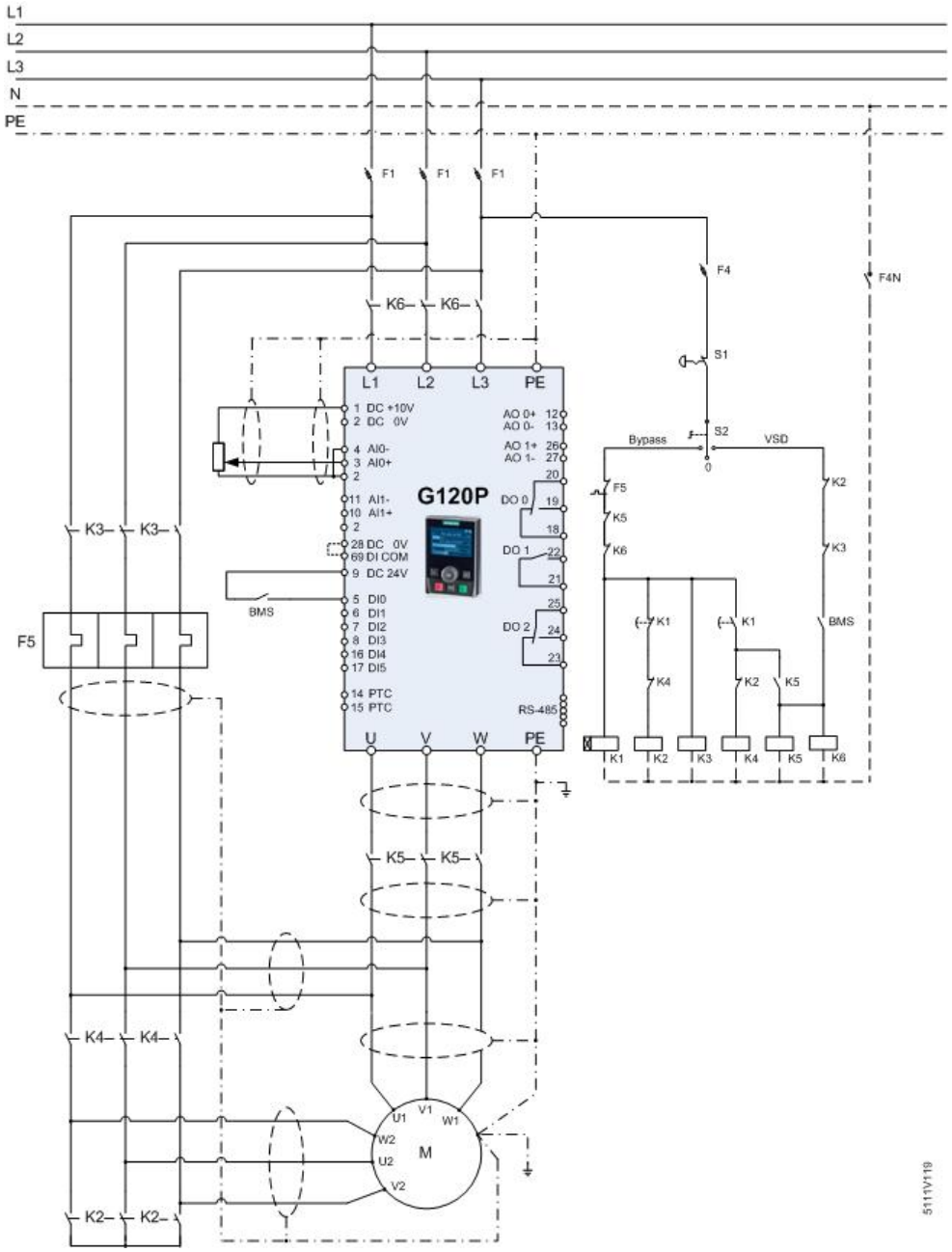
Legend	
K1 VSD contactor	F4 Fuse (control circuit)
K2 ON delay contactor (VSD ON/OFF command)	F4N F4 Neutral isolator
K3 Bypass contactor	F5 Thermal relay
F1 Fuse (power supply)	S1 EMERGENCY STOP
F2 Fuse (network bypass current)	S2 Switch (bypass/VSD/OFF)
	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with star-delta (wye-delta) start



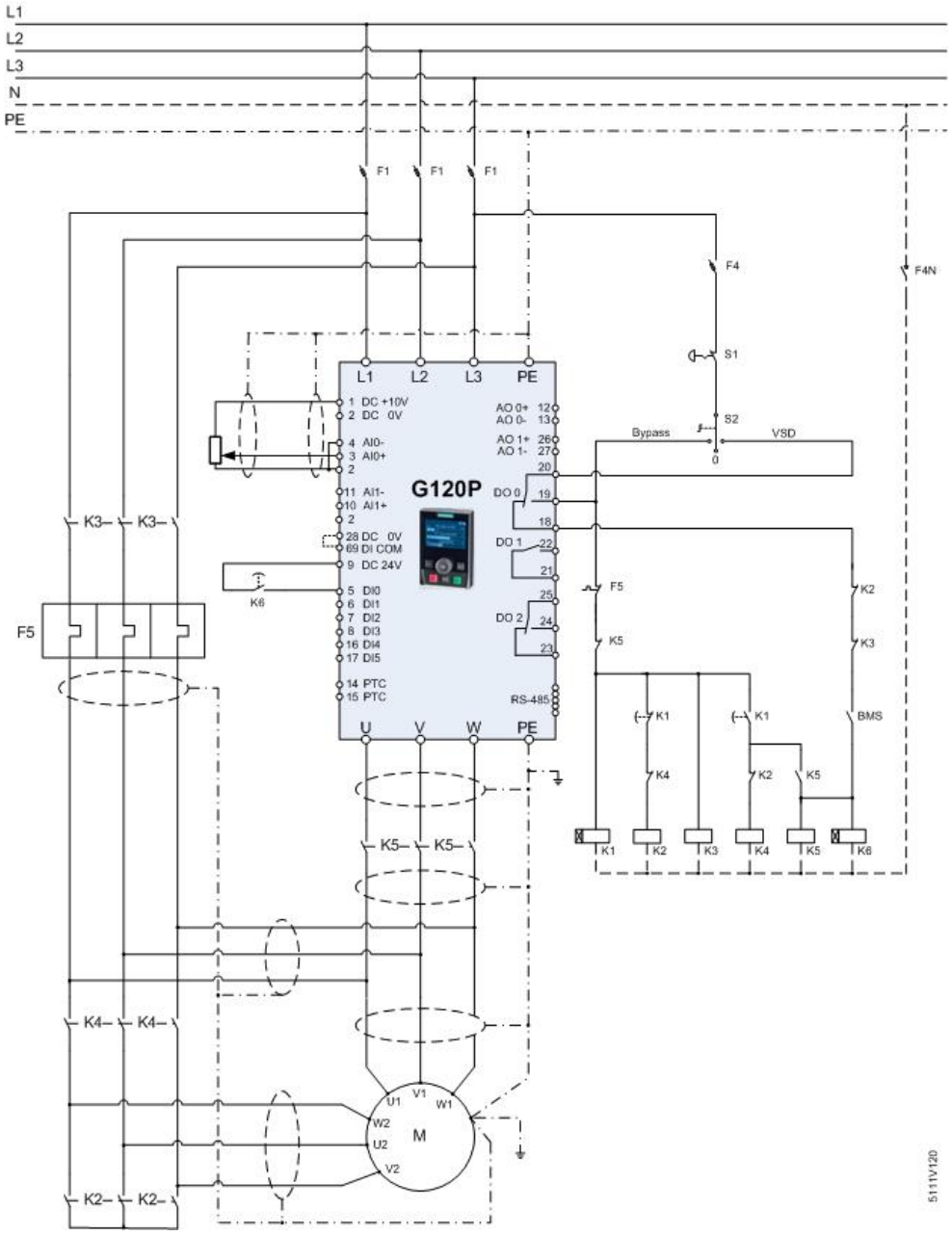
Legend	
K1 ON delay contactor (star-delta (wye-delta) start)	F1 Fuse (power supply)
K2 Star (wye) contactor	F4 Fuse (control circuit)
K3 Bypass contactor	F4N F4 Neutral isolator
K4 Delta contactor	F5 Thermal relay
K5 VSD output contactor	S1 EMERGENCY STOP
K6 ON delay contactor (VSD ON/OFF command)	S2 Switch (bypass/VSD/OFF)
	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with star-delta (wye-delta), 3 contactors



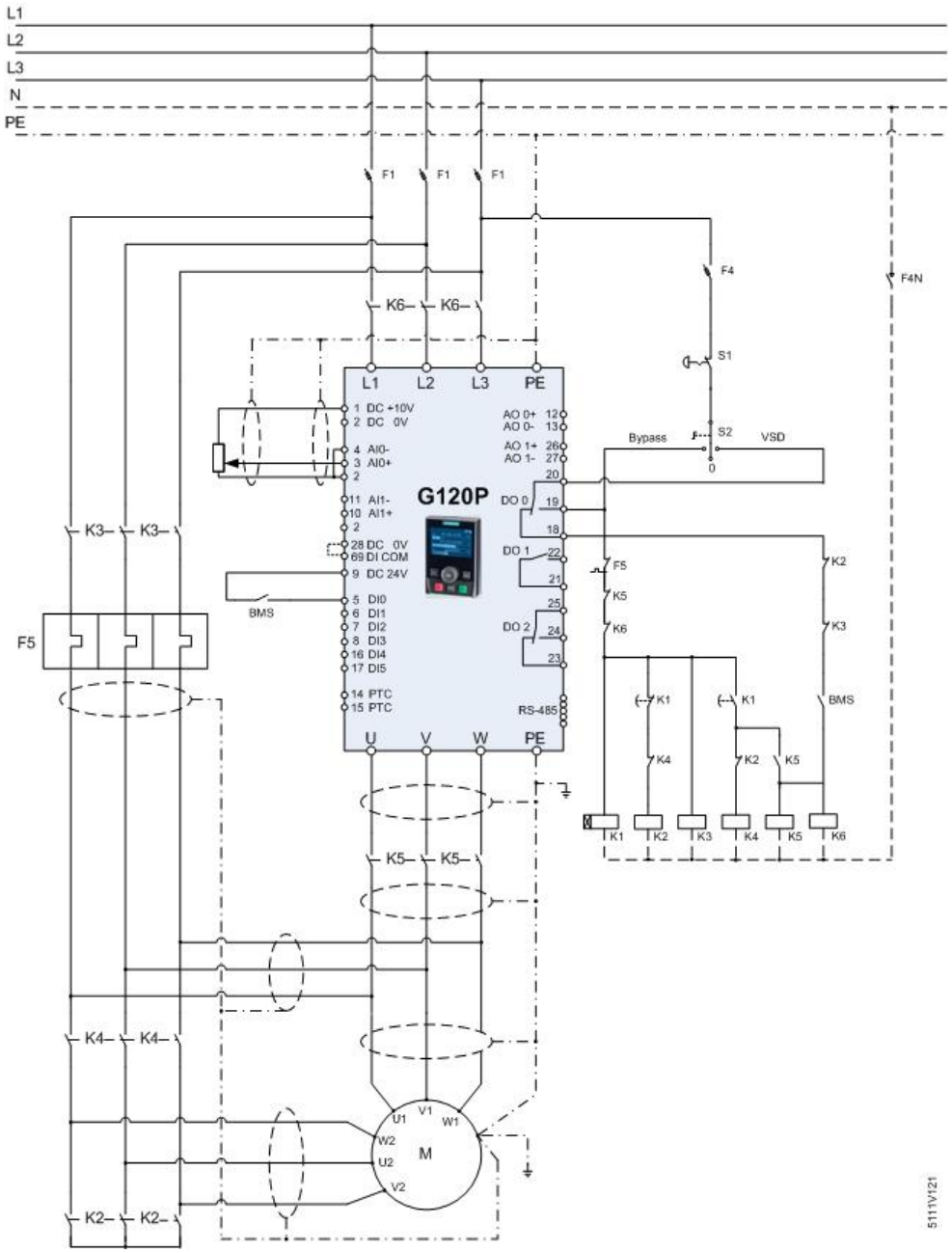
Legend	
K1 ON delay contactor (star-delta (wye-delta) start)	F1 Fuse (power supply)
K2 Star (wye) contactor	F4 Fuse (control circuit)
K3 Bypass contactor	F4N F4 Neutral isolator
K4 Delta contactor	F5 Thermal relay
K5 VSD output contactor	S1 EMERGENCY STOP
K6 VSD input contactor	S2 Switch (bypass/VSD/OFF)
	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with star-delta (wye-delta) start, troubleshooting



Legend	
K1 ON delay contactor (star-delta (wye-delta) start)	F1 Fuse (power supply)
K2 Star (wye) contactor	F4 Fuse (control circuit)
K3 Bypass contactor	F4N F4 Neutral isolator
K4 Delta contactor	F5 Thermal relay
K5 VSD output contactor	S1 EMERGENCY STOP
K6 ON delay contactor (VSD ON/OFF command)	S2 Switch (bypass/VSD/OFF)
	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

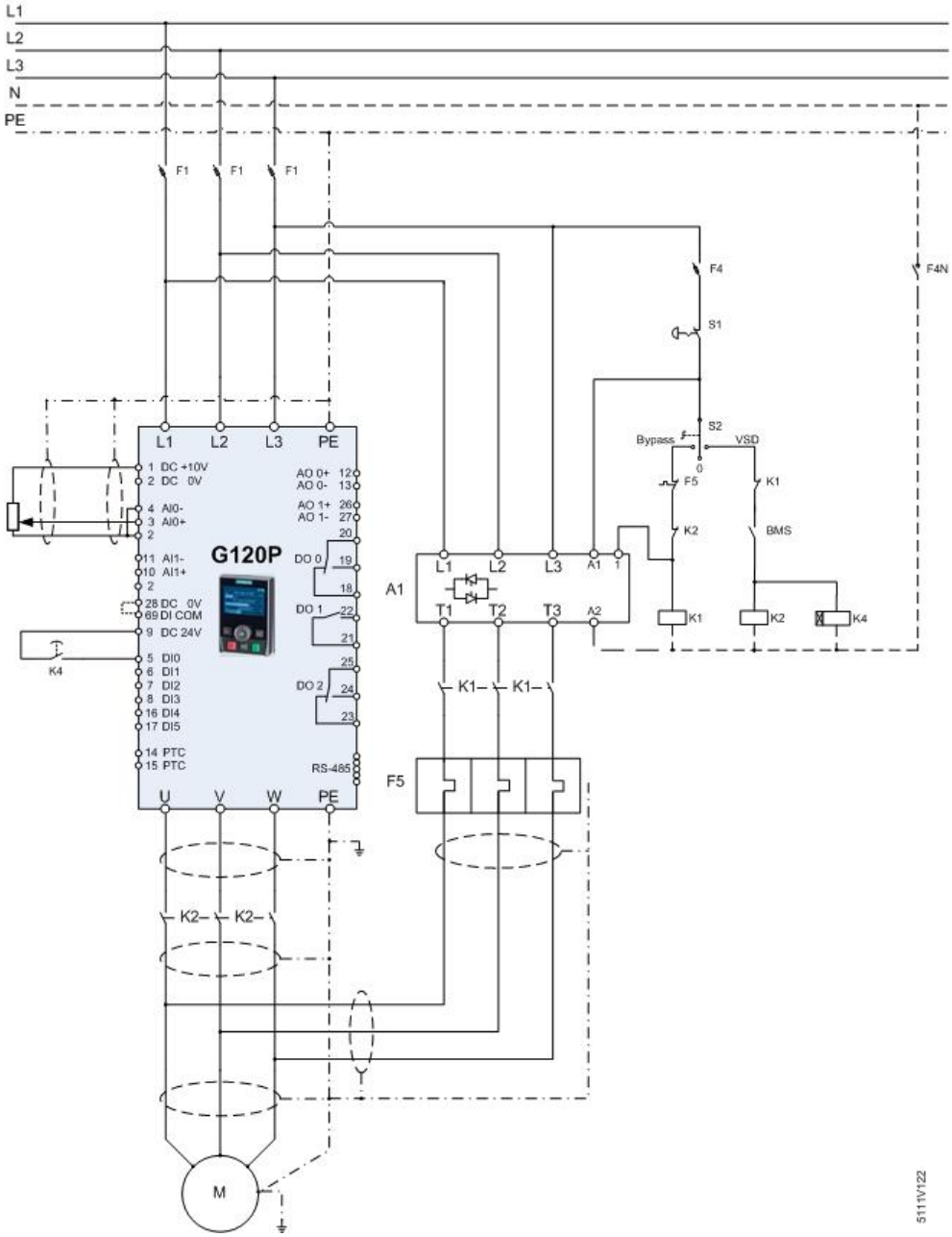
External bypass with star-delta (wye-delta), troubleshooting, 3 contactors



Legend	
K1 ON delay contactor (star-delta (wye-delta) start)	F1 Fuse (power supply)
K2 Star (wye) contactor	F4 Fuse (control circuit)
K3 Bypass contactor	F4N F4 Neutral isolator
K4 Delta contactor	F5 Thermal relay
K5 VSD output contactor	S1 EMERGENCY STOP
K6 VSD input contactor	S2 Switch (bypass/VSD/OFF)
	BMS Building management station (ON/OFF command)
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation"	p1200 = 1 (flying restart)

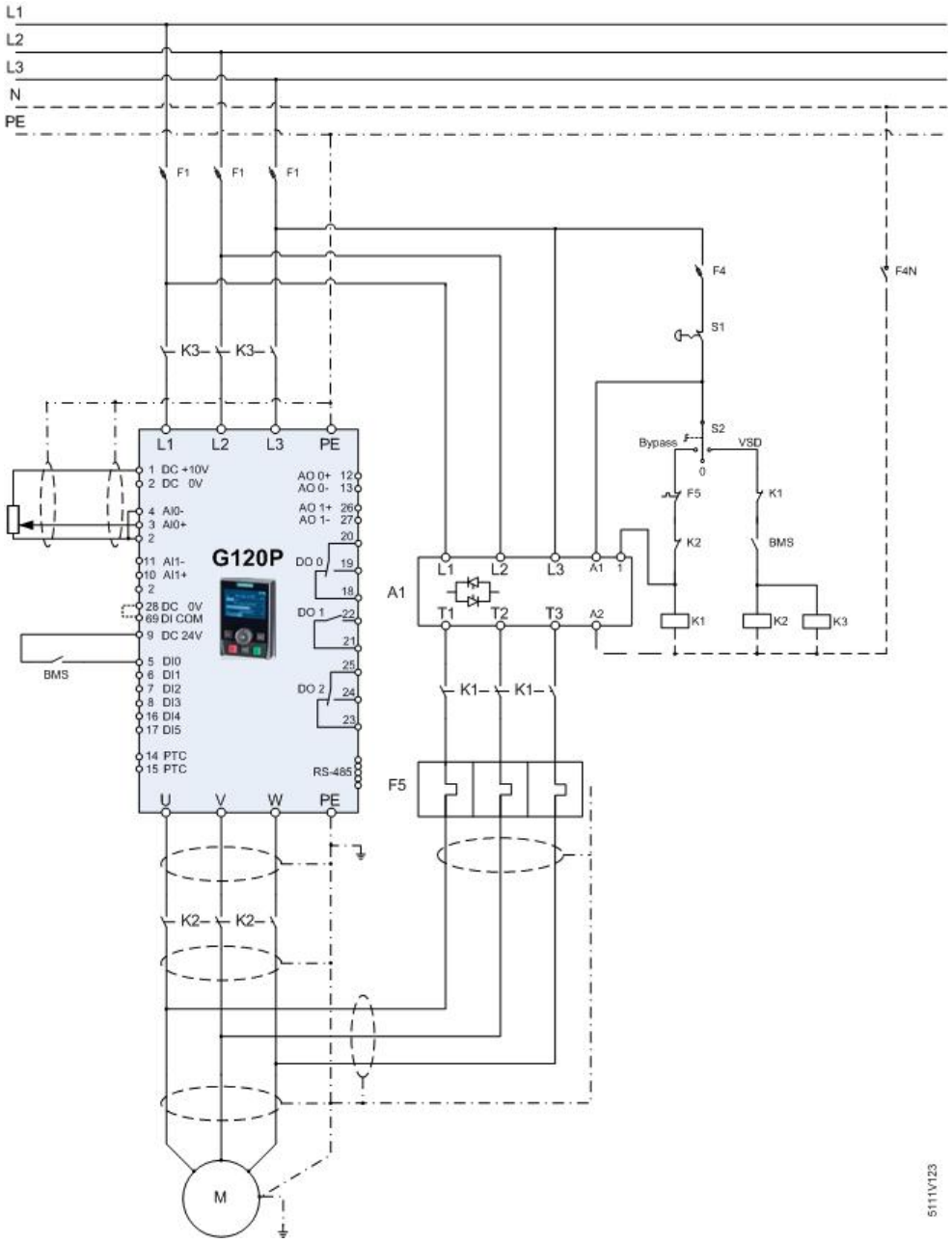
command to DI0)	

External bypass with soft start



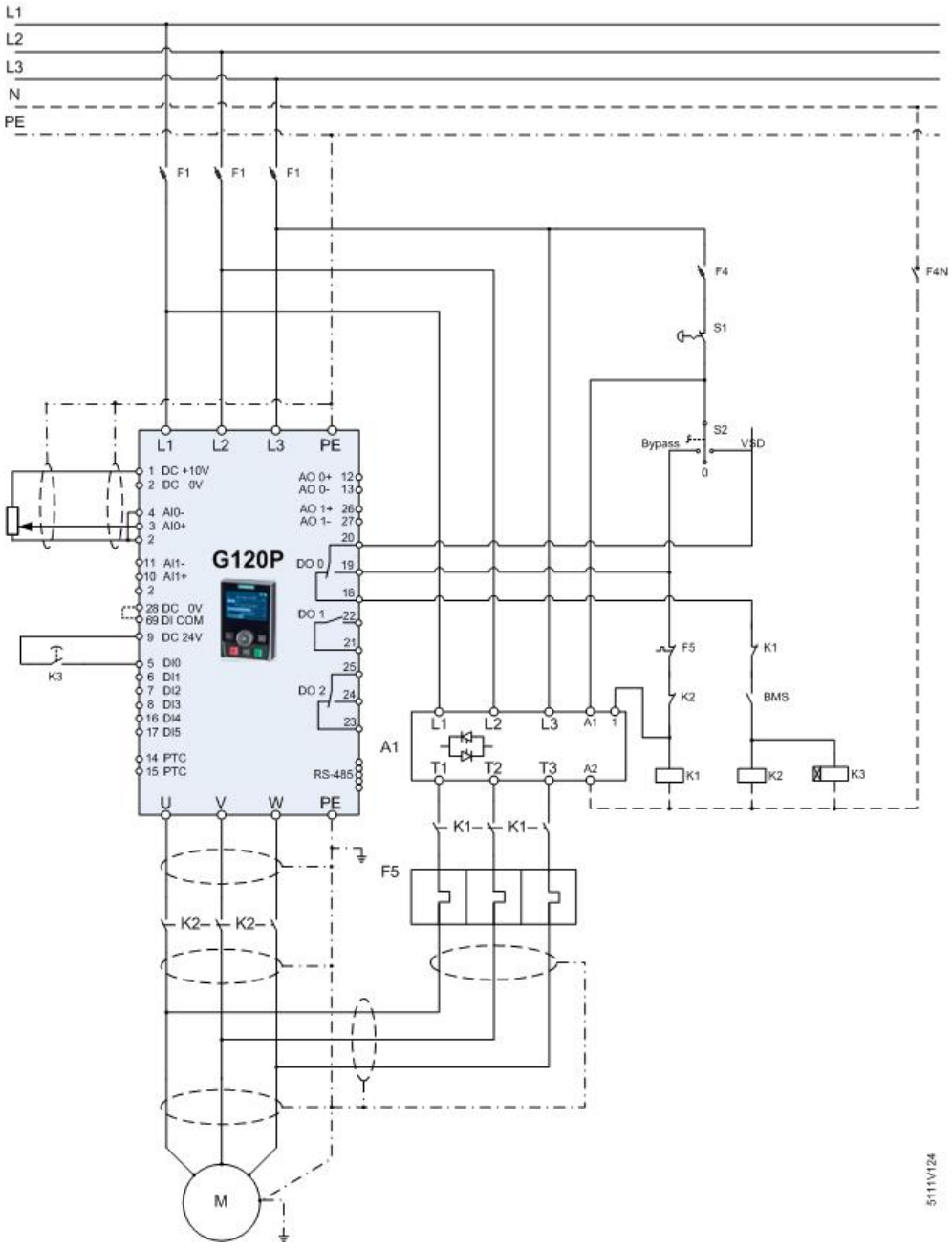
Legend	
K1 Bypass contactor	F5 Thermal relay
K2 VSD contactor	S1 EMERGENCY STOP
F1 Fuse (power supply)	S2 Switch (bypass/VSD/OFF)
F4 Fuse (control circuit)	BMS Building management station (ON/OFF command)
F4N F4 Neutral isolator	A1 Siemens Sirius soft starter
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with soft starter, 3 contactors



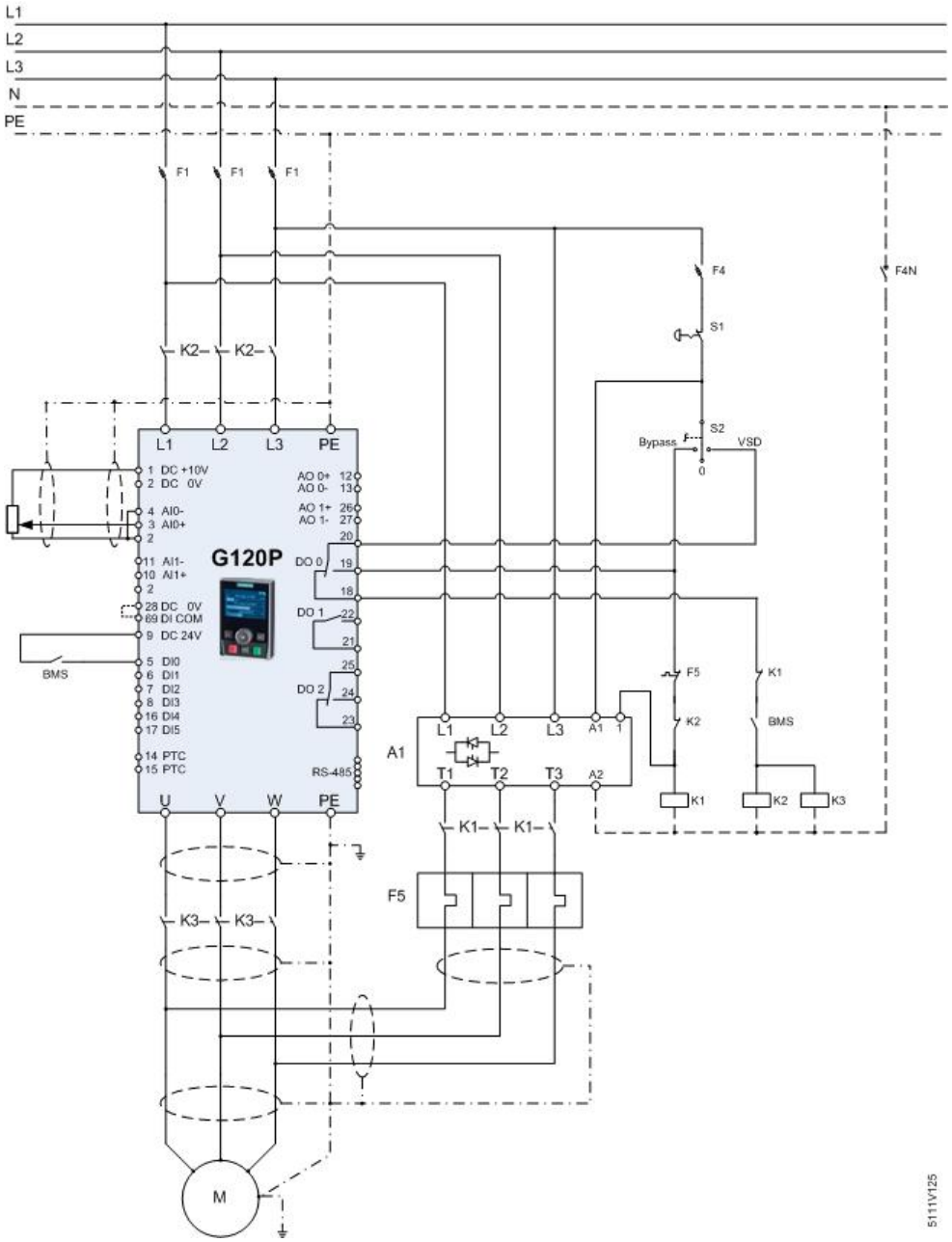
Legend	
K1 Bypass contactor	F5 Thermal relay
K2 VSD contactor output	S1 EMERGENCY STOP
K3 VSD contactor output	S2 Switch (bypass/VSD/OFF)
F1 Fuse (power supply)	BMS Building management station (ON/OFF command)
F4 Fuse (control circuit)	A1 Siemens Sirius soft starter
F4N F4 Neutral isolator	
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with soft starter, troubleshooting



Legend	
K1 Bypass contactor	F5 Thermal relay
K2 VSD contactor	S1 EMERGENCY STOP
K3 ON delay contactor (VSD ON/OFF command)	S2 Switch (bypass/VSD/OFF)
F1 Fuse (power supply)	BMS Building management station (ON/OFF command)
F4 Fuse (control circuit)	A1 Siemens Sirius soft starter
F4N F4 Neutral isolator	
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

External bypass with soft starter, troubleshooting, 3 contactors



Legend	
K1 Bypass contactor	F5 Thermal relay
K2 VSD contactor input	S1 EMERGENCY STOP
K3 VSD contactor output	S2 Switch (bypass/VSD/OFF)
F1 Fuse (power supply)	BMS Building management station (ON/OFF command)
F4 Fuse (control circuit)	A1 Siemens Sirius soft starter
F4N F4 Neutral isolator	
Function parameter settings	
p0840[0] = 722.0 (BICO connection from ON command to DI0)	p1210 = 26 (automatic restart)
p0852[0] = 722.0 (BICO connection from "Activate operation" command to DI0)	p1200 = 1 (flying restart)

6.3.10 Torque monitoring

In many applications, it is desirable to monitor the torque.

Using active torque monitoring, the variable speed drive detects critical or hazardous situations and can output a warning to alert a service technician to the problem.

- Detects missing flow rate even if there is no flow rate monitor
- Detects torn V-belts even if there is no flow monitor
- Detects faulty ball bearings at an early stage

The effect on the torque varies depending on the cause.

No water supply to the pump

If the lack of water supply is due to a closed valve, the required pump torque increases in a closed circuit at the same speed.

If no water is available due to a leak, for example, the required pump torque decreases at the same speed.

If the torque deviated from the conventional value, the variable speed drive can switch off the pump and output a warning.

Torn V-belts

The motor rotates in no-load operation if the v-belts are torn. The required torque at the same speed drops significantly.

The variable speed drive can switch off the fan and output a warning.

Faulty ball bearings

A faulty ball bearing increases the required torque at the same speed.

The variable speed drive can switch off the drive and output a warning.

!	*NOTICE*
	Significant deviations from the target torque Significant deviations between the actual torque and the target torque can significantly reduce the service life of the motor and the driven components, or even lead to their damage or destruction. • Eliminate the cause of the deviation as quickly as possible.

Control type

- Use the sensorless vector control (SLVC) for the torque monitoring (p1300) for a higher level of measurement accuracy.

Setting the permitted deviation

▷ The permitted torque deviation setting (p2193) must be as accurate as possible to avoid unnecessary alarms. You can decide when a response (p2181) should take place:
- Torque or speed too low
- Torque or speed too high
- Torque or speed outside the tolerance

- Set the permitted torque deviation in % (+/-) of the conventional value.
  The setting must be made for each of 3 freely-selectable speeds (p2182, p2183, p2184) on the load curve.
  - Input of 3 minimum values for monitoring a torque that is too low (p2186, p2188, p2190)
  - Input of 3 maximum values for monitoring a torque that is too high (p2185, p2187, p2189)
  - Input of 3 minimum and 3 maximum values for monitoring the torque tolerance
    (p2185, p2186, p2187, p2188, p2189, p2190)

⇨ The various setting options allow optimum adaptations to be made to the corresponding area of application.

The size of the setpoint deviation varies depending on the cause:
In the event of a missing water supply or torn V-belts, the deviation is large and setting the permitted tolerance does not pose any problems.
A faulty ball bearing causes smaller deviations and requires the permitted tolerance to be set more accurately.

Delay time

- Use the adjustable delay time (p2192) to output an alarm. This prevents an alarm from being output for temporary deviations.

Preventing restarts

▷ To prevent the drive from switching back on automatically after an alarm (A = alarm) or fault (F = fault), the following settings must also be made:

1. Under number p1206, set the parameter "F w/out auto AR" (faults without automatic restart) = 7925, for example
2. Under number p2100, set the parameter "F_no F response" (set fault number for fault response) = 7925, for example
3. Under number p2101, set the parameter "Fault response" (fault response setting) = 2 (OFF2)

The set value for p1206 and p2100 must correspond with the warning or fault value that was set under **Load monitoring response** (load torque monitoring response) (range 7920-7925). 7925 only applies for the setting **M/n out** (tolerance monitoring with fault message F).

Parameters

Parameters	Description
No-load monitoring	
p2179	**Current limit for no-load detection** If the variable speed drive current is below this value, the message "no load" is output.
p2180	**Delay time for the "no load" message**
Stall protection	
p2177	**Delay time for the "motor locked" message**
Speed-dependent torque monitoring	
p2181	**Load monitoring response** Setting the response for evaluation of load monitoring. 0: Load monitoring disabled >0: Load monitoring enabled
p2182	**Load monitoring, speed threshold 1**
p2183	**Load monitoring, speed threshold 2**
p2184	**Load monitoring, speed threshold 3**
p2185	**Load monitoring, torque threshold 1, upper**
p2186	**Load monitoring torque threshold 1, lower**
p2187	**Load monitoring, torque threshold 2, upper**
p2188	**Load monitoring torque threshold 2, lower**
p2189	**Load monitoring, torque threshold 3, upper**
p2190	**Load monitoring torque threshold 3, lower**
p2192	**Load monitoring delay time** Delay time for the message "Leave torque monitoring tolerance band"

For more information about these functions, see the List Manual (function diagram 8013 and the parameter list).

6.3.11 Essential Service Mode (fire/emergency operation)

The Essential Service Mode (ESM) function ensures that when required, the motor is operated for as long as possible so that, for example, smoke gases can be extracted or people affected by a fire can escape.

	*NOTICE*
	Loss of warranty for the variable speed drive in Essential Service Mode In the case of the Essential Service Mode, the customer can no longer lodge any claims for warranty. Essential Service Mode and the faults which arise during this mode are logged in a password-protected memory and can be read by the repair center. • Only activate the Essential Service Mode in the event of an emergency.

Refer to parameters p3880 to r3889 in the List Manual for more information on the Essential Service Mode.

In order to operate the variable speed drive in the Essential Service Mode, the appropriate degrees of protection and connection and installation guidelines applicable to the system should be observed. The current standards can be found in the ESM G120P guide.

Application example

In order to improve air circulation in stairwells, slight underpressure is frequently generated using ventilation control. With this control, a fire would mean that smoke gases enter into the stairwell. This would then mean that the stairway would be blocked as an escape or evacuation route.

Using the Essential Service Mode function, the ventilation switches over to control an overpressure. This prevents the propagation of smoke gases in the stairwell, thereby keeping the stairs free as an escape route.

Activating the Essential Service Mode function

The Essential Service Mode is activated by interconnecting p3880 with a digital input of your choice.

If you wish to activate the Essential Service Mode with the digital input, for example, set p3880 = 722.3.

	*NOTICE*
	Only 1 command source for the Essential Service Mode The Essential Service Mode can only be switched on from precisely one command source. The setting of the source for the Essential Service Mode via p3880 is always referred to the data set that is currently active. • Do not logically combine the digital input for the Essential Service Mode with any other functions. • Detailed information is given in the ESM manual.

The last setpoint recognized is taken as the emergency setpoint in the factory setting. You can use p3881 to define another value:

- p3881 = 0: Last recognized setpoint (factory setting)

- p3881 = 1: Fixed setpoint 15
- p3881 = 2: Analog setpoint
- p3881 = 3: Fieldbus
- p3881 = 4: Technology controller

New to FW4.6 and later

- p3881 = 6: OFF1 -> motor stops with normal ramp time
- p3881 = 7: OFF2 -> motor runs to a stop

If you specify the emergency setpoint via the analog setpoint, fieldbus, or technology controller, you must ensure the appropriate monitoring so that an alternative setpoint can be used in the event of failure.

Possible forms of monitoring for the different setpoint sources:

- Analog setpoint: Using F03505
- Fieldbus status in r2043
- Technology controller r2349

You will find additional details on this in the List Manual in the function diagrams for Essential Service Mode, setpoint channel, and technology controller.

When in the factory setting, if the setpoint is lost, the drive continues using the last recognized setpoint. p3882 can be used to switch to the following values:

- p3882 = 0: Last recognized setpoint (factory setting)
- p3882 = 1: Fixed speed setpoint which is defined in p1015
- p3882 = 2: Maximum speed (value of p1082)

For the technology controller to be able to specify the emergency setpoint, it must be activated (p2200 = 1) and set as the main setpoint (p2251 = 0).

Direction of rotation in the Essential Service Mode

- Emergency setpoint via p3881 = 0, 1, 2, 3
  Depending on the system, it may be necessary to invert the setpoint on site for the Essential Service Mode. You can therefore use p3883 to determine the direction of rotation of the emergency setpoint. To do this, p3883 must be linked with a free digital input, e.g. p3883 = r722.12.
  – p3883 = 0 -> normal direction of rotation in an emergency,
  – p3883 = 1 -> inverted direction of rotation in an emergency.
- Emergency setpoint via p3881 = 4
  If the emergency setpoint is specified using the technology controller, it is depicted using variables within the process and depends on these. Inversion using a digital input is therefore locked in such cases and must be implemented in the technology controller.

Bypass operation in the Essential Service Mode

- If the motor is running in bypass operation when the emergency happens, the user must query the "Bypass control/status word" (r1261) and make an appropriate interconnection to ensure that the motor is switched to the variable speed drive and continues to run with the emergency setpoint.
- If the variable speed drive has failed in the Essential Service Mode because of an internal fault and if it cannot be switched back on using the automatic restart function, the user can interconnect bit 7 of the status word for the automatic restart (r1214.7) with p1266 to operate the motor directly on the line. You will find additional information about bypass operation in the Bypass section.

Special features of the Essential Service Mode

- The automatic restart function is internally activated – independent of the setting of p1210 – as soon as the Essential Service Mode kicks in. This results in the variable speed drive being restarted if a pulse inhibit (OFF2) occurs due to an internal fault.
- In the Essential Service Mode, variable speed drive shutdown due to faults is suppressed, with the exception of faults that would lead to the destruction of the variable speed drive. A list of these faults can be found at the end of this section.
- The Essential Service Mode is triggered by a continuous signal (level-triggered) using the digital input which was defined in p3880 as the source for the Essential Service Mode.
- In the Essential Service Mode, the motor can only be stopped if the line voltage is switched off.
- If the Essential Service Mode is deactivated, the variable speed drive reverts to normal operation and its behavior depends on the pending commands and setpoints.
- The Essential Service Mode has priority over other operating modes

Parameters

Parameters	Description
Setting the source for the Essential Service Mode	
p3880 = 722.3	**ESM activation** (here, via DI3, high-active) Signal source for activating the Essential Service Mode 722.x for high active, 723.x for low active
Additional parameters to set the Essential Service Mode	
p3881	**ESM setpoint source**0 to 4
p3882	**ESM alternative setpoint source** Setpoint should the parameterized ESM setpoint be lost
p3883	**ESM direction of rotation** Signal source for direction of rotation in the Essential Service Mode, is not evaluated when p3881 = 4
p3884	**ESM setpoint technology controller** If p3884 is not connected up, then the technology controller uses the main setpoint corresponding to p2251 = 0.
r3887	**ESM: Number of activations and faults** Indicates how frequently ESM has been activated (index 0) and how many faults occurred during ESM (index 1).
p3888	**ESM: Reset number of activations and faults** p3888 = 1 resets 3887[0] and 3887[1].
r3889	**ESM status word**

Faults which are not ignored when operating in the Essential Service Mode

F01000	Internal software error
F01001	Floating Point Exception
F01002	Internal software error
F01003	Acknowledgement delay when accessing the memory
F01015	Internal software error
F01040	Save parameter settings and carry out a POWER ON
F01044	Error in description data
F01205	Time slice overflow
F01512	BICO: No scaling available
F01662	Error, internal communications
F07901	Drive: Motor overspeed
F30001	Power unit: Overcurrent

F30002	Power unit: DC-link voltage overvoltage
F30003	Power unit: DC-link voltage undervoltage
F30004	Power unit: Overtemperature heat sink inverter
F30005	Power unit: Overload I^2t
F30017	Power unit: Hardware current limit has responded too often
F30021	Power unit: Ground fault
F30024	Power unit: Overtemperature, thermal model
F30025	Power unit: Chip overtemperature
F30027	Power unit: Time monitoring for DC link pre-charging
F30036	Power unit: Internal overtemperature
F30071	No new actual values received from the Power Module
F30072	Setpoints can no longer be transferred to the Power Module
F30105	PU: Actual value sensing fault
F30662	Internal communication error
F30664	Fault during power-up
F30802	Power unit: Time slice overflow
F30805	Power unit: EPROM checksum error
F30809	Power unit: Switching information not valid

6.4 Protection functions

The variable speed drive offers protection functions against overtemperature and overcurrent for both the variable speed drive as well as the motor. Furthermore, the variable speed drive protects itself against an excessively high DC link voltage when the motor is in generator mode.

6.4.1 Variable speed drive temperature monitoring

The variable speed drive protects itself against overtemperature with different monitoring functions:

- I^2t monitoring (alarm A07805, fault F30005)
  The I^2t monitoring measures the actual utilization on the basis of a current reference value.
  The parameter r0036 [%] displays the current utilization in %. As long as the actual current does not exceed the reference value, then the utilization in r0036 = 0.
- Monitoring the chip temperature of the power unit (alarm A05006, fault F30024)
  The variable speed drive monitors the difference in temperature between the power chip (IGBT) and the heat sink. The measured values are in r0037[1] [°C].
- Heat sink monitoring (alarm A05000, fault F30004)
  The variable speed drive monitors the heat sink temperature of the Power Module. The values are in r0037[0] [°C].

Variable speed drive response

The variable speed drive temperature is essentially determined by the resistive losses of the output current and the switching losses which occur when pulsing the motor. Parameter p0290 defines how the variable speed drive responds to an excessively high temperature.

Parameters	Description
P0290	**Power unit overload reaction** (factory setting: 2 Setting the reaction to a thermal overload of the power unit:

Parameters	Description	
	0	Reduce output current (in sensorless vector control mode) or speed (in V/f control mode)
	1	No reduction, shutdown when overload threshold is reached (F30024)
	2	Reduce pulse frequency and output current (in sensorless vector control mode) or pulse frequency and speed (in V/f mode)
	3	Reduce pulse frequency
P0292	**Power unit temperature warning threshold** (factory setting: Heat sink [0] 5 °C, power semiconductor [1] 15 °C) The value is set as a difference to the shutdown temperature.	

6.4.2 Motor temperature monitoring using a temperature sensor

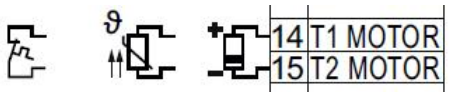
When operating below the rated speed, the cooling effect of the fan mounted on the motor shaft is reduced. To ensure that the motors are protected against overheating under such circumstances, we recommend installing a temperature sensor.

Connecting a temperature sensor

You can use one of the following sensors to protect the motor against overtemperature:

- Temperature switch (e.g. bimetallic switch)
- PTC sensor
- KTY84 sensor

Connect the temperature sensor of the motor to terminals 14 and 15 of the variable speed drive.



Temperature switch

The variable speed drive evaluates the temperature switch as follows:

- Overtemperature alarm (A07910):
  The variable speed drive interprets a resistance ≥ 100 Ω as an open-circuit temperature switch and responds with an alarm.
- Overtemperature fault (F07011):
  If p0610 = 1 or p0610 = 2, in addition to an alarm, the variable speed drive responds to this with a fault.

PTC sensor

The variable speed drive evaluates the PTC sensor as follows:

- Overtemperature alarm (A07910):
  For a resistance > 1,650 Ω, the variable speed drive responds with an alarm.
- Overtemperature fault (F07011):
  If p0610 = 1 or p0610 = 2, in addition to an alarm, the variable speed drive responds to this with a fault.
- Alarm and fault sensor monitoring (A07015 or F07016):
  – The variable speed drive interprets a resistance < 20 Ω as a short-circuit.
  – The variable speed drive responds to the short-circuit with a warning. If the alarm is present longer than 100 ms, then this is followed by a fault.

!	*NOTICE*
	False polarity in the KTY sensor If a KTY sensor is connected with the incorrect polarity, this can destroy the motor due to overheating, as the variable speed drive cannot detect a motor overtemperature condition. • Ensure the correct polarity when connecting the KTY sensor.

The variable speed drive evaluates the KTY sensor as follows:

- Temperature measurement:
  The variable speed drive determines the motor temperature in the range from -48 °C to 248 °C.
- Overtemperature alarm (A07910):
  The variable speed drive signals an alarm for a motor temperature > p0604.
- Overtemperature fault (F07011):
  The variable speed drive signals a fault in the following cases:
  –Primarily in the case of a motor temperature > p0605.
  – Also in the case of a motor temperature > p0604 if p0610 = 1 or p0610 = 2.
- Warning and fault sensor monitoring (A07015 or F07016):
  – Wire breakage:
  The variable speed drive interprets a resistance > 2,120 Ω as a wire breakage.
  – Short-circuit:
  The variable speed drive interprets a resistance < 50 Ω as a short-circuit.
  – The variable speed drive responds to a wire breakage or short-circuit with an alarm.
  If the alarm lasts for longer than 100 ms, the fault ensues.

Parameters for the temperature monitoring

Parameters	Description	
p0335	**Specify the motor cooling**	
	0	Self-ventilated - with fan on the motor shaft (factory setting)
	1	Forced ventilation - with a separately driven fan
	2	Self-ventilated and inner cooling (open-circuit cooling)
	3	Forced ventilation and inner cooling (open-circuit cooling)
p0601	**Motor temperature sensor type**	
	0	No sensor (factory setting)
	1	PTC (→ p0604)
	2	KTY84 (→ p0604, p0605)
	4	Temperature switch
p0604	**Motor temperature alarm threshold** (factory setting 130 °C)	
p0605	**Motor temperature fault threshold** (factory setting: 145° C) Setting for KTY84 sensor. The parameter has no significance for a PTC sensor.	
p0610	**Motor overtemperature response** Determines the response when the motor temperature reaches the alarm threshold p0604.	
	0	Alarm (A07910), but no response of the motor.
	1	Alarm (A07910) and reduction of the current limit (factory setting) - this reduces the motor speed.
	2	Fault (F07011) and shutdown.
p0640	**Current limit** (input in A)	

Additional information on the motor temperature monitoring can be found in function diagram 8016 of the List Manual.

6.4.3 Protecting the motor by calculating the motor temperature

The temperature calculation is only possible in the sensorless vector control mode (p1300 ≥ 20) and functions by calculating a thermal motor model.

Parameters to sense the temperature without using a temperature sensor

Parameters	Description	
P0621 = 1	**Motor temperature measurement after restarting**	
	0	No temperature identification (factory setting)
	1	Temperature identification after the motor is switched on for the first time
	2	Temperature measurement each time that the motor is switched on
P0622	**Magnetization time of the motor for temperature measurement after starting** (set automatically as the result of motor data identification)	
P0625 = 20	**Ambient motor temperature** Enter the ambient motor temperature in °C at the instant that the motor data is acquired (factory setting: 20 °C). The difference between the motor temperature and motor environment (P0625) must lie within a tolerance range of approx. ± 5 °C.	

6.4.4 Overcurrent protection

During sensorless vector control, the motor current remains within the current torque limits set.

During V/f control, the maximum current controller (I_{max} controller) protects the motor and variable speed drive against overload by limiting the output current.

Method of operation of I_{max} controller

If an overload situation occurs, the speed and stator voltage of the motor are reduced until the current is within the permissible range. If the motor is in generator mode, i.e. it is being driven by the connected machine, the I_{max} controller increases the speed and stator voltage of the motor to reduce the current.

The variable speed drive load is only reduced if the motor torque decreases at lower speeds (e.g. for fans).

In the generator mode, the current only decreases if the torque decreases at a higher speed.

Settings

You only have to change the factory settings of the I_{max} controller if the drive tends to oscillate when it reaches the current limit or it is shut down due to overcurrent.

Parameters	Description
p0305	**Rated motor current**
p0640	**Motor current limit**
p1340	**Proportional gain of the I-max controller for speed reduction**
p1341	**Integral time of the I-max controller for speed reduction**
r0056.13	**Status: I_{max} controller active**
r1343	**Speed output of I_{max} controller** Shows the amount to which the I_{max} controller reduces the speed.

For more information about this function, see function diagram 1690 in the List Manual.

In the case of overvoltage, the motor switches off with OFF2 and flags the fault F07801.

6.4.5 Protection against short circuit

Short-circuit protection is covered by the function Overcurrent protection [→ 189] . The G120P detects the short-circuit via the rapid increase in current and outputs the fault code F30022. It also provides the location of the short-circuit via the additional bit:

- Bit 0: Short-circuit in U phase
- Bit 1: Short-circuit in V phase
- Bit 2: Short-circuit in W phase

In the case of a short-circuit at the output terminals on the motor side of the variable speed drive, the fault code F07807 appears.

The following alarms are also output:

- A30031 power unit: Hardware current limiting in phase U
- A30032 power unit: Hardware current limiting in phase V
- A30033 power unit: Hardware current limiting in phase W

In the event of a short-circuit, the motor switches off with OFF2.

6.4.6 Protection against ground fault

Ground fault protection is covered by the function Overcurrent protection [→ 189] . As for a short-circuit, the G120P detects the ground fault via the rapid increase in current. In the case of a ground fault, however, the total current does not equal 0.

The trip values for ground-fault monitoring can be set via p0287.

A ground fault is displayed at r3113.05 and also using fault codes F30001 and F30021. In the case of a ground fault in the DC link, fault code F30027 appears.

In the event of a short-circuit, the motor is switched off with OFF2.

6.4.7 Phase failure

If a phase should fail, the G120P continues to run up to approx. 50% of the speed, for example in fans and pumps.

The value depends on the motor load. In the case of a greater motor load, for example, in compressors, the achievable speed is significantly lower.

In the case of a very high load, the speed can drop to 0. In this case, the motor switches off with OFF2 and displays the phase failure with the fault code F30011. The fault code for under-voltage in the DC link (F30003) can also appear in the event of a phase failure.

You can add this fault to exception list p1206 to prevent an automatic restart. For further information, refer to Automatic restart [→ 122].

In this way, you can prevent frequent restart attempts that can lead to the motor winding overheating due of a lack of cooling.

You can also prevent this by reducing the number of restart attempts. By reducing the G120P's starting current, the time interval compared to conventional variable speed drives can, however, be significantly less than 6 minutes.

6.4.8 Limiting the maximum DC-link voltage

How does the motor generate overvoltage?

An induction motor operates as a generator if it is driven by the connected load. A generator converts mechanical power into electrical power.

The electrical power flows back into the variable speed drive and causes VDC in the variable speed drive to increase.

Above a critical DC-link voltage both the variable speed drive and the motor will be damaged. Before the voltage can reach critical levels, however, the variable speed drive switches the motor off with the fault message "DC link overvoltage".

Protecting the motor and variable speed drive against overvoltage

To the extent the application permits, the VDC_max controller prevents the DC-link voltage from reaching critical levels. The VDC_max controller increases the ramp-down time of the motor during braking, so that the motor feeds back only as little power to the variable speed drive as is covered by the losses in the variable speed drive.

The VDC_max controller is not suitable for applications that require permanent motor generator operation.

There are two different groups of parameters for the VDC_max controller, depending on whether the motor is being operated with V/f control or sensorless vector control.

Parameter for V/f control	Parameter for vector control	Description
p1280 = 1	p1240 = 1	**VDC controller or VDC monitoring configuration** (factory setting: 1)1: Enable VDC_max controller
r1282	r1242	**VDC_max controller switch-in level** Shows the value of the DC-link voltage above which the VDC_max controller is active
p1283	p1243	**VDC_max controller dynamic factor** (factory setting: 100 %) Scaling of the control parameters p1290, p1291, and p1292
p1290	p1250	**VDC_max controller proportional gain** (factory setting: 1)
p1291	p1251	**VDC_max controller integral time** (factory setting p1291:40 ms, factory setting p1251:0 ms)
p1292	p1252	**VDC_max controller rate time** (factory setting p1292:10 ms, factory setting p1252:0 ms)
p1294	p1254	**VDC_max controller automatic ON level detection** (factory setting p1294:0, factory setting p1254:1) Activates or deactivates the automatic detection of the VDC_max control's switch-on levels 0: Automatic detection disabled 1: Automatic detection enabled
p0210	p0210	**Unit supply voltage** If p1254 or p1294 = 0, the variable speed drive uses this parameter to calculate the intervention thresholds of the VDC_max controller. Set this parameter to the actual value of the input voltage.

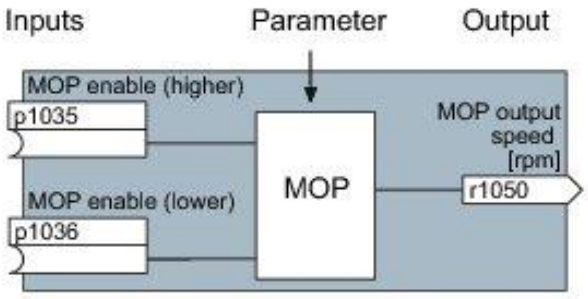
For more information about this function, see function diagram 6320 or 6220 in the List Manual.

6.5 Function & logic blocks (BICO technology)

6.5.1 Basic principles

Operating principle

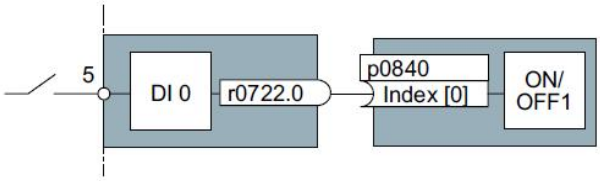
Open/closed-loop control functions, communication functions as well as diagnostic and operator functions are implemented in the variable speed drive. Every function comprises one or several BICO blocks that are interconnected with one another.



Most of the BICO blocks can be assigned parameters. You can adapt the blocks to your application using parameters.

You cannot change the signal interconnection within the block. However, the interconnection between blocks can be changed by interconnecting the inputs of a block with the appropriate outputs of another block.

The signal interconnection of the blocks is realized, contrary to electric circuitry, not using cables, but in the software.



Connectors and binectors

Connectors and binectors are used to exchange signals between the individual BICO blocks:

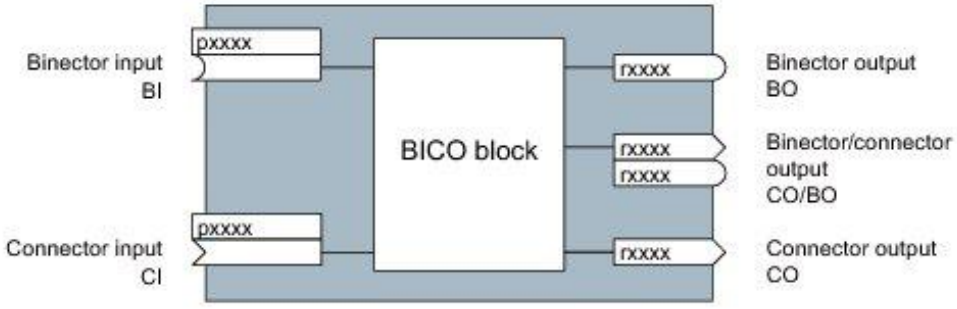
- Connectors are used to interconnect analog signals, for example motorized potentiometer output speed
- Binectors are used to interconnect digital signals, for example the command "Enable MOP raise"

Definition of BICO technology

BICO technology represents a type of parameter assignment that can be used to disconnect all internal signal interconnections between BICO blocks or establish new connections. This takes place using binectors and connectors, hence the name BICO technology. (Binector Connector Technology)

BICO parameters

You can use the BICO parameters to define the sources of the input signals of a block. Using BICO parameters you define from which connectors and binectors a block reads in its input signals. This is how you interconnect the blocks stored in the devices according to your particular application requirements. The five different BICO parameter types are shown in the following diagram:



Connector/binector outputs (CO/BO) are parameters that combine more than one binector output in a single word, e.g. r0052 CO/BO: Status word 1. Each bit in the word represents a digital (binary) signal. This summary reduces the number of parameters and simplifies parameter assignment.

BICO outputs (CO, BO, or CO/BO) can be used more than once.

A new feature of the G120P is the inclusion of logic blocks, which enable logical connectives and calculations to be made.

When do you need to use BICO technology?

BICO technology allows you to adapt the variable speed drive to a wide range of different requirements with ease. This does not necessarily have to involve highly complex functions.

Example 1: Assign a different function to a digital input.

Example 2: Switch the speed setpoint from the fixed speed to the analog input.

What precautions should you take when using BICO technology?

Always apply caution when handling internal interconnections. Note which changes you make as you go along since the process of analyzing them later can be quite difficult.

The STARTER commissioning tool offers various screens that make it much easier for you to use BICO technology. The signals that you can interconnect are displayed in plain text, which means that you do not need any prior knowledge of BICO technology.

What sources of information do you need to help you set parameters using BICO technology?

This manual is sufficient for simple signal interconnections, e.g. assigning a different significance to the digital inputs.

The parameter list in the List Manual is sufficient for signal interconnections that go beyond just simple ones.

You can also refer to the function diagrams in the List Manual for complex signal interconnections.

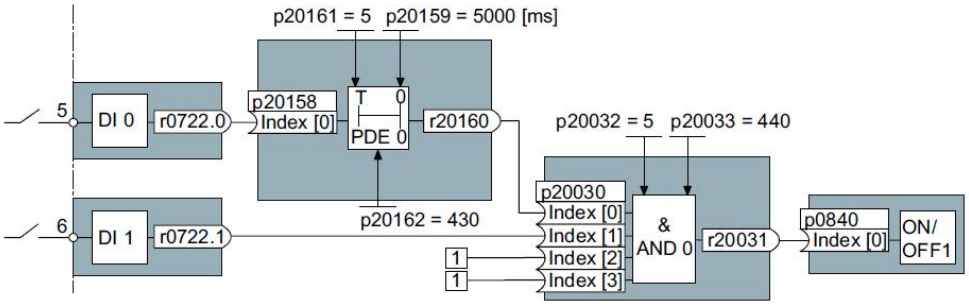
6.5.2 Example

Shifting a basic PLC functionality into the variable speed drive

A conveyor system is to be configured in such a way that it can only start when two signals are present simultaneously. These could be the following signals, for example:

- The oil pump is running, although the required pressure level is not reached until after 5 seconds
- The protective door is closed

The task is realized by inserting free blocks between digital input 0 and the internal ON/OFF1 command and interconnecting them.



The signal of digital input 0 (DI 0) is fed through a time block (PDE 0) and is interconnected with the input of a logic block (AND 0). The signal of digital input 1 (DI 1) is interconnected to the second input of the logic block. The logic block output issues the ON/OFF1 command to switch on the motor.

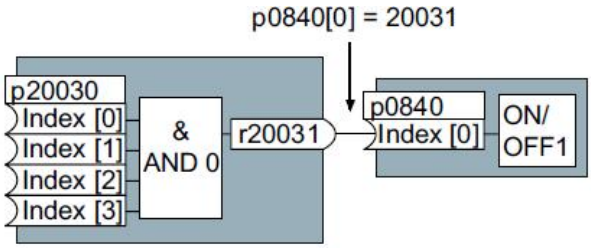
Parameter settings

Parameters	Description
p20161 = 5	The time block is enabled by assigning to runtime group 5 (time slice of 128 ms)
p20162 = 430	Run sequence of the time block within runtime group 5 (processing before the AND logic block)
p20032 = 5	The AND logic block is enabled by assigning to runtime group 5 (time slice of 128 ms)
p20033 = 440	Run sequence of the AND logic block within runtime group 5 (processing after the time block)
p20159 = 5000.00	Setting the delay time [ms] of the time module: 5 s
p20158 = 722.0	Wiring the DI 0 status to the time module input r0722.0 = parameter that displays the status of digital input 0
p20030 [0] = 20160	Interconnecting the time block to the first AND input
p20030 [1] = 722.1	Wiring the DI 1 status to the second AND input r0722.1 = parameter that displays the status of digital input 1
p0840 = 20031	Interconnecting the AND output to the control command ON/OFF1

Explanation of the example using the ON/OFF1 command

Parameter P0840[0] is the input of the "ON/OFF1 command" block of the variable speed drive.

Parameter r20031 is the output of the AND block. To interconnect the ON/OFF1 command with the output of the AND block, set P0840 to 20031.



Principle when connecting BICO blocks using BICO technology

An interconnection between two BICO blocks comprises a connector or binector and a BICO parameter. The interconnection is always established from the perspective of the input of a particular BICO block. This means that the output of an upstream block must always be assigned to the input of a downstream block. Be sure to enter the number of the connector/binector from which the required input signals are read in a BICO parameter.

This interconnection logic involves the question: Where does the signal come from?

!	*NOTICE*
	Loss of BICO settings For the basic commissioning, you determine the function of the interfaces for your variable speed drive via predefined settings using the macro parameter (p0015). • Please be aware that if you subsequently select a different predefined setting for the function of the interfaces, then all BICO interconnections that you changed will be lost.

6.5.3 Free function blocks

In addition to the BICO blocks for normal control functionality, further BICO blocks (the "free function blocks") are available for additional functions.

None of the free function blocks in the variable speed drive are used in the factory setting.

The following free function blocks are available:

- Logic blocks AND, OR, XOR, and NOT
- Arithmetic blocks ADD, SUB, MUL, DIV, AVA (device for forming absolute values), NCM (numeric comparator), and PLI (polyline)
- Time modules MFP (pulse generator), PCL (pulse shortening), PDE (ON delay), PDF (OFF delay), and PST (pulse stretching)
- Memory: RSR (RS flip-flop), DSR (D flip-flop)
- Switches NSW (numeric change-over switch) and BSW (binary change-over switch)
- Controllers LIM (limiter), PT1 (smoothing element), INT (integrator), and DIF (differentiating element)
- Limit value monitoring (LVM)

You will find an overview of all of the free function blocks and their parameters in the List Manual, in Chapter "Function diagrams" in Section "Free function blocks" (function diagrams 7210 ff).

Activating the free blocks

▷ Proceed as follows to use a free function block:

1. Select the function block via the function diagram in the parameter list. This is where you will find all necessary parameters for interconnecting the block.
2. Assign the block to a runtime group.
3. Define the run sequence within the runtime group. This is only required if you have assigned several blocks in the same runtime group.
4. Interconnect the block's inputs and outputs with the corresponding signals on the variable speed drive.

The runtime groups are calculated at different intervals (time slices).

Please refer to the following table to see which free function blocks can be assigned to which time slices.

	Runtime groups 1 to 6 with associated time slices					
Free function blocks	**1**	**2**	**3**	**4**	**5**	**6**
	8 ms	**16 ms**	**32 ms**	**64 ms**	**128 ms**	**256 ms**
Logic blocks AND, OR, XOR, and NOT	✓	✓	✓	✓	✓	✓
Arithmetic blocks ADD, SUB, MUL, DIV, AVA, NCM, and PLI					✓	✓
Time modules MFP, PCL, PDE, PDF, and PST					✓	✓
Memory RSR, DSR	✓	✓	✓	✓	✓	✓
Switch NSW					✓	✓
Switch BSW	✓	✓	✓	✓	✓	✓
Controllers LIM, PT1, INT, and DIF					✓	✓
Limit value monitoring LVM					✓	✓

✓ = The block can be assigned to the runtime group

Scaling analog signals

If you interconnect a physical quantity, e.g. speed or voltage to the input of a free function block using BICO technology, then the signal is automatically scaled to a value of 1. The analog output signals of the free function blocks are also available as scaled quantities (0 ≙ 0%, 1 ≙ 100%).

As soon as you have interconnected the scaled output signal of a free function block to functions that require physical input quantities, e.g. the signal source of the upper torque limit (p1522), then the signal is automatically converted into the physical quantity.

The quantities with their associated scaling parameters are listed in the following:

- Speeds p2000 reference speed (corresponds 100%)
- Voltage values p2001 reference voltage (corresponds 100%)
- Current values p2002 reference current (corresponds 100%)
- Torque values p2003 reference torque (corresponds 100%)
- Power values p2004 reference power (corresponds 100%)
- Angle p2005 reference angle (corresponds 100%)
- Acceleration p2007 reference acceleration (corresponds 100%)
- Temperature 100 °C (corresponds 100%)

Scaling examples

- Speed:
  Reference speed p2000 = 3,000 rpm, actual speed 2,100 rpm. As a consequence, the following applies to the scaled input quantity:
  2100 / 3000 = 0,7.
- Temperature:
  Reference quantity is 100 °C. For an actual temperature of 120 C, the input value is obtained from 120 C / 100 C = 1.2.

Enter limits within the function blocks as scaled values. The scaled value can be calculated as follows using the reference parameters:
Scaled limit value = physical limit value or value of the reference parameter.
The reference parameter assignment can be found in the parameter list in the individual parameter descriptions.

Example: Logic combination of two digital inputs

▷ You want to switch on the motor via digital input 0 and also via digital input 1:

1. Activate a free OR block by assigning it to a runtime group, and define the run sequence.
2. Interconnect the status signals of the two digital inputs DI 0 and DI 1 via BICO to the two inputs of the OR block.
3. Interconnect the OR block output with the internal ON command (p0840).

Parameters	Description
p20048 = 1	**Assignment of block OR 0 to runtime group 1** (factory setting: 9999) The block OR 0 is calculated in the time slice with 8 ms
p20049 = 60	**Definition of run sequence** within runtime group 1 (factory setting: 60) Within one runtime group, the block with the smallest value is calculated first.
p20046 [0] = 722.0	**Interconnection of first OR 0 input** (factory setting: 0) The first OR 0 input is linked to digital input 0 (r0722.0)
p20046 [1] = 722.1	**Interconnection of second OR 0 input** (factory setting: 0) The second OR 0 input is linked to digital input 1 (r0722.1)
p0840 = 20047	**Interconnection of the OR 0 output** (factory setting: 0) The OR 0 output (r20047) is connected with the motor's ON command

You can find additional information in the following manuals:

- "Free function blocks" Function Manual (http://support.automation.siemens.com/WW/view/en/35125827)
- "Description of the DCC standard blocks" Function Manual (http://support.automation.siemens.com/WW/view/en/29193002)

7 Communication

7.1 Overview

The **CU230P-2** has various interfaces for communication.

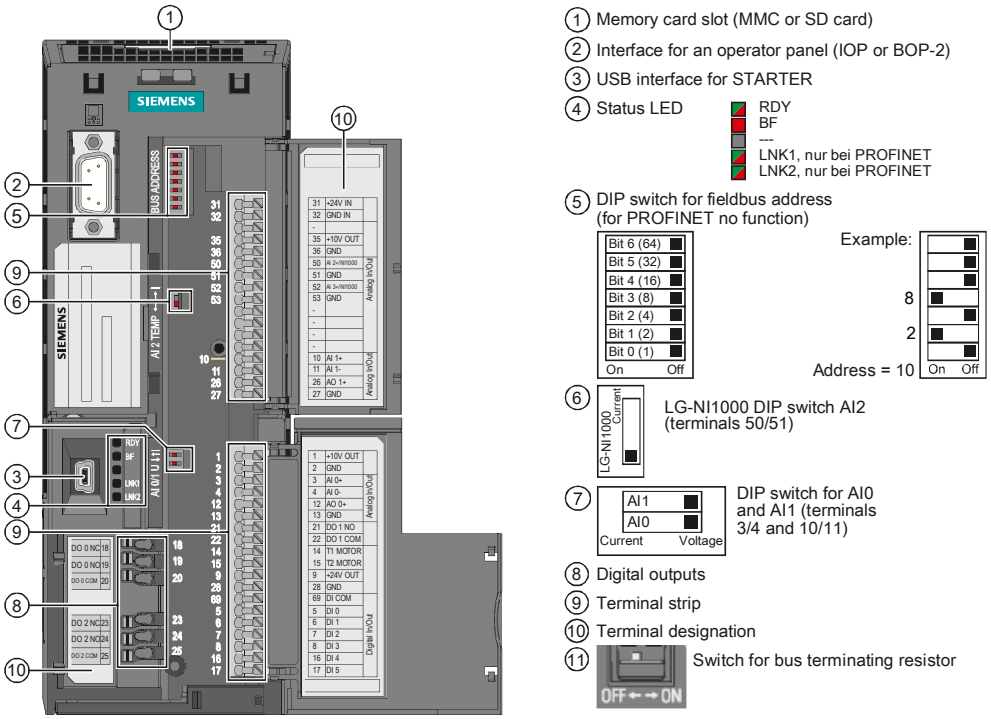
The following interfaces are available regardless of the type ordered:

- Interface for BOP-2 or IOP
- USB for communication with the STARTER software

The following interfaces are also available depending on the type ordered:

- The standard CU in the G120P BT bundle, the **CU230P-2 BT**, has an RS485 interface for connecting to various fieldbus systems (USS, Modbus RTU, and BACnet MS/TP.
- **CU230P-2 DP** has a SUB-D interface for connecting to PROFIBUS DP.
- **CU230P-2 CAN** has a SUB-D interface for connecting to CANopen.
- **CU230P-2 PN** has an RJ45 interface (Ethernet) for connecting to PROFINET.

Overview of the interfaces



7.2 Interface for BOP-2 or IOP

The operating device and display device for the CU are attached to this interface.

The following two devices are available:

- BOP-2 basic operator panel
- IOP intelligent operator panel

The devices are automatically detected by the CU. No configuration is required for these interfaces.

7.3 USB

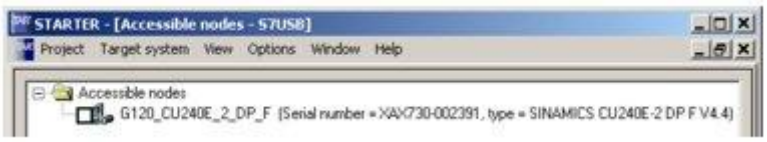
The USB interface is used for the connection between the CU230P-2 and a computer which has STARTER software installed.

▷ Proceed as follows to connect the variable speed drive and the computer:

1. Switch on the variable speed drive power supply and connect the variable speed drive to the PC via USB.
2. Install the USB driver if you are connecting the variable speed drive and PC together for the first time. Windows 7 automatically installs the driver; for older Windows versions, you must confirm the automatic installation.
3. Start the STARTER commissioning software.
4. If you are using STARTER for the first time, check whether the USB interface is correctly set. To do this, click in STARTER on  "Accessible nodes".

Case 1: USB interface OK - no setting is required

➔ If the interface is correctly set, the following screen form shows the variable speed drive that is directly connected to your computer via the USB interface.



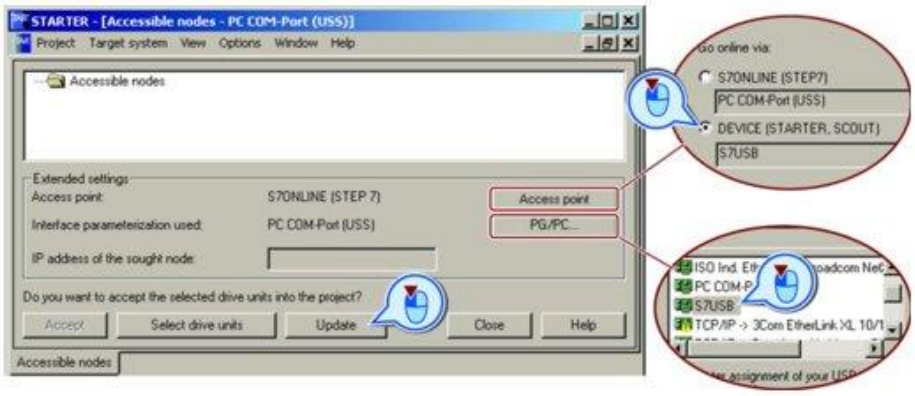
- Close this screen without selecting a variable speed drive.

⇨ The USB interface is ready and you can create your STARTER project.

Case 2: USB interface must be set

▷ In this case, the "No further node found" message appears.
Set the following in the "Accessible nodes" screen:

1. Under "Access point", activate the option "DEVICE (STARTER, Scout)".
2. Under "PG/PC", select the option "S7USB".
3. Then click on "Update".



4. Close this screen without selecting a variable speed drive.

⇨ The USB interface is ready and you can create your STARTER project.

7.4 RS485

The RS485 interface is provided for connecting to a fieldbus system. The following systems/protocols are supported:

- USS
- Modbus RTU
- BACnet MS/TP

Short description

The connection via RS485 enables communication to take place between different devices. It has a high level of immunity and facilitates communication over longer distances.

The RS485's connections have short-circuit proof, isolated pins.

Switch-in the bus terminating resistor for the first and last nodes.

You can disconnect one or more slaves from the bus (by unplugging the bus connector) without interrupting the communication for the other stations, but not the first or last.

When the bus is operating, the first and last bus station must be continuously connected to the supply.

Integration into Desigo

See Engineering Manual TX G120P (document ID: CM110576xx_01).

Connections on the CU230P-2 BT

1 0 V, reference potential
2 RS485P, receive and transmit (+)
3 RS485N, receive and transmit (-)
4 Cable shield
5 Not connected
11 Switch for bus terminating resistor

7.4.1 Communication via USS

Using the USS protocol (protocol of the universal serial interface), you can set up a serial data connection between a higher-level master system and several slave systems (RS485 interface). Master systems can be building services control systems, e.g. Desigo, programmable logic controllers, or PCs.

The variable speed drives are always slaves on the bus system.

Communication using the USS protocol takes place over the RS485 interface with a maximum of 31 slaves.

The maximum cable length is 1,200 m (3,300 ft).

Basic settings for communication

Setting the address

You can set the variable speed drive's USS address via the address switch on the Control Unit via p2021 or in STARTER under "Control Unit/Communications/fieldbus".

Valid address range: 1…30

Procedure

Method	Description
Address	If you have specified a valid address using the address switch, this address will always

Method	Description
switch	be the one that takes effect and parameter p2021 cannot be changed.
p2021/STARTER	**Fieldbus address** (factory setting: 0) The setting in p2021 or via STARTER is only effective if the address, set using the address switch, is invalid (0 or > 30).

For a modified bus address to be effective, you have to switch the variable speed drive and – if need be – any external 24 V supply off and on.

Additional settings

Parameters	Description				
p0015 = 21	**Drive unit macro** Select the value 21 (from firmware 4.6 and later: 108) (with IOP: "USS fieldbus")				
p2020	**Set the baud rate**				
	Value	Baud rate		Value	Baud rate
	4 5 6 7 8	2400 4800 9600 19200 38400		9 10 11 12 13	57600 76800 93750 115200 187500
p2021	**USS addresses** Valid USS addresses: 1…30 Invalid USS addresses: 0.31…127				
p2022	**Fieldbus interface USS PZD number** Sets the number of 16-bit words in the PZD part of the USS telegram Setting range: 0 to 8 (0 to 8 words)				
p2023	**Fieldbus interface USS PKW number** Sets the number of 16-bit words in the PKW part of the USS telegram Setting range: ● 0, 3, 4: 0, 3, or 4 words ● 127: variable lengths				
p2040	**Fieldbus interface monitoring time [ms]** Sets the monitoring time to monitor the process data received via the fieldbus. If no process data is received within this time, an appropriate message is output. The 0 ms setting deactivates the monitoring process.				

7.4.2 Communication over Modbus RTU

The Modbus protocol is a communication protocol with linear topology based on a master/slave architecture. In the Modbus RTU (Remote Terminal Unit), the data is transferred in binary format and the data throughput is greater than in ASCII code.

The Control Unit supports Modbus RTU as a slave with even parity.

1 bit Start	8-bit data	1 bit Parity even	1 bit Stop

Communication settings

- Communication using Modbus RTU takes place over the RS485 interface with a maximum of 247 slaves.
- The maximum cable length is 1,200 m (3,281 ft).
- Two 100 kΩ resistors are provided to polarize the receive and send cables.

The "Unit switchover" function is not permissible with this bus system.

Basic settings for communication

Setting the address

You can set the variable speed drive's Modbus-RTU address via the address switches on the Control Unit via p2021 or in STARTER under "Control Unit/Communications/fieldbus".

Valid address range: 1…247

Procedure

Method	Description
Address switch	If you have specified a valid address using the address switch, this address will always be the one that takes effect and parameter p2021 cannot be changed.
p2021/STARTER	**Fieldbus address** (factory setting: 1) The setting in p2021 or via STARTER is effective only if you set all address switches to "OFF" (0).

Additional settings

Parameters	Description
p0015 = 21	**Drive unit macro** Select the value 21 (from firmware 4.6 and later: 109)
p2030 = 2	**Fieldbus protocol selection** (only with firmware < 4.6) 2: Modbus
p2020	**Fieldbus baud rate** Baud rates from 4,800 bit/s to 187,500 bit/s can be set for communication, factory setting = 19,200 bit/s.
p2021	**Modbus RTU addresses** Valid Modbus RTU addresses: 1…247 Invalid Modbus RTU address: 0
p2024	**Modbus timing** ● Index 0: Maximum slave telegram processing time: The time after which the slave must have sent a response to the master. ● Index 1: Character delay time: Character delay time: Maximum permissible delay time between the individual characters in the Modbus frame (Modbus standard processing time for 1.5 bytes). ● Index2: Inter-telegram delay: Maximum permissible delay time between Modbus telegrams (Modbus standard processing time for 3.5 bytes).
p2029	**Fieldbus fault statistics** Displays receive faults on the fieldbus interface
p2040	**Process data monitoring time** Determines the time after which an alarm is generated if no process data is transferred. The 0 ms setting deactivates the monitoring process. **Note**: This time must be adapted depending on the number of slaves and the baud rate set for the bus (factory setting = 100 ms).

7.4.3 Communication via BACnet MS/TP

In BACnet, components and systems are considered to be black boxes which contain a number of objects. BACnet objects only define behavior outside the device, internal functions are not determined by BACnet.

Each component is represented by a series of object types and their instances.

Each BACnet device has precisely one BACnet device object. A BACnet device is uniquely identified by an NSAP (Network Service Access Point), comprising a network number and MAC address. The MAC (Medium Access Control) address is BACnet-specific and must not be confused with the Ethernet MAC address.

Data exchange with the client

The variable speed drive receives control commands and setpoints via service instructions from the control and transmits its status back to the control. The variable speed drive can also send telegrams automatically itself and execute services, e.g. IAm.

Communication settings

- The Control Unit supports BACnet via RS485 (BACnet MS/TP)
- The maximum cable length is 1,200 m (3,281 ft).

Protocol Implementation Conformance Statement

You will find the Protocol Implementation Conformance Statement (PICS) on the Internet under the following link: BACnet files:
http://support.automation.siemens.com/WW/view/en/38439094

The "Unit switchover" function is not permissible with this bus system.

Basic settings for communication

Setting the address

You can set the variable speed drive's MAC ID using the address switch on the Control Unit via p2021 or in STARTER under "Control Unit/Communications/fieldbus".

Valid address range: 0 to 127 (with address 0, the variable speed drive responds to a broadcast)

▷ Observe the following to improve performance:

1. Assign the consecutive addresses (1, 2, 3, 4, and not 1, 4, 5, 9, etc.).
2. Restrict the max master in the G120P to the highest address assigned.
3. Max. info frame: 10

For further information, see Chapter 6 in "Basic Ethernet, TCP/IP, and BACnet on Ethernet/IP" (CM110666xx).

Procedure

Method	Description
Address switch	If you have specified a valid address using the address switch, this address will always be the one that takes effect and parameter p2021 cannot be changed.
p2021/STARTER	**Fieldbus address** (factory setting: 1) The setting in p2021 or via STARTER is effective only if you set all address switches to "OFF" (0).

For a modified bus address to be effective, you have to switch the variable speed drive and – if need be – any external 24 V supply off and on.

Additional settings

Parameters	Description
p0015 = 21	**Drive unit macro** Select the value 21 (from firmware 4.6 and later: 110)
p2030 = 5	**Fieldbus telegram selection** (only with firmware < 4.6) 5: BACnet
p2020	**Baud rate** 6: 9600 (factory setting) 7: 19200 8: 38400 10: 76800
p2024[0 to 2]	● **Processing times** [0]: 0 ms to 10,000 ms, maximum processing time (APDU timeout), factory setting = 1,000 ms, ● [1…2]: No significance for BACnet
p2025[0 to 3]	**BACnet communication parameter** ● [0]: 0 to 4194303: Device object instance number, factory setting = 1 ● [1]: 1 to 10: Maximum info frames, factory setting = 1 ● [2]: 0 to 99: Number of APDU retries (repeated attempts after fault telegrams), factory setting = 3 ● [3]: 1 to 127: Maximum master address, factory setting = 127
p2026	**Setting of the COV_Increment** (COV = change of values) 0 to 4194303.000, factory setting = 1000 COV_Increment: Value change of the "Present Value" of an object instance where an UnConfirmedCOV_Notification or ConfirmedCOV_Notification should be transferred from the server. ● p2026 [0]: COV_Increment of object instance "Analog Input 0" ● p2026 [1]: COV_Increment of object instance "Analog Input 1" ● p2026 [2]: COV_Increment of object instance "Analog Input 10" ● p2026 [3]: COV_Increment of object instance "Analog Input 11" You can use these parameters to set for which value changes an UnConfirmedCOV_Notification or ConfirmedCOV_Notification result is sent. Therefore, the factory setting 1000 means that an UnConfirmedCOV_Notification or ConfirmedCOV_Notification is sent if the value being considered (e.g. for a control range from 0 to 10 V) changes by an absolute value of ≥ 0.1. Of course, this only applies if previously a SubscribeCOV_Service was activated for the particular object instance. You can also set the COV_Increment using the object property "COV_Increment" of the particular analog input.
p2040	**Fieldbus monitoring time** 0 ms to 1,999,999 ms, factory setting = 100 ms **Note:** The factory setting for communication with BACnet is possibly too low and must be increased. Adapt the value to the requirements and properties of your particular plant or system. The reason for the factory setting of 100 ms is that the communication protocols for USS and Modbus RTU should also be executed via the RS485 interface. The 0 ms setting deactivates the monitoring process.

Fieldbus control word

r2090	BACnet	Function	Parameters
Bit 0	BV20	Command execution	p0840
Bit 1	BV27	No OFF2	p0844
Bit 2	BV28	No OFF3	p0848
Bit 3	BV26	Enable operation	p0852

r2090	BACnet	Function	Parameters
Bit 4	BV26	Permit RFG enable	p1140
Bit 5	BV26	Enable RFG	p1141
Bit 6	BV26	Enable setpoint	p1142
Bit 7	BV22	Acknowledge faults	p2103
Bit 8	N/A	Reserved	-
Bit 9	N/A	Reserved	-
Bit 10	BV93	Master control by PLC	p0854
Bit 11	BV21	Inversion direction	p1113
Bit 12	N/A	Reserved	-
Bit 13	N/A	MOP setpoint raise	p1035
Bit 14	N/A	MOP setpoint lower	p1036
Bit 15	N/A	Reserved	-

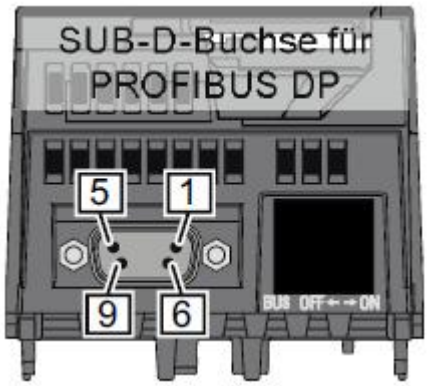
The configuration workload can be reduced by leaving out values which are not required. In this case, the appropriate parameters must be set manually.

Example: If you are not using BV93, set p0854 to 1.

7.5 PROFIBUS DP

CU230P-2 DP has a SUB-D interface for connecting to PROFIBUS DP.

Connections on the CU230P-2 DP



1) Shield, ground connection
2 Not assigned
3 RxD/TxD-P, receive and transmit (B/B')
4 CNTR-P, control signal
5 DGND, reference potential for data (C/C')
6 VP, supply voltage
7 Not assigned
8 RxD/TxD-N, receive and transmit (A/A')
9 Not assigned

Checklist for communication via PROFIBUS

Check the communication settings using the following points. If you answer "Yes" to the questions, you have correctly set the communication settings and can control the variable speed drive via the fieldbus.

- Is the variable speed drive correctly connected to the PROFIBUS?
- Have you configured the communication between the variable speed drive and the higher-level controller?
- Do the bus addresses in the variable speed drive and the higher-level controller match?
- Is the same telegram set in the higher-level controller and in the variable speed drive?
- Are the signals that the variable speed drive and the controller exchange via PROFIBUS correctly interconnected?

You can find information on the individual points in the following sections.

Connecting the variable speed drive to PROFIBUS

Permissible cable lengths, routing and shielding the PROFIBUS cable

Information can be found on the Internet:

- Product support
  http://www.automation.siemens.com/net/html_00/support/printkatalog.htm
- PROFIBUS user organization installation guidelines
  http://www.profibus.com/community/regional-pi-associations/germany-new/downloads/installations-richtlinien

Recommended PROFIBUS connectors

We recommend connectors with the following order numbers for connecting the PROFIBUS cable:

- 6GK1500-0FC00
- 6GK1500-0EA02

Pin assignment at the variable speed drive

You must supply the Control Unit with 24 V DC at terminals 31 and 32 if you wish to maintain communication with the control system when the line voltage is switched off.

In the case of short interruptions of the 24 V voltage supply, the variable speed drive may report the fault F without communications with the controller being interrupted.

Configuring communication to the control

To be able to configure communication between the variable speed drive and control, you require the GSD description file of the variable speed drive.

Procedure

▷ Import the GSD of the variable speed drive into the PROFIBUS master, i.e. into your control system.

1. There are two ways of obtaining the GSD for your variable speed drive:
   – You can find the GSD for a SINAMICS variable speed drive on the Internet under
   http://support.automation.siemens.com/WW/view/en/22339653/133100
   – The GSD is saved in the variable speed drive. The GSD is written to the directory /SIEMENS/SINAMICS/DATA/CFG if you insert a memory card into the variable speed drive and set p0804 to 12.
2. Configure the communication between the control and the variable speed drive in your control.

Setting the address

You can set the variable speed drive's PROFIBUS address via the address switch on the Control Unit via p0918 or in STARTER under "Control Unit/Communications/PROFIBUS".

Valid address range: 1…125

Procedure

Method	Description
Address switch	If you have specified a valid address with the address switches, this address will always be the one that takes effect and parameter p0918 cannot be changed.
p0918/STARTER	**PROFIBUS address** (factory setting: 126) Setting in p0918 or via STARTER is effective only if you set all address switches to "OFF" (0) or "ON" (1).

For a modified bus address to be effective, you have to switch the variable speed drive and – if need be – any external 24 V supply off and on.

Select telegram

During basic commissioning, you have defined a telegram for communication.

In order to set a different telegram, you may need to also adapt the assignment of the interfaces.

Procedure

▷ Carry out the basic commissioning again

1. Adapt the interface assignment
2. Select the telegram.

Parameters	Description	
p0015	**Macro drive unit** Configure the interface in basic commissioning, and select a telegram.	
p0922	**PROFIdrive telegram selection** (factory setting for variable speed drives with PROFIBUS or PROFINET interfaces: Standard telegram 1, PZD-2/2) Settings for the transmit and receive telegram.	
	1: 20: 350: 352 353: 354: 999:	Standard telegram 1, PZD-2/2 Standard telegram 20, PZD-2/6 SIEMENS telegram 350, PZD-4/4 SIEMENS telegram 352, PZD-6/6 SIEMENS telegram 353, PZD-2/2, PKW-4/4 SIEMENS telegram 354, PZD-6/6, PKW-4/4 Expand telegrams and change signal interconnection

7.6 CANopen

CU230P-2 CAN has an interface for CANopen.

General information on CAN

General information about CAN can be found on the CAN Internet site under: http://www.cancia.org

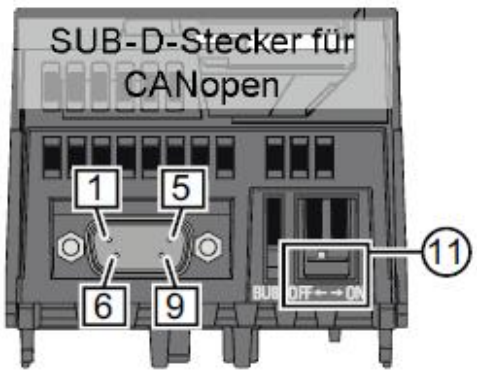
The CANdictionary under CANdownloads provides an explanation of CAN terminology: http://www.can-cia.org/index.php?id=6

The EDS file is the description file of the SINAMICS G120 variable speed drive for CANopen networks.

If you load the EDS file into your CAN controller, you can use the objects of the DSP 402 device profile.

- You can find the EDS file of the variable speed drive on the Internet under: http://support.automation.siemens.com/WW/view/en/48351511

Connections on the CU230P-2 CAN



1 Not assigned
2 CAN_L, CAN signal (dominant low)
3 CAN_GND, CAN ground
4 Not assigned
5 (CAN _SHLD), optional shield
6 (GND), optional ground
7 CAN_H, CAN signal (dominant high)
8 Not assigned
9 Not assigned
11 Switch for bus terminating resistor

Connecting a variable speed drive to a CAN bus

Connect the variable speed drive to the fieldbus via the 9-pin SUB-D pin connector.

The connections of this pin connector are short-circuit proof and isolated. If the variable speed drive forms the first or last slave in the CANopen network, switch-in the bus terminating resistor.

Integrating the variable speed drive into CANopen

▷ To integrate the variable speed drive into CANopen, proceed as follows:

1. Set the node ID and baud rate.
2. Monitor the communication and response of the variable speed drive.
3. Integrate the variable speed drive into CAN using the Predefined Connection Set.
4. If required, make additional specific changes using the free PDO mapping.
5. Adapt the BICO interconnection

CANopen functionality of the variable speed drive

CANopen is a CAN-based communication protocol with linear topology that operates on the basis of communication objects (COB).

The communication between the variable speed drive and control can be established via the Predefined Connection Set or via free PDO mapping.

Communication objects (COB)

The variable speed drive operates with communication objects from the following profiles:

- CANopen communication profile DS 301 Version 4.0
- Device profile DSP 402 (Drives And Motion Control) Version 2.0
- Indicator profile DR303-3 Version 1.0

Specifically, these are:

- SDO
  Service data objects for reading and changing parameters
- PDO
  Process data objects to transfer process data; TPDO to transmit, RPDO to receive
- NMT
  Network management objects (NMT) for controlling CANopen communication and for monitoring the individual nodes on the basis of a master-slave relationship.
- SYNC
  Synchronization objects

- EMCY
  Time stamp and fault messages

COB ID

A communication object includes data – which is transferred – and an 11-bit COB ID, which uniquely identifies it. The priority when executing the communication objects is controlled using the COB ID. The communication object with the lowest COB ID has the highest priority.

COB ID for individual communication objects

You will find the specifications for the COB IDs of the individual communication objects below:

- COB IDNMT = 0 cannot be changed
- COB IDSYNC = free – in most cases, this is preassigned with 80 hex
- COB IDEMCY = free – in most cases COB IDSYNC + node ID = COB IDEMCY
- COB IDTPDO = free in free PDO mapping
- COB IDRPDO = free in free PDO mapping
- COB IDTSDO = 580 + node ID
- COB IDRSDO = 600 + node ID
- COB IDNode Guarding/Heartbeat = 700 + node ID

Commissioning CANopen

Setting the node ID and baud rate

In the variable speed drive, you must set the node ID and the baud rate to permit communication.

Changes made to the node ID or baud rate only become effective after switching off and on again. It is particularly important that any external 24 V supply is switched off.

Note that before turning off, you must save the changes using RAM -> ROM.

The currently active node ID is displayed in parameter r8621.

You can define the node ID either using the address switch on the CU via parameter p8620 or in STARTER in the screen form under "Control Unit/Communications/CAN" under the CAN interface tab.

Valid address range: 1…126

When a valid node ID has been set using the address switches, then this is always effective and p8620 cannot be changed.

If you set all address switches to "OFF" (0) or "ON" (1), specify the node ID via p8620 or STARTER.

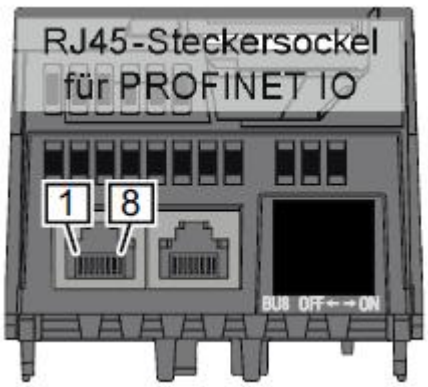
Setting the data transmission rate

You can set the transmission rate in the range from 10 kbit/s to 1 Mbit/s using parameter p8622 or in the STARTER screen form "Control Unit/Communication/CAN" under the CAN interface tab.

7.7 PROFINET

CU230P-2 PN has an RJ45 interface for connecting to PROFINET

Connections on the CU230P-2 PN



1 RX+, receive data +
2 RX-, receive data -
3 TX+. transmit data +
4 Not assigned
5 Not assigned
6 TX-, transmit data -
7 Not assigned
8 Not assigned

Functions

The Control Unit provides the following functions:

- **IRT**
  without isochronous mode
- **MRP**
  Media redundancy, not bumpless with 200 ms
  Precondition: Ring topology
- **MRPD**
  Media redundancy, bumpless
  Precondition: IRT and the ring topology created in the control
- **Diagnostic interrupt**
  According to error classes specified in the PROFIdrive profile
- **Device replacement without removable medium**
  Precondition: Topology created in the control

The Control Units have two RJ45 sockets, which you can use to implement a line topology. You can implement all topologies by using switches.

Additional information

General information on PROFINET can be found on the Internet under Industrial Communication:
http://www.automation.siemens.com/mcms/automation/de/industriellekommunikation/profinet/Seiten/Default.aspx

The configuration of the functions is described in the PROFINET system description manual.
http://support.automation.siemens.com/WW/view/en/19292127

Checklist for communication via PROFINET

Check the communication settings using the following points. If you answer "Yes" to the questions, you have correctly set the communication settings and can control the variable speed drive via the fieldbus.

- Is the variable speed drive correctly connected to the PROFINET?
- Do the IP address and device name in the variable speed drive and controller match?
- Is the same telegram set in the variable speed drive as in the higher-level controller?
- Are the signals that the variable speed drive and the controller exchange via PROFINET correctly interconnected?

Connecting the variable speed drive to PROFINET

Connect the variable speed drive (IO device) and your PG/PC (IO supervisor) via PROFINET cables with the control.

Recommended PROFINET connectors and pin assignment

We recommend the following connector with order number: 6GK1901-1BB10-2Ax0 for connecting the PROFINET cable.

Instructions for assembling the SIMATIC NET Industrial Ethernet FastConnect RF45 Plug 180 can be found on the Internet under product information "Assembly instructions for SIMATIC NET Industrial Ethernet FastConnect RJ45 Plug" at:

http://support.automation.siemens.com/WW/view/en/37217116/133300

Laying and shielding the PROFINET cable

Information can be found on the Internet: PROFIBUS user organization installation guidelines at:

http://www.profibus.com/community/regional-pi-associations/germanynew/downloads/installations-richtlinien/

Configuring communication to the control

In order to establish communication between the variable speed drive and control system via PROFINET, load the device file of the variable speed drive "GSDML" into your control.

You can then configure the communication.

Procedure

▷ Import the GSDML of the variable speed drive into the PROFINET controller, i.e. into your control system.
You have two options for obtaining the GSDML for your variable speed drive:

1. You can find the GDSML for the SINAMICS variable speed drive on the Internet at:
http://support.automation.siemens.com/WW/view/en/22339653/133100
2. The GSDML is saved in the variable speed drive. The GSDML is written to the directory /SIEMENS/SINAMICS/DATA/CFG if you insert a memory card into the variable speed drive and set p0804 to 12.
3. Configure the communication between the control and the variable speed drive in your control.

Select telegram

During basic commissioning, you have defined a telegram for communication.

In order to set a different telegram, you may need to also adapt the assignment of the interfaces.

Procedure

▷ Carry out the basic commissioning again

1. Adapt the interface assignment
2. Select the telegram.

Parameters	Description	
p0015	**Macro drive unit** Configure the interface in basic commissioning, and select a telegram.	
p0922	**PROFIdrive telegram selection** (factory setting for variable speed drives with PROFIBUS or PROFINET interfaces: Standard telegram 1, PZD-2/2) Settings for the transmit and receive telegram.	
	1: 20: 350: 352 353:	Standard telegram 1, PZD-2/2 Standard telegram 20, PZD-2/6 SIEMENS telegram 350, PZD-4/4 SIEMENS telegram 352, PZD-6/6 SIEMENS telegram 353, PZD-2/2, PKW-4/4

Parameters	Description	
	354: 999:	SIEMENS telegram 354, PZD-6/6, PKW-4/4 Expand telegrams and change signal interconnection

Activating diagnostics via the control

The variable speed drive allows you to transmit fault and alarm messages/diagnostic messages to the control according to the PROFIdrive error classes.

The functionality must be selected in the control and activated by a ramp-up.

You can output the messages directly on an HMI panel via the control.

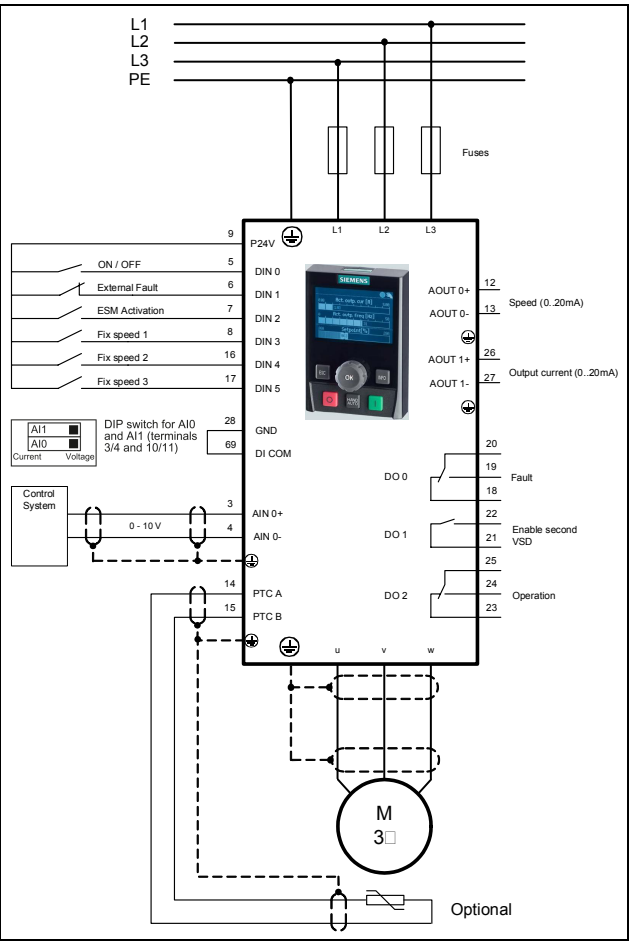
8 Applications

8.1 Universal application

- Macro 101 "Universal application"
- Setpoint via a 0 to 10 V signal
- Analog setpoint can be overridden with 3 fixed speeds
- Flying restart and automatic restart are activated
- Essential Service Mode (in the event of fire) with a fixed setpoint
- The fault code is generated via digital output 0
- The operating display is generated via digital output 2

Note:

In the case of the Essential Service Mode, the customer can no longer lodge any claims for warranty. Essential Service Mode and the faults which arise during this mode are logged in a password-protected memory and can be read by the repair center.

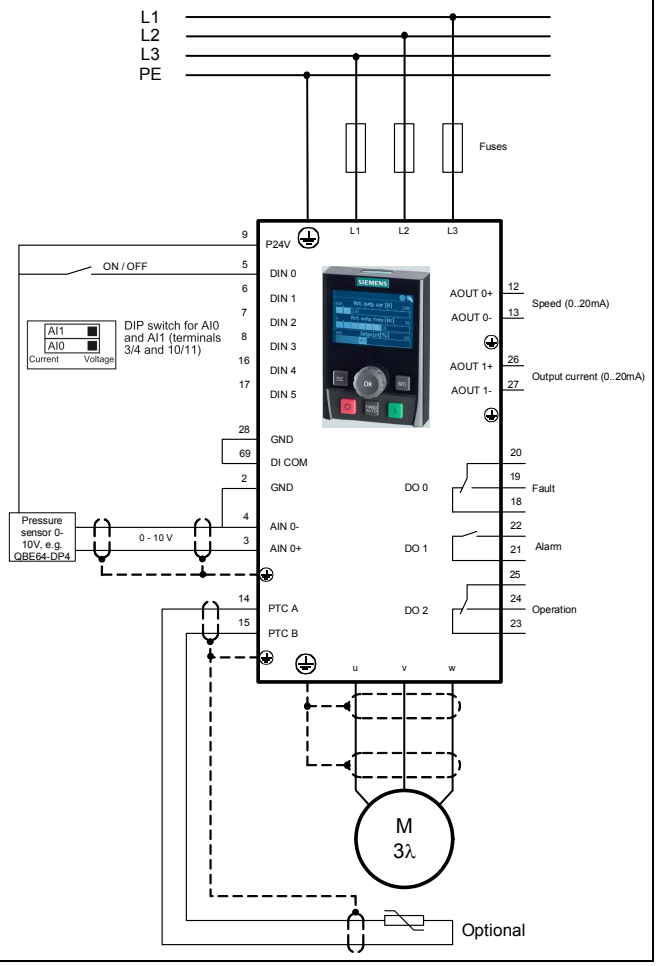


Parameters	Value	Description
p731	r52.2	Signal source for terminal DO 1
p756[0]	0	Unipolar voltage input (0 to 10 V)
p840[0]	r20047.0	ON/OFF (OFF1)
p1000[0]	32	Speed setpoint selection
p1001[0]	800 rpm	Fixed speed setpoint 1
p1002[0]	1000 rpm	Fixed speed setpoint 2
p1003[0]	1,200 rpm	Fixed speed setpoint 3
p1015[0]	1,500 rpm	Fixed speed setpoint 15
p1020[0]	r722.3	Fixed speed setpoint selection bit 0
p1021[0]	r722.4	Fixed speed setpoint selection bit 1
p1022[0]	r722.5	Fixed speed setpoint selection bit 2
p1071[0]	r20220	Main setpoint scaling
p1113[0]	0	Setpoint inversion
p1200[0]	1	Flying restart always active (start in setpoint direction)
p1210	26	Acknowledging all faults and restarting for an ON command
p2103[0]	0	Acknowledge faults

Parameters	Value	Description
p2106[0]	r722.1	External fault
p3880	r722.2	ESM activation
p3881	1	ESM setpoint source: Fixed setpoint 15 (p1015)
p20046[0]	r722.0	OR input I0
p20046[1]	r1025.0	OR input I1
p20048	1	OR runtime group
p20218[0]	100%	NSW input X0
p20218[1]	0	NSW input X1
p20219	r1025.0	NSW switch position I
p20221	5	NSW runtime group

8.2 Pump pressure control

- Macro 103 "Pump pressure control"
- Differential pressure is regulated by the integrated PID controller
- Flying restart and automatic restart are activated
- The fault code is generated via digital output 0
- The operating display is generated via digital output 2



Parameters	Value	Description
p596	4	Reference quantity technological unit
p0010	5	Parameter filter change, technological unit
p595	3	Technological unit selection: bar
p0010	0	Parameter filter ready
p756[0]	0	Unipolar voltage input (0 to 10 V)

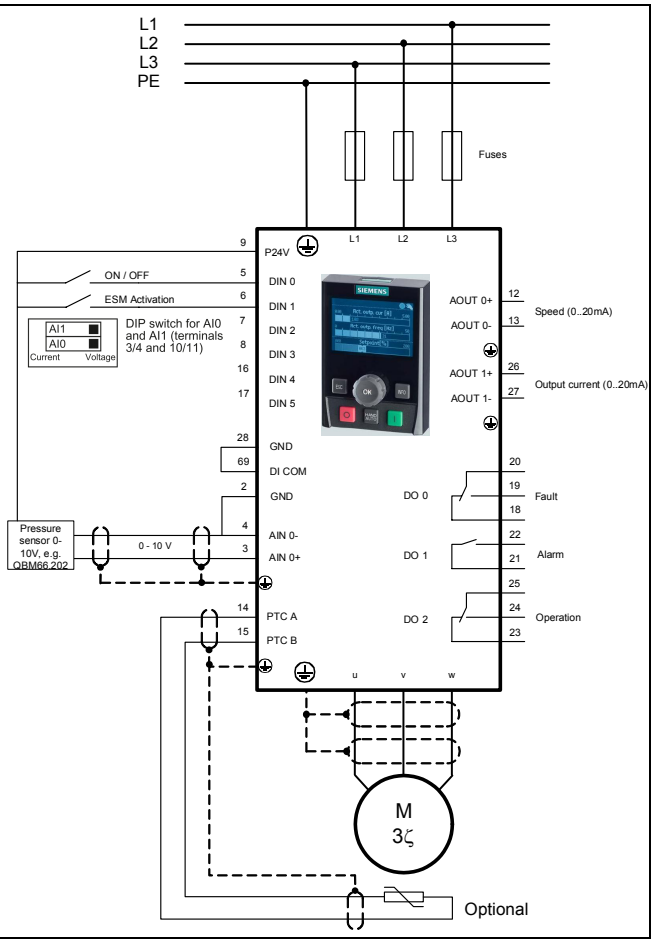
Parameters	Value	Description
p0840	r722.0	ON/OFF (OFF1)
p1200[0]	1	Flying restart always active (start in setpoint direction)
p1210	26	Acknowledging all faults and restarting for an ON command
p2200[0]	1	Technology controller enable
p2201[0]	2 bar	Technology controller fixed value 1 Set the pressure setpoint to suit the application. This example uses a 0 to 4 bar sensor (e.g. QBE64).
p2253[0]	p2201	Technology controller setpoint 1
p2257	30 s	Technology controller setpoint ramp-up time
p2258	30 s	Technology controller setpoint ramp-down time
p2264[0]	r755[0]	Technology controller actual value
p2265	10 s	Technology controller actual value filter time constant
p2267	4.2 bar	Technology controller upper limit actual value
p2268	-1 bar	Technology controller lower limit actual value
p2293	30 s	Technology controller ramp-up/ramp-down time

8.3 Pressure controlled supply fan + ESM fixed speed

- Macro 105 "Pressure controlled supply fan + ESM fixed speed"
- Pressure in the air duct is regulated by the integrated PID controller
- Flying restart and automatic restart are activated
- Essential Service Mode (in the event of fire) with fixed frequency
- The fault code is generated via digital output 0
- The operating display is generated via digital output 2

Note:

In the case of the Essential Service Mode, the customer can no longer lodge any claims for warranty. Essential Service Mode and the faults which arise during this mode are logged in a password-protected memory and can be read by the repair center.

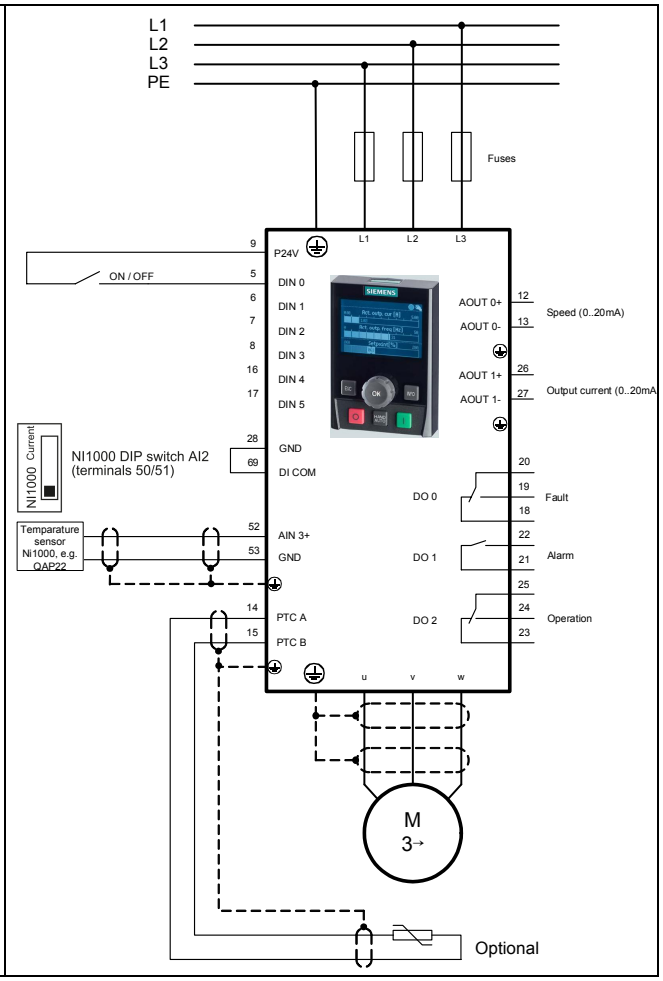


Parameters	Value	Description
p596	500	Reference quantity technological unit

Parameters	Value	Description
p0010	5	Parameter filter change, technological unit
p595	5	Technological unit selection: Pa
p0010	0	Parameter filter ready
p756[0]	0	Unipolar voltage input (0 to 10 V)
p0840	r722.0	ON/OFF (OFF1)
p1015[0]	1,350 rpm	Fixed speed setpoint 15
p1113[0]	0	Setpoint inversion
p1200[0]	1	Flying restart always active (start in setpoint direction)
p1210	26	Acknowledging all faults and restarting for an ON command
p2200[0]	1	Technology controller enable
p2201[0]	200 Pa	Technology controller fixed value 1
p2253[0]	p2201	Technology controller setpoint 1
p2257	30 s	Technology controller setpoint ramp-up time
p2258	30 s	Technology controller setpoint ramp-down time
p2264[0]	r755[0]	Technology controller actual value
p2265	10 s	Technology controller actual value filter time constant
p2267	600 Pa	Technology controller upper limit actual value
p2268	-50 Pa	Technology controller lower limit actual value
p2293	30 s	Technology controller ramp-up/ramp-down time
p3880	r722.1	ESM activation
p3881	1	ESM setpoint source: Fixed setpoint 15 (p1015)

8.4 Cooling tower fan (LG-Ni1000) + energy-saving mode

- Macro 107 "Cooling tower LG-Ni1000 sensor + energy-saving mode"
- Control of the cooling tower fan based on the temperature of the cooling water
- LG-Ni1000 temperature sensor on AI3
- Hibernation
- Flying restart and automatic restart are activated
- The fault code is generated via digital output 0
- The operating display is generated via digital output 2

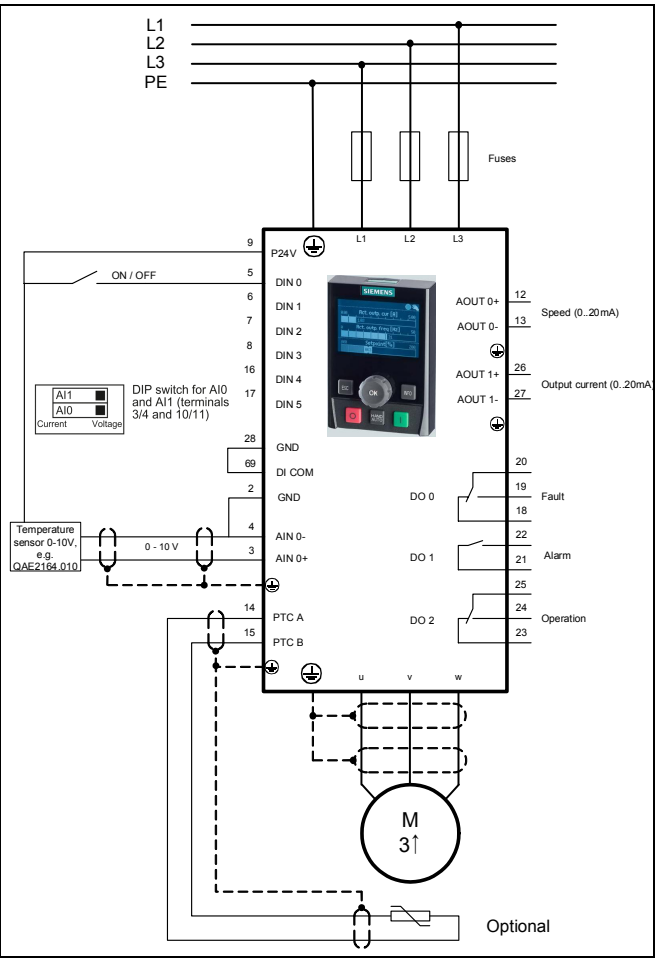


Parameters	Value	Description
p596	100	Reference quantity technological unit
p0010	5	Parameter filter change, technological unit
p595	4	Technological unit selection: °C
p0010	0	Parameter filter ready
p756[3]	6	LG-Ni1000 temperature sensor
p0840	r722.0	ON/OFF (OFF1)
p1200[0]	1	Flying restart always active (start in setpoint direction)
p1210	26	Acknowledging all faults and restarting for an ON command
p2200[0]	1	Technology controller enable
p2201[0]	26 °C	Technology controller fixed value 1
p2253[0]	p2201	Technology controller setpoint 1
p2257	30 s	Technology controller setpoint ramp-up time
p2258	30 s	Technology controller setpoint ramp-down time
p2264[0]	r755[3]	Technology controller actual value
p2265	10 s	Technology controller actual value filter time constant
p2267	100 °C	Technology controller upper limit actual value

Parameters	Value	Description
p2268	-10 °C	Technology controller lower limit actual value
p2293	30 s	Technology controller ramp-up/ramp-down time
p2306	1	Technology controller fault-signal inversion
p2390[0]	50 rpm	Hibernation start speed
p2391[0]	60 s	Hibernation delay time
p2392	1 °C	Hibernation restart value with technology controller
p2398	1	Hibernation mode

8.5 Cooling tower fan (active sensor) + energy-saving mode

- Macro 106 "Cooling tower active sensor + energy saving mode"
- Control of the cooling tower fan based on the temperature of the cooling water
- Temperature sensor 0 to 10 V on AI0
- Hibernation
- Flying restart and automatic restart are activated
- The fault code is generated via digital output 0
- The operating display is generated via digital output 2



Parameters	Value	Description
p596	100	Reference quantity technological unit
p0010	5	Parameter filter change, technological unit
p595	4	Technological unit selection: °C
p0010	0	Parameter filter ready
p756[0]	0	Unipolar voltage input (0 V to 10 V)
p0840	r722.0	ON/OFF (OFF1)
p1200[0]	1	Flying restart always active (start in setpoint direction)

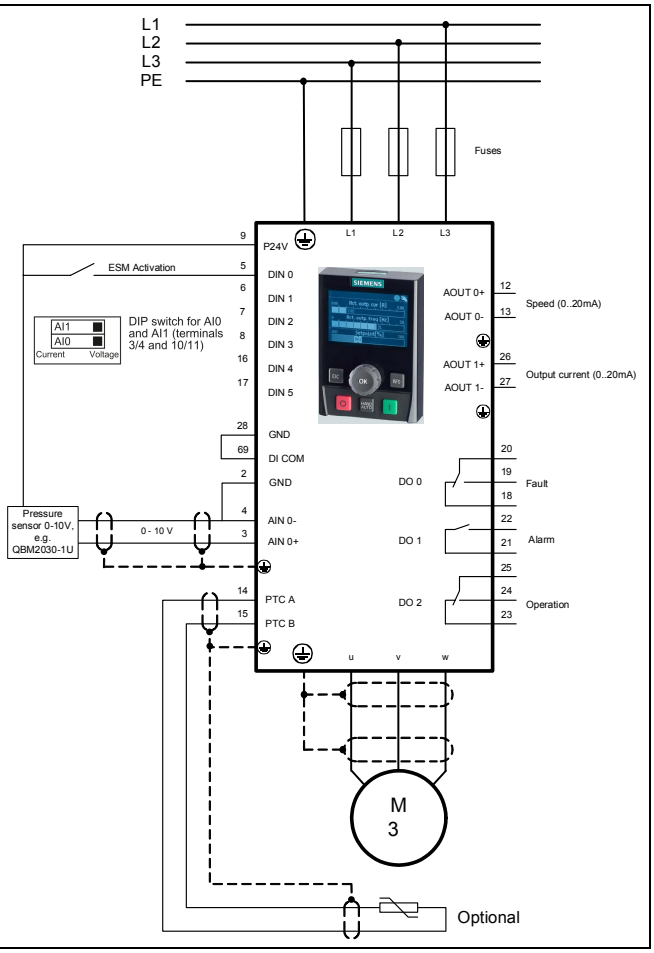
Parameters	Value	Description
p1210	26	Acknowledging all faults and restarting for an ON command
p2200[0]	1	Technology controller enable
p2201[0]	26 °C	Technology controller fixed value 1
p2253[0]	p2201	Technology controller setpoint 1
p2257	30 s	Technology controller setpoint ramp-up time
p2258	30 s	Technology controller setpoint ramp-down time
p2264[0]	r755[0]	Technology controller actual value
p2265	10 s	Technology controller actual value filter time constant
p2267	110 °C	Technology controller upper limit actual value
p2268	-10 °C	Technology controller lower limit actual value
p2293	30 s	Technology controller ramp-up/ramp-down time
p2306	1	Technology controller fault-signal inversion
p2390[0]	50 rpm	Hibernation start speed
p2391[0]	60 s	Hibernation delay time
p2392	1 °C	Hibernation restart value with technology controller
p2398	1	Hibernation mode

8.6 Stairwell pressurization (ESM)

- Macro 104 "ESM stairwell pressurization"
- Central fire alarm system starts the fan
- Essential Service Mode (in the event of fire) with pressurization, e.g. in a stairwell, in order to keep escape routes clear
- Flying restart and automatic restart are activated
- The fault code is generated via digital output 0
- The operating display is generated via digital output 2

Note:

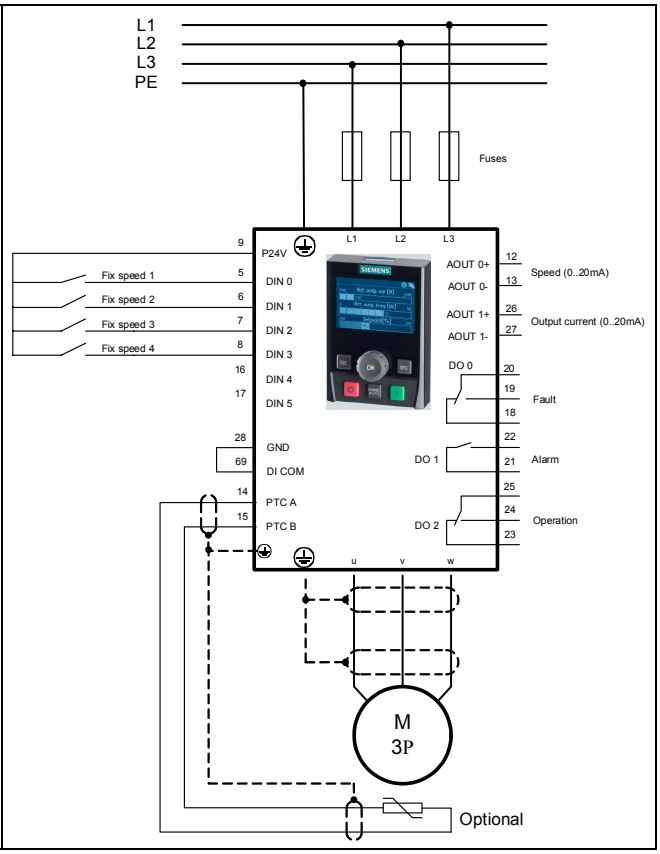
In the case of the Essential Service Mode, the customer can no longer lodge any claims for warranty. Essential Service Mode and the faults which arise during this mode are logged in a password-protected memory and can be read by the repair center.



Parameters	Value	Description
p596	100	Reference quantity technological unit
p0010	5	Parameter filter change, technological unit
p595	5	Technological unit selection: Pa
p0010	0	Parameter filter ready
p1113[0]	0	Setpoint inversion
p1200[0]	1	Flying restart always active (start in setpoint direction)
p1210	26	Acknowledging all faults and restarting for an ON command
p2200[0]	1	Technology controller enable
p2201[0]	40 Pa	Technology controller fixed value 1
p2253[0]	p2201	Technology controller setpoint 1
p2264[0]	r755[0]	Technology controller actual value
p2267	120 Pa	Technology controller upper limit actual value
p2268	-10 Pa	Technology controller lower limit actual value
p3880	r722.0	ESM activation
p3881	4	ESM setpoint from the technology controller
p3884	p2201	ESM technology controller setpoint Fixed setpoint

8.7 Fixed setpoints

- Release and selection of 4 fixed speeds via digital inputs 0 to 4
- The fault code is generated via digital output 0
- The operating display is generated via digital output 2
- If there are several inputs active simultaneously, the setpoints are added. Combined with three inputs, there are six different speed levels available. The variable speed drive starts when one of the inputs is in ON position.

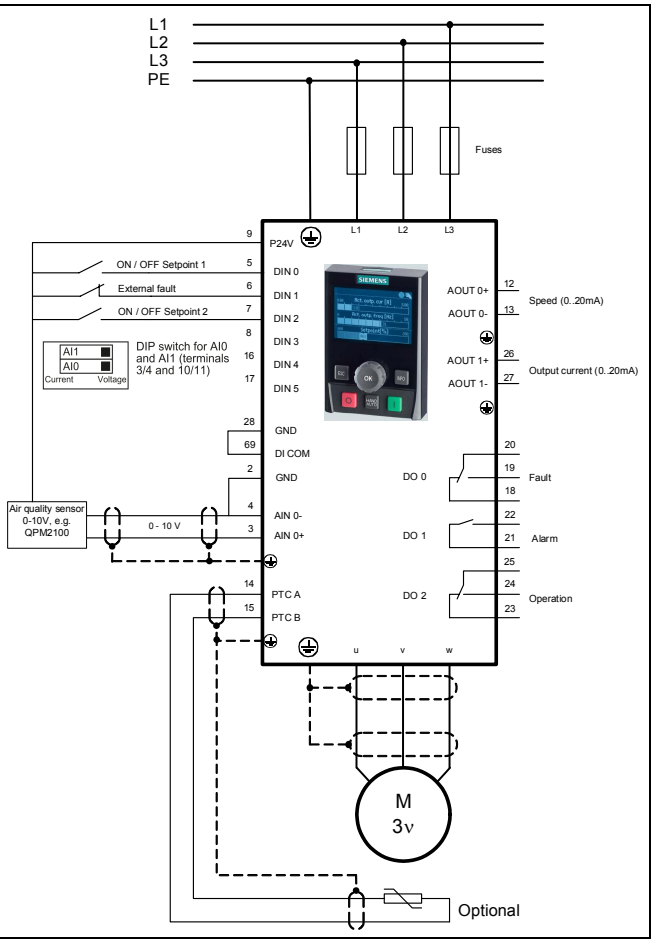


Parameters	Value	Description
p840[0]	r1025.0	ON/OFF (OFF1)

Parameters	Value	Description
p1000[0]	3	Speed setpoint selection: Fixed speed
p1001[0]	300 rpm	Fixed speed setpoint 1
p1002[0]	600 rpm	Fixed speed setpoint 2
p1003[0]	900 rpm	Fixed speed setpoint 3
p1004[0]	1,200 rpm	Fixed speed setpoint 4
p1020[0]	r722.0	BI: Fixed speed setpoint selection bit 0
p1021[0]	r722.1	BI: Fixed speed setpoint selection bit 1
p1022[0]	r722.2	BI: Fixed speed setpoint selection bit 2
p1023[0]	r722.3	BI: Fixed speed setpoint selection bit 3
p1113[0]	0	BI: Setpoint inversion
p2103[0]	0	BI: 1. Acknowledge faults

8.8 CO2 sensor, 2 PID setpoints

- ON/OFF and PID setpoint selection via DI0 or DI2
- Set the fixed setpoint (50% corresponding to the CO2 equivalent 1,000 ppm)
- External alarm at DI1. The fan is stopped.
- The fault code is generated via digital output 0
- The operating display is generated via digital output 2
- If DI0 and DI2 are active simultaneously, the setpoints are added. The variable speed drive starts when one of the inputs is in ON position.



Parameters	Value	Description
p756[0]	0	Unipolar voltage input (0 to 10 V)
p840[0]	r2225.0	ON/OFF (OFF1)
p1113[0]	0	Setpoint inversion
p2103[0]	0	BI: 1. Acknowledge faults
p2106[0]	r722.1	External fault

Parameters	Value	Description
p2200[0]	1	Technology controller enable
p2201[0]	50	Technology controller fixed value 1
p2203[0]	10	Technology controller fixed value 3
p2220[0]	r722.0	BI: Technology controller fixed value selection bit 0
p2222[0]	r722.2	BI: Technology controller fixed value selection bit 2
p2253[0]	r2224	Technology controller setpoint 1
p2264[0]	r755[0]	Technology controller actual value
p2267	120%	Technology controller upper limit actual value
p2268	-10%	Technology controller lower limit actual value
p2306	1	Technology controller fault-signal inversion

9 Appendix

9.1 Technical data

Electrical data	
Power (low overload LO)	0.37 to 90 kW
Line voltage	380 to 480 V 3 AC ±10%
Line frequency	47 to 63 Hz
Overload capability of frame sizes A – C (low overload LO)	● 1.5 x base-load current (150%) for 3 s every 300 s ● 1.1 x base-load current (110%) for 57 s every 300 s
Overload capability of frame sizes D – F (low overload LO)	1.1 x base-load current (110%) for 60 s every 300 s
Rated input current (LO: at 40 °C)	1.3 to 166 A (IP55) 1.3 to 135 A (IP20)
Base-load current LO: at 40 °C)	1.3 to 178 A (IP55) 1.3 to 145 A (IP20)
Operating temperature	0 to 60 °C while derating (see derating factors)
Relative humidity	< 95% RH, non-condensing
Output frequency	0 to 650 Hz
Pulse frequency	4 kHz (default) to 16 kHz. The pulse frequency can be changed manually in 2 kHz steps.
Frequency range that can be skipped	4, parameterizable
Fixed frequencies	15, parameterizable
Digital inputs and outputs	● 6 DI, 3 DO, 4 AI, 2 AO ● 1 x KTY/PTC/ThermoClick sensor ● 2 x PSU-out (10 VDC, 24 VDC) ● 1 x PSU-in (24 VDC)

Mechanical data	
Vibratory load ● Transport (in transport packaging) according to EN 60721-3-2 ● Operation Test values according to EN 60068-2-6	 Class 2M3 Class 3M2
Shock stressing ● Transport (in transport packaging) according to EN 60721-3-2 All devices and components ● Operation Test values according to EN 60068-2-6 Frame sizes A to F	 Class 2M3 Class 3M2

Ambient conditions	
Protection class according to EN 61800-5-1	Class I (with protective conductor system) and Class III (PELV)
Touch protection according to EN 61800-5-1	If used as intended
Permissible ambient and coolant temperature (air) during operation for line-side power components	See derating factors for derating

Ambient conditions	
and Power Modules ● Low overload (low overload LO) ● High overload (high overload HO)	 0 to 40 °C (32 to 104 °F) without derating > 40 to 60 °C (104 to 160 °F) with derating 0 to 50 °C (32 to 122 °F) without derating > 50 to 60 °C (122 to 160 °F) with derating
Permissible ambient and coolant temperature (air) during operation for Control Units and supplementary system components	● With CU230P-2: 0 to 60 °C (32 to 140 °F) ● With IOP-2: 0 to 50 °C (32 to 122 °F) ● With BOP-2: 0 to 50 °C (32 to 122 °F) ● With blanking cover: 0 to 60 °C (32 to 140 °F) ● Up to 2000 m above sea level
Climatic ambient conditions ● Storage (in transport packaging) according to EN 60721-3-1 ● Transport (in transport packaging) according to EN 60721-3-2 ● Operation acc. to EN 60721-3-3	 Class 1K3 Temperature -25 to 55 °C (-13…131 °F) Class 2K4 Temperature -40 to 70 °C (104…158 °F), max. humidity 95% at 40 °C (104 °F) Class 3K3 Condensation, splashwater, and ice formation not permitted (EN 60204, Part 1)
Environmental class/harmful chemical substances: ● Storage (in transport packaging) according to EN 60721-3-1 ● Transport (in transport packaging) according to EN 60721-3-2 ● Operation acc. to EN 60721-3-3	 Class 1C2 Class 2C2 Class 3C2
Organic/biological influences: ● Storage (in transport packaging) according to EN 60721-3-1 ● Transport (in transport packaging) according to EN 60721-3-2 ● Operation acc. to EN 60721-3-3	 Class 1B1 Class 2B1 Class 3B1
Degree of pollution according to EN 61800-5-1	2

Standards and Directives	
Standards conformance	UL, CE, c-tick
CE marking	According to Low-Voltage Directive 2006/95/EC
EMC Directive acc. to EN 61800-3: 2004 ● Frame sizes FSA to FSF with integrated line filter class A ● Frame sizes FSA to FSF with integrated or external line filter class B	With shielded motor cable up to 25 m: Category C2, corresponds to Class A acc. to EN 55011 Category C1, corresponds to class B acc. to EN 55011 for conducted interference emission
Variable-speed electrical power drive systems – part 3: EMC product standard including specific test methods	EN 61800-3: 2004
Electromagnetic compatibility – part 3-12: Limit values for temperature monitoring	EN 61000-3-12: 2011 (RSCE > 250)

UL approval for frame sizes FSD to FSF will be available soon.

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Issued by
Siemens Schweiz AG
Infrastructure & Cities Sector
Building Technologies Division
International Headquarters
Gubelstrasse 22
CH-6301 Zug
Tel. +41 41-724 24 24
www.siemens.com/buildingtechnologies

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