Bonfiglioli
Vectron

ACTIVE CUBE

Operating Instructions
Frequency inverter 230 V / 400 V / 525 V / 690 V
0.25 kW ... 400 kW

Bonfiglioli
Forever Forward

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1 General Information about the Documentation

1.1 Instruction manuals

For better clarity, the documentation is structured according to the customer-specific requirements made on the frequency inverter.

Quick Start Guide

The "Quick Start Guide" describes the basic steps required for mechanical and electrical installation of the frequency inverter. The guided commissioning supports you in the selection of necessary parameters and the configuration of the frequency inverter by the software.

Operating Instructions

The Operating Instructions document the complete functionality of the frequency inverter. The parameters required for special purposes, for adjustment to the application and the numerous additional functions are described in detail.

Application manual

The application manual supplements the documentation for purposeful installation and commissioning of the frequency inverter. Information on various topics in connection with the use of the frequency inverter is described in context with the specific application.

If you need a copy of the documentation or additional information, contact your local representative of BONFIGLIOLI.

The following instructions are available for the *ACTIVE CUBE* series:

ACTIVE CUBE Operating Instructions	Function of frequency inverter.
Quick Start Guide *ACTIVE CUBE*	Installation and commissioning Supplied with the device.
Manuals Communication interfaces	CM-CAN: CANopen manual CM-PDP-V1: Profibus DP-V1 manual CM-232/CM-485: VABus manual (serial protocol) CM-232/CM-485 Modbus: Modus ASCII and RTU manual CM-VABus/TCP: Ethernet Module CM-VABus/TCP CM-ModbusTCP: Ethernet Module CM-Modbus/TCP CM-EtherCAT®: Ethernet Module CM-EtherCAT® CM-ProfiNet: Ethernet Module CM-ProfiNet CM-EtherNet-I/P: Ethernet Module CM-EtherNet-I/P (i.V.)
Manuals Extension modules	EM-ABS-01: Absolute encoder module EM-ENC-01: Speed sensor (encoder) module EM-ENC-02: Speed sensor (encoder) module EM-ENC-03: Speed sensor (encoder) module EM-ENC-04: Speed sensor (encoder) module EM-ENC-05: Speed sensor (encoder) module EM-IO-01: Extension module for digital inputs/outputs EM-IO-02: Extension module for digital inputs/outputs EM-IO-03: Extension module for digital inputs/outputs EM-IO-04: Extension module for digital inputs/outputs EM-RES-01: Resolver module EM-RES-02: Resolver module EM-RES-03: Resolver module EM-SYS: System Bus module
Safe Torque Off (STO) manual	Safety function STO
Liquid Cooling - Complement to Operating Instructions	Properties specific to liquid cooled frequency inverters
Application manual "Parallel connection"	Parallel connection of Size 8 frequency inverters
PLC application manual	Logic linking of digital signals. Functions for analog signals such as comparisons and mathematical functions. Graphical support for programming with function blocks.
Application manual "Positioning"	Positioning functions of Configurations x40.
Application manual "Electronic gear"	Linking of at least 2 drives as electronic gear with Slave drive in Configuration x15 or x16.
Application manual "Hoist unit drives"	Advanced brake control for hoist unit drives.

The products for CANopen® communication comply with the specifications of the user organization CiA® (CAN in Automation).

The products for EtherCAT® communication comply with the specifications of the user organization ETG (EtherCAT Technology Group).

The present documentation was prepared with great care and it was subjected to extensive and repeated reviews. For reasons of clarity, it was not possible to include all details of all types of the product in the documentation. Neither was it possible to consider all conceivable installation, operation or maintenance situations. If you require further information or if you meet with specific problems which are not dealt with in sufficient detail in the documentation, contact your local BONFIGLIOLI agent.
The present document was created in German. Other language versions are translations.

1.2 This document

This documentation describes the frequency inverters of the *ACTIVE Cube* series. The modular hardware and software structure enables customer-specific adaptation of the frequency inverters. Applications with high functionality and dynamism requirements can be realized easily.
The Operating Instructions contain important information on the installation and the use of the product in its specified application range. Compliance with this user manual contributes to avoiding risks, minimizing repair cost and downtimes and increasing the reliability and service live of the frequency inverter.
For this reason, make sure you read the Operating Instructions carefully.
IMPORTANT:
Compliance with the documentation is required to ensure safe operation of the frequency inverter. Bonfiglioli Vectron GmbH shall not be held liable for any damage caused by any non-compliance with the documentation.

In case any problems occur which are not covered by the documentation sufficiently, please contact the manufacturer.

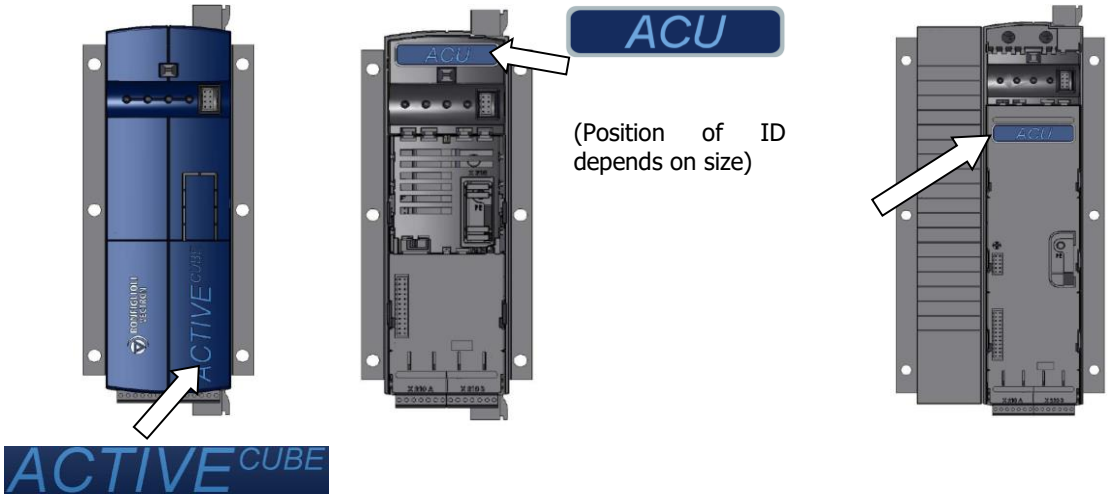
For safe commissioning and operation of the ACU (ACTIVE Cube) series, the following documentation must be complied with:

- This Operating Instructions Document
- Application manual "Safe Torque Off ACU"

This documentation applies to the following frequency inverter series:

- ACTIVE Cube 210
- ACTIVE Cube 410
- ACTIVE Cube 510
- ACTIVE Cube 610

The ACTIVE Cube series can be recognized by its label on the case and the identification below the top cover.



1.3 Warranty and liability

BONFIGLIOLI Vectron GmbH (hereinafter referred to as "manufacturer") notes that the contents of this Operating Instructions document do not form part of any previous or existing agreement, assurance or legal relationship between the manufacturer and the user of these Operating Instructions (hereinafter referred to as the "User"). Neither are they intended to supplement or replace such agreements, assurances or legal relationships. Any obligations of the manufacturer shall solely be based on the relevant purchase agreement which also includes the complete and solely valid warranty stipulations. These contractual warranty provisions are neither extended nor limited by the specifications contained in this documentation.

The manufacturer reserves the right to correct or amend the specifications, product information and omissions in these operating instructions without prior notice. The manufacturer assumes no responsibility to update these Operating Instructions. The manufacturer shall not be liable for any damage, injuries or costs which may be caused by the aforementioned reasons.

In addition, the manufacturer excludes any warranty and disclaims all liability, including without limitation direct, indirect, special, punitive, incidental, exemplary or consequential damages arising out of or in connection with one or more of the following causes:

- inappropriate use of the frequency inverter,
- non-compliance with the instructions, warnings and prohibitions contained in the documentation,
- unauthorized modifications of the frequency inverter,
- insufficient monitoring of parts of the machine/plant which are subject to wear,
- repair work at the machine/plant not carried out properly or in time,
- catastrophes by external impact and Force Majeure.

1.4 Obligation

These Operating Instructions must be read before commissioning and complied with. Anybody entrusted with tasks in connection with the

- transport,
- assembly,
- installation of the frequency inverter and
- operation of the frequency inverter

must have read and understood the Operating Instructions and, in particular, the safety instructions in order to prevent personal and material losses.

1.5 Copyright

In accordance with applicable law any copyrights relating to this document shall remain with

BONFIGLIOLI Vectron GmbH
Europark Fichtenhain B6
47807 Krefeld
Germany

This document is intended for the operator of the frequency inverter. Any disclosure or copying of this document, exploitation and communication of its contents (as hardcopy or electronically) shall be forbidden, unless permitted expressly.
Any non-compliance will constitute an offense against the copyright law, the law against unfair competition and the German Civil Code and may result in claims for damages. All rights relating to patent, utility model or design registration reserved.

1.6 Storage

The documentation forms an integral part of the frequency inverter. It must be stored such that it is accessible to operating staff at all times. If the frequency inverter is sold on to other users, then the documentation must also be handed over.

1.7 Final decommissioning

After the end of product service life, the user/operator must take the device out of operation.

For more information about the decommissioning of the device refer to the applicable operating instructions document.

Disposal requirements under European Union WEEE regulations

The product is marked with the WEEE symbol shown below.
This product cannot be disposed as general household waste. Users responsible for the final disposal must make sure that it is carried out in accordance with the European Directive 2012/19/EU, where required, as well as the relative national transposition rules. Fulfil disposal also in according with any other legislation in force in the country.

2 General safety instructions and information on use

This chapter contains general safety instructions for the Operator and the Operating Staff. At the beginning of certain main chapters, some safety instructions are included which apply to all work described in the relevant chapter. Special work-specific safety instructions are provided before each safety-relevant work step.

2.1 Terminology

According to the documentation, different activities must be performed by certain persons with certain qualifications.
The groups of persons with the required qualification are defined as follows:

Operator

This is the entrepreneur/company who/which operates the frequency inverter and uses it as per the specifications or has it operated by qualified and instructed staff.

Operating staff

The term Operating Staff covers persons instructed by the Operator of the frequency inverter and assigned the task of operating the frequency inverter.

Skilled Personnel

The term Skilled Personnel covers staff that are assigned special tasks by the Operator of the frequency inverter, e.g. installation, maintenance and service/repair and troubleshooting. Based on their qualification and/or know-how, Skilled Personnel must be capable of identifying defects and assessing functions.

Qualified electrician

The term Qualified Electrician covers qualified and trained staff who has special technical know-how and experience with electrical installations. In addition, Qualified Electricians must be familiar with the applicable standards and regulations, they must be able to assess the assigned tasks properly and identify and eliminate potential hazards.

Instructed person

The term Instructed Person covers staff who was instructed and trained about/in the assigned tasks and the potential hazards that might result from inappropriate behavior. In addition, instructed persons must have been instructed in the required protection provisions, protective measures, the applicable directives, accident prevention regulations as well as the operating conditions and verified their qualification.

Expert

The term Expert covers qualified and trained staff who has special technical know-how and experience relating to frequency inverter. Experts must be familiar with the applicable government work safety directives, accident prevention regulations, guidelines and generally accepted rules of technology in order to assess the operationally safe condition of the frequency inverter.

2.2 Designated use

The frequency inverter is designed according to the state of the art and recognized safety regulations.
The frequency inverters are electrical drive components intended for installation in industrial plants or machines. Commissioning and start of operation is not allowed until it has been verified that the machine meets the requirements of the EC Machinery Directive 2006/42/EC and DIN EN 60204-1.
The frequency inverters meet the requirements of the low voltage directive 2014/35/EU and DIN EN 61800-5-1. CE-labelling is based on these standards. Responsibility for compliance with the EMC Directive 2014/30/EU lies with the operator. Frequency inverters are only available at specialized dealers and are exclusively intended for commercial use as per EN 61000-3-2.
No capacitive loads may be connected to the frequency inverter.
The technical data, connection specifications and information on ambient conditions are indicated on the rating plate and in the documentation and must be complied with in any case.

2.3 Misuse

Any use other than that described in "Designated use" shall not be permissible and shall be considered as misuse.
For, example, the machine/plant must not be operated

- by uninstructed staff,
- while it is not in perfect condition,
- without protection enclosure (e.g. covers),
- without safety equipment or with safety equipment deactivated,
- when general requirements, such as operating conditions and technical data, are not met.

The manufacturer shall not be held liable for any damage resulting from such misuse. The sole risk shall be borne by the operator.

Explosion protection

The frequency inverter is an IP 20 ingress protection rating device. For this reason, use of the device in explosive atmospheres is not permitted.

2.4 Residual risks

Residual risks are special hazards involved in handling of the frequency inverter which cannot be eliminated despite the safety-compliant design of the device. Residual risks are not obviously identifiable and can be a potential source of injury or a health hazard.
Typical residual hazards include:

- Electrical hazard
- Danger of contact with energized components due to a defect, opened covers or enclosures or improper working on electrical equipment.
- Danger of contact with energized components in frequency inverter if no external disconnection device was installed by the operator.

During operation, all covers must be installed correctly, and all electrical cabinet doors must be closed to minimize electrical hazards.
When LEDs and other indicating elements on the frequency inverter go out, this does not necessarily mean that the device is deenergized. Before carrying out any Work at the device where contact with energized parts might be possible, it must be checked in any case, i.e. irrespective of the status of any indicating elements that may be installed, if the device is deenergized.

Charged capacitors in DC link

Sizes 1 through 7 (up to 160 kW): The DC-link may have dangerous voltage levels even up to 3 minutes after shutdown.
Size 7 and 8 (as from 160 kW): The DC-link may have dangerous voltage levels even up to 10 minutes after shutdown.

Electrostatic charging

Touching electronic components entails the risk of electrostatic discharges.

Thermal hazards

Risk of accidents by hot machine/plant surfaces, e.g. heat sink, transformer, fuse or sine filter.

Danger of equipment falling down/over, e.g. during transport

Center of gravity is not the middle of the electrical cabinet modules.

2.5 Safety and warning signs on frequency inverter

- Comply with all safety instructions and danger information provided on the frequency inverter.
- Safety information and warnings on the frequency inverter must not be removed.

2.6 Warning information and symbols used in the Operating Instructions

2.6.1 Hazard classes

The following hazard identifications and symbols are used to mark particularly important information:

DANGER

Identification of immediate threat holding a **high** risk of death or serious injury if not avoided.

WARNING

Identification of immediate threat holding a **medium** risk of death or serious injury if not avoided.

CAUTION

Identification of immediate threat holding a **low** risk of minor or moderate physical injury if not avoided.

NOTICE

Identification of a threat holding a risk of material damage if not avoided.

2.6.2 Hazard symbols

Symbol	Meaning	Symbol	Meaning
	General hazard		Suspended load
	Electrical voltage		Hot surfaces
	Danger of crushing		

2.6.3 Prohibition signs

Symbol	Meaning
	No switching; it is forbidden to switch the machine/plant, assembly on

2.6.4 Personal safety equipment

Symbol	Meaning
	Wear body protection
	Wear ear protectors

2.6.5 Recycling

Symbol	Meaning
	Recycling, to avoid waste, collect all materials for reuse

2.6.6 Grounding symbol

Symbol	Meaning
	Ground connection

2.6.7 ESD symbol

Symbol	Meaning
	ESD: Electrostatic Sensitive Devices, i.e. components and assemblies sensitive to electrostatic energy

2.6.8 Information signs

Symbol	Meaning
	Tips and information making using the frequency inverter easier.

2.6.9 Font style in documentation

Example	Font style	Use
1234	bold	Representation of parameter numbers
Parameter	inclined, font: Times New Roman	Representation of parameter names
P.1234	bold	Representation of parameter numbers without name, e.g. in formulas
Q.1234	bold	Representation of source numbers

2.7 Directives and guidelines to be adhered to by the operator

The operator must follow the following directives and regulations:

- Ensure that the applicable workplace-related accident prevention regulations as well as other applicable national regulation are accessible to the staff.
- An authorized person must ensure, before using the frequency inverter, that the device is used in compliance with its designated use and that all safety requirements are met.
- Additionally, comply with the applicable laws, regulations and directives of the country in which the frequency inverter is used.
- For liquid cooled frequency inverters, comply with the cooling water guideline VGB-R 455 P.
- Any additional guidelines and directives that may be required additionally shall be defined by the operator of the machine/plant considering the operating environment.

2.8 Operator's general plant documentation

- In addition to the Operating Instructions, the operator should issue separate internal user manuals for the frequency inverter. The Operating Instructions of the frequency inverter must be included in the Operating Instructions of the whole plant.

2.9 Operator's/operating staff's responsibilities

2.9.1 Selection and qualification of staff

- Any work on the frequency inverter may only be carried out by skilled personnel. The staff must not be under the influence of any drugs. Note the minimum age required by law. Define the staff's responsibility pertaining to all work on the frequency inverter clearly.
- Work on the electrical components may only be performed by a qualified electrician according to the applicable rules of electrical engineering.
- The operating staff must be trained for the relevant work to be performed.

2.9.2 General work safety

- In addition to the Operating Instructions of the machine/plant, any applicable legal or other regulations relating to accident prevention and environmental protection must be complied with. The staff must be instructed accordingly.
  Such regulations and/or requirements may include, for example, handling of hazardous media and materials or provision/use of personal protective equipment.
- In addition to this Operating Instructions, issue any additional directives that may be required to meet specific operating requirements, including supervision and reporting requirements, e.g. directives relating to work organization, workflow and employed staff.
- Unless approved of expressly by the manufacturer, do not modify the frequency inverter in any way, including addition of attachments or retrofits.

- Only use the frequency inverter if the rated connection and setup values specified by the manufacturer are met.
- Provide appropriate tools as may be required for performing all work on the frequency inverter properly.

2.9.3 Ear protectors

- The frequency inverter produces noise. Due to noise development, frequency inverters should only be installed in normally unstaffed areas.
- Noise emission in operation is < 85 dB(A) in the case of sizes 1 through 7.
- Noise emission in operation is approx. 86 dB(A) in the case of size 8. Ear protectors must be used when staying near the frequency inverter.

2.10 Organizational measures

2.10.1 General

- Train your staff in the handling and use of the frequency inverter and the machine/plant as well as the risks involved.
- Use of any individual parts or components of the frequency inverter in other parts of the operator's machine/plant is prohibited.
- Optional components for the frequency inverter must be used in accordance with their designated use and in compliance with the relevant documentation.

2.10.2 Use in combination with third-party products

- Please note that Bonfiglioli Vectron GmbH will not accept any responsibility for compatibility with third-party products (e.g. motors, cables or filters)..
- In order to enable optimum system compatibility Bonfiglioli Vectron GmbH offers components facilitating commissioning and providing optimum synchronization of the machine/plant parts in operation.
- If you use the frequency inverter in combination with third-party products, you do so at your own risk.

2.10.3 Handling and installation

- Do not commission any damaged or destroyed components.
- Prevent any mechanical overloading of the frequency inverter. Do not bend any components and never change the isolation distances.
- Do not touch any electronic construction elements and contacts. The frequency inverter is equipped with components which are sensitive to electrostatic energy and can be damaged if handled improperly. Any use of damaged or destroyed components will endanger the machine/plant safety and shall be considered as non-compliance with the applicable standards.
- Only install the frequency inverter in a suitable operating environment. The frequency inverter is exclusively designed for installation in industrial environments.
- If seals are removed from the case, this can result in the warranty becoming null and void.

2.10.4 Electrical connections

- The five safety rules must be complied with.
- Never touch live terminals. In sizes 1 through 7, the DC-link may have dangerous voltage levels up to 3 minutes after shutdown. In size 8, the DC-link may have dangerous voltage levels up to 10 minutes after shutdown.
- When performing any work on/with the frequency inverter, always comply with the applicable national and international regulations/laws on work on electrical equipment/plants of the country in which the frequency inverter is used.
- The cables connected to the frequency inverters may not be subjected to high-voltage insulation tests unless appropriate circuitry measures are taken before.
- Only connect the frequency inverter to suitable supply mains. The frequency inverter may be operated in TN, TT and IT grid types. Precautions must be taken for operation in IT grids, see Chapter 7 "Electrical installation". Operation in a corner-grounded TN grid shall not be permissible.

2.10.4.1 The five safety rules

When working on/in electrical plants, always follow the five safety rules:

- Disconnect
- Secure to prevent restarting

- check for absence of voltage,
- carry out earthing and short-circuiting
- cover or shield neighboring live parts

2.10.5 Safe operation

- During operation of the frequency inverter, always comply with the applicable national and international regulations/laws on work on electrical equipment/plants.
- Before commissioning and the start of the operation, make sure to fix all covers and check the terminals. Check the additional monitoring and protective devices according to the applicable national and international safety directives.
- During operation, all covers must be installed correctly, and all electrical cabinet doors must be closed. During operation, never open the machine/plant.
- No connection work shall be carried out while power supply is on.
- The machine/plant holds high voltage levels during operation, is equipped with rotating parts (fan) and has hot surfaces. Any unauthorized removal of covers, improper use, wrong installation or operation may result in serious injuries or material damage.
- Some components, e.g. the heat sink or braking resistor, may be hot even some time after the machine/plant was shut down. Don't touch any surfaces directly after shutdown. Wear safety gloves where necessary.
- The frequency inverter may hold dangerous voltage levels until the capacitor in the DC link is discharged. After shutdown, wait for at least 3 minutes (sizes 1 through 7) and at least 10 minutes (size 8) before starting any electrical or mechanical work on the frequency inverter. Even after this waiting time, make sure that the equipment is deenergized in accordance with the safety rules before starting the work.
- In order to avoid accidents or damage, only skilled personnel and electricians may carry out the work such as installation, commissioning or setup.
- In the case of a defect of terminals and/or cables, immediately disconnect the frequency inverter from mains supply.
- Persons not familiar with the operation of the frequency inverter and children must not have access to the device.
- Do not bypass nor decommission any protective devices.
- The frequency inverter may be connected to power supply every 60 s. This must be considered when operating a mains contactor in jog operation mode. For commissioning or after an emergency stop, a non-recurrent, direct restart is permissible.
- After a failure and restoration of the power supply, the motor may start unexpectedly if the AutoStart function is activated.
  If staff are endangered, a restart of the motor must be prevented by means of external circuitry.
- Before commissioning and the start of the operation, make sure to fix all covers and check the terminals. Check the additional monitoring and protective devices according to EN 60204 and applicable the safety directives (e.g. Working Machines Act or Accident Prevention Directives).

2.10.6 Maintenance and service/troubleshooting

- Visually inspect the frequency inverter when carrying out the required maintenance work and inspections at the machine/plant.
- Perform the maintenance work and inspections prescribed for the machine carefully, including the specifications on parts/equipment replacement.
- Work on the electrical components may only be performed by a qualified electrician according to the applicable rules of electrical engineering. Only use original spare parts.
- Unauthorized opening and improper interventions in the machine/plant can lead to personal injury or material damage. Any repair work may only be carried out by the manufacturer or persons approved/licensed by the manufacturer. Any repair work must be carried out by qualified electricians. Check protective equipment regularly.
- Before performing any maintenance work, the machine/plant must be disconnected from mains supply and secured against restarting. The five safety rules must be complied with.

2.10.7 Final decommissioning

Unless separate return or disposal agreements were made, recycle the disassembled frequency inverter components:

- Scrap metal materials
- Recycle plastic elements

- Sort and dispose of other component materials

Electric scrap, electronic components, lubricants and other utility materials must be treated as special waste and may only be disposed of by specialized companies.

In any case, comply with any applicable national disposal regulations as regards environmentally compatible disposal of the frequency inverter. For more details, contact the competent local authorities.

2.11 Safety Instructions on Function "Safe Torque Off" (STO)

The function „Safe Torque Off" (STO) is a functional safety feature, i.e. it protects staff from damage, provided that projecting, installation and operation are performed properly. This function does not disconnect the plant from power supply.
In order to disconnect the plant from power supply (e.g. for maintenance work), an "Emergency Stop" provision as per EN 60204 must be installed.

WARNING

Uncontrolled Starting
Improper installation of the safety circuitry may result in uncontrolled starting of the drive. This may cause death, serious injuries and significant material damage.

- Safety functions may only be installed and commissioned by skilled personnel.

The STO function is not suitable for emergency stop as per EN 60204. An emergency stop can be realized by installing a mains contactor.
An emergency stop according to EN 60204 must be functioning in all operation modes of the frequency inverter. Resetting of an emergency stop must not result in uncontrolled starting of the drive.
The drive is started again when the function STO is no longer required. In order to comply with EN 60204, it must be ensured by taking external measures that the drive does not start without prior confirmation.
Without a mechanical brake, the drive will not stop immediately but coast to a standstill. If this may result in personal or material damage, additional safety measures must be taken.

- If persons may be endangered after disconnection of the motor power supply by STO, access to the hazard areas must be prevented until the drive has stopped.
- Check the safety function at regular intervals according to the results of your risk analysis. Bonfiglioli Vectron GmbH recommends that the check be performed after one year, at the latest.

The STO function is fail-safe for one fault. However, on rare occasions, the occurrence of component defects may cause jerking of the motor shaft (max. 180°/pole pair, e. g. jerk by 90° with 4-pole motor, 180°/2).

- Check if this causes a dangerous movement of the machine.
- If the STO function is used, the special safety, installation and instructions on use instructions shall be complied with.

WARNING

Dangerous voltage!

The safety function "Safe Torque Off" may only be used if mechanical work is to be performed on the driven machines, not for work on live components.

After disconnection of an external DC 24 V power supply, the DC link of the frequency inverter is still connected to mains supply.

Even if power supply to the motor is disconnected, and the motor is coasting to a standstill or has already stopped, high voltages may still be present on the motor terminals.

Before working (e. g. maintenance) on live parts, the plant must always be disconnected from mains supply (main switch). This must be documented on the plant.

When the function "Safe Torque Off" is triggered, the motor is not isolated from the DC link of the frequency inverter. High voltage levels may be present at the motor.

- Do not touch live terminals.

The application manual "Safe Torque Off STO" must be complied with, particularly if the safety function described there is used.

3 Storage and transport

NOTICE

Draining the heat sink

Liquid cooled devices may be transported only with the heat sink completely drained of the coolant.

- Use compressed air to drain the heat sink radiator.

3.1 Storage

NOTICE

Damage caused by incorrect storage

- Wrong or inappropriate storage may result in damage, e.g. due to moisture and dirt. Avoid major temperature variations and high air humidity.
- During storage, protect the device against moisture and dirt.

- The frequency inverters must be stored in an appropriate way. During storage, the devices must remain in their original packaging.
- The units may only be stored in dry rooms which are protected against dust and moisture and are exposed to small temperature deviations only. The requirements of DIN EN 60721-3-1 for storage, DIN EN 60721-3-2 for transport and labeling on the packaging must be met.
- The duration of storage without connection to the permissible nominal voltage may not exceed one year. After one year of storage, connect the device to mains voltage for 60 minutes.

3.2 Special safety instructions on transport of heavy frequency inverters

WARNING



High weight and unusual center of gravity!

Tilting the frequency inverter may result in death or serious injuries. Due to the size and weight of the frequency inverter, there is the risk of accidents during transport. Center of gravity is not the middle of the frequency inverter. The underside of the frequency inverter, due to its design, cannot support the frequency inverter.

- Take utmost care during transport in order to prevent damage and deformation. Transport, attachment and lifting of loads may only be carried out by specially instructed staff who are familiar with the work.
- Only use suitable transport and lifting equipment with sufficient carrying capacity. The lifting cables/chains used must be able to carry the weight of the frequency inverter. Check the ropes or chains for damage.
- Wear appropriate safety clothing.
- When lifting the frequency inverter up ensure that it does not fall over, is displaced, swings out or falls down.
- Before the frequency inverter is lifted up, everybody must have left the work area.
- Before transport, make sure the transport path has sufficient carrying capacity.
- Do not step under suspended loads.
- Do not put the frequency inverter down in upright position without providing a suitable supporting structure.

3.3 Dimensions/weight

For information on the weight and dimensions of the frequency inverter, refer to chapter 5 “Technical data”.

3.4 Transfer to place of installation

Transfer to the place of installation is done with the product in its original packaging. Frequency inverters as from size 7 must be transferred to the place of installation in horizontal position, rear-side down. A fork lift truck or crane with crane fork can be used for transfer to the place of installation.

- Apply the fork in the middle of the transport unit.
- Secure the transport unit to prevent it from falling down and overturning.
- Lift the transport unit up carefully.
- At the place of installation, put the transport unit down on a level and bearing surface.

3.5 Unpacking the device

- Carefully remove packaging.
- Check if the delivered devices corresponds to the order.
- Check the device for transport damage and completeness.
- Any defects/damage must be reported to the supplier immediately.

Ensure that all packaging materials are disposed of in an environmentally compatible manner.

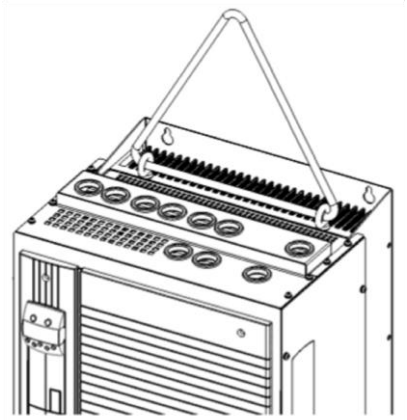
3.6 Bringing the device into installation position

3.6.1 Sizes 1 through 6

- Depending on the weight, one or two persons are required for lifting the device into the installation position in the electrical cabinet. For information on installation, refer to Chapter 6 "Mechanical installation".

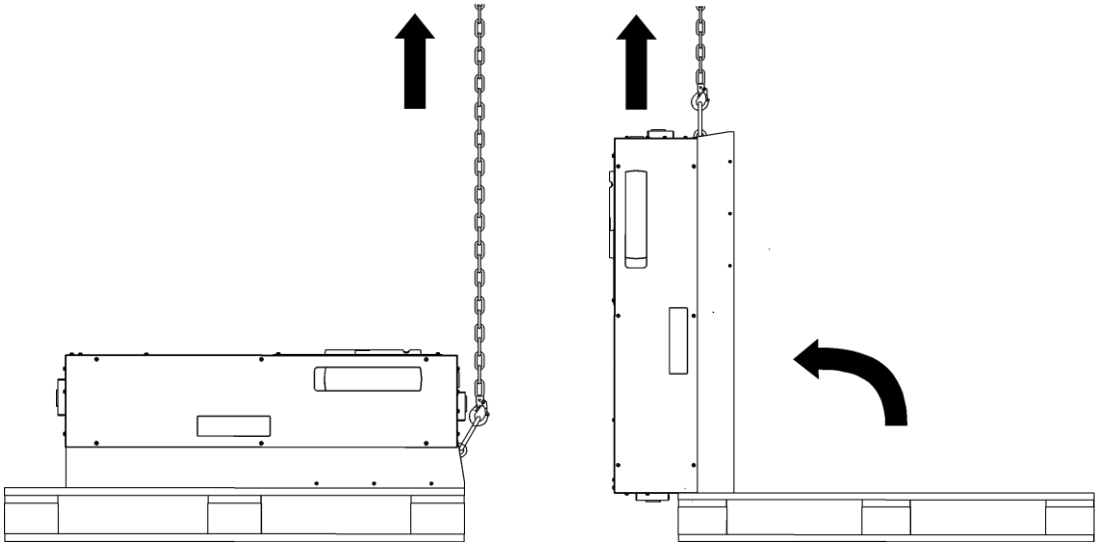
3.6.2 Sizes 7 and 8

- Fix two crane eyes (M8) in the marked threaded holes on the top side of the device.
- Use appropriate lifting means.



NOTICE

The pull angle must not be smaller than 60°.



- Use appropriate lifting means and a crane to lift the frequency inverter up carefully. Bring the device into vertical position by turning it up on the pallet via the rear lower edge of the case.

NOTICE

- Do not leave the device standing in upright position.

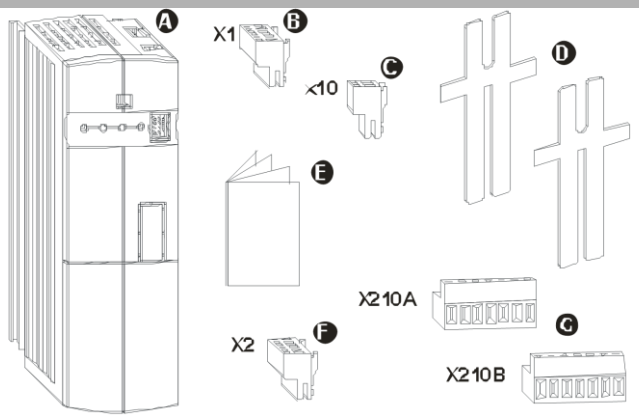
- Move the frequency inverter to its installation position in the electrical cabinet and fix it there, see Chapter 6 "Mechanical installation".
- After mechanical installation, disconnect the device from the crane and remove the crane eyes.

4 Scope of supply

Due to modular hardware components, the frequency inverters can be integrated in the automation concept easily. The scope of delivery described can be supplemented by optional components and adapted to the customer-specific requirements. The plug-in type connection terminals enable a safe function and quick and easy assembly.

4.1 Sizes 1 and 2: ACU 210 (up to 3.0 kW) and 410 (up to 4.0 kW)

Scope of supply

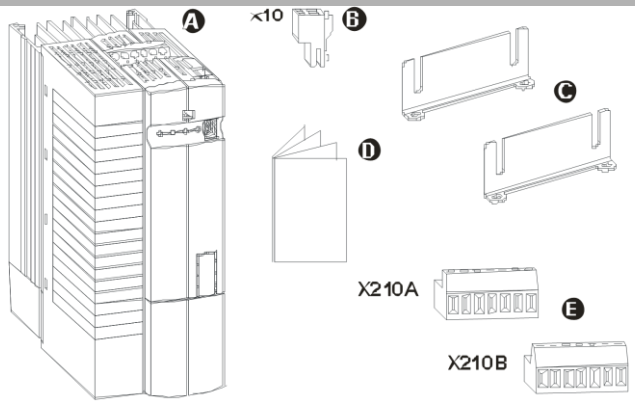


A	Frequency inverter
B	Terminal strip X1 (Phoenix ZEC 1,5/ST7,5). Plug-in terminals for mains connection and DC linking
C	Terminal strip X10 (Phoenix ZEC 1.5/3ST5.0). Plug-in terminals for the relay output
D	Standard fixtures for vertical assembly
E	Quick Start Guide
F	Terminal strip X2 (Phoenix ZEC 1,5/ST7,5). Plug-in terminal for braking resistor and motor connection
G	Control terminals X210A / X210B (Wieland DST85 / RM3.5). Plug-in terminal for connection of the control signals

Please check incoming goods for quality, quantity and type without delay. Obvious defects such as exterior damage of the packing and/or the unit must be notified to the sender within seven days for insurance reasons.

4.2 Sizes 3 and 4: ACU 210 (4.0 to 9.2 kW) and 410 (5.5 to 15.0 kW)

Scope of supply

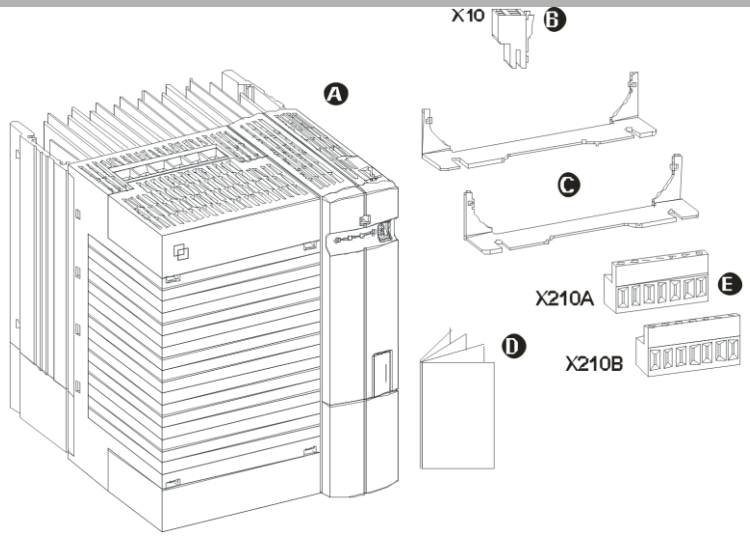


A	Frequency inverter
B	Terminal strip X10 (Phoenix ZEC 1.5/3ST5.0). Plug-in terminals for the relay output
C	Standard fittings with fitting screws (M4x20, M4x60) for vertical assembly
D	Quick Start Guide
E	Control terminals X210A / X210B (Wieland DST85 / RM3.5). Plug-in terminal for connection of the control signals

Please check incoming goods for quality, quantity and type without delay. Obvious defects such as exterior damage of the packing and/or the unit must be notified to the sender within seven days for insurance reasons.

4.3 Size 5 ACU 410 (18.5 to 30.0 kW)

Scope of supply

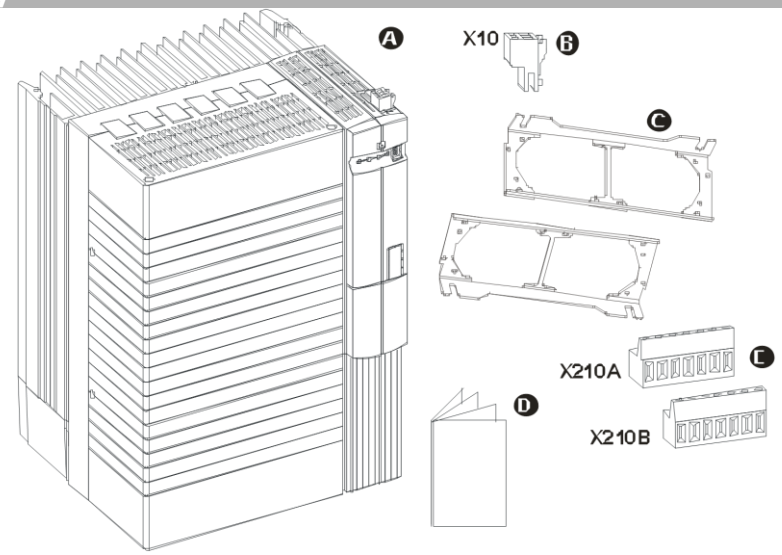


A	Frequency inverter
B	Terminal strip X10 (Phoenix ZEC 1.5/3ST5.0) Plug-in terminals for the relay output
C	Standard fittings with fitting screws (M4x20, M4x70) for vertical assembly
D	Quick Start Guide
E	Control terminals X210A / X210B (Wieland DST85 / RM3.5) Plug-in terminal for connection of the control signals

Please check incoming goods for quality, quantity and type without delay. Obvious defects such as exterior damage of the packing and/or the unit must be notified to the sender within seven days for insurance reasons.

4.4 Size 6 ACU 410 (37.0 to 65.0 kW)

Scope of supply

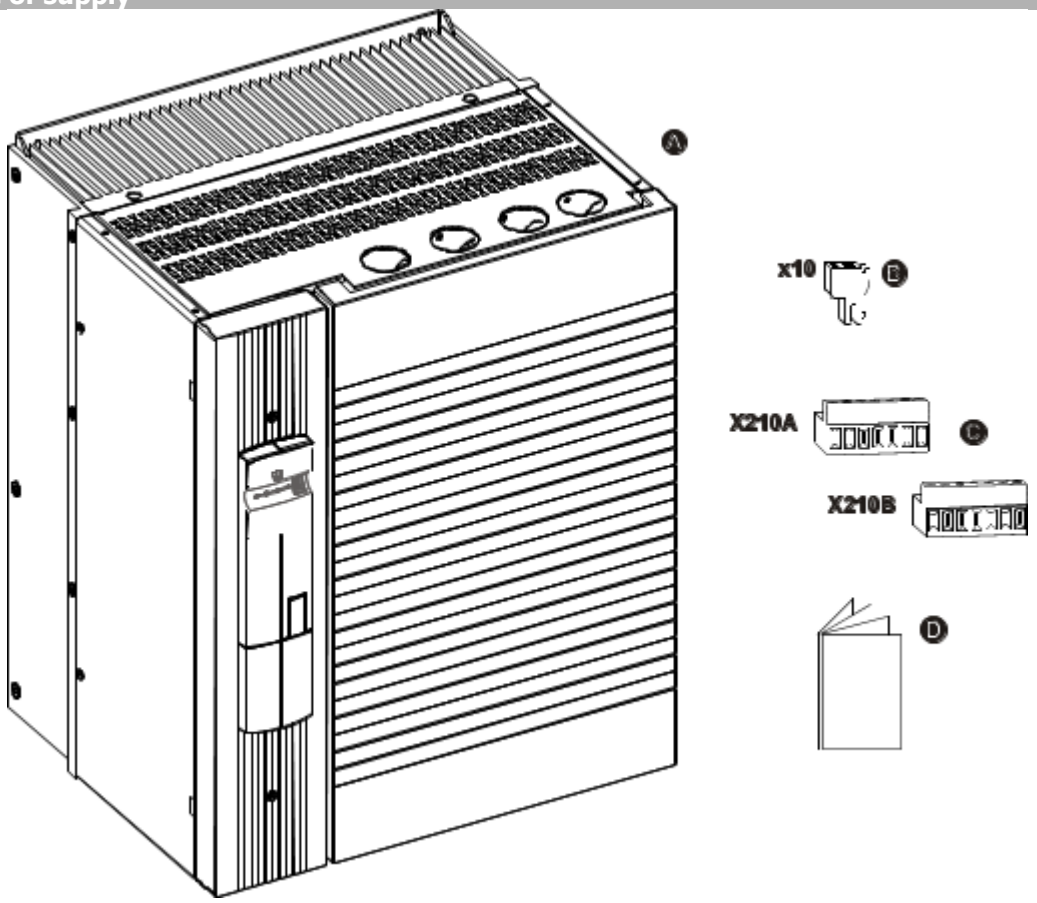


A	Frequency inverter The illustration shows an air-cooled frequency inverter as an example.
B	Terminal strip X10 (Phoenix ZEC 1.5/3ST5.0). Plug-in terminals for the relay output
C	For air-cooled frequency inverters only: Standard fittings with fitting screws (M5x20) for vertical assembly
D	Quick Start Guide
E	Control terminals X210A / X210B (Wieland DST85 / RM3.5). Plug-in terminal for connection of the control signals

Please check incoming goods for quality, quantity and type without delay. Obvious defects such as exterior damage of the packing and/or the unit must be notified to the sender within seven days for insurance reasons.

4.5 Size 7 ACU 410 (75.0 to 160.0 kW)

Scope of supply

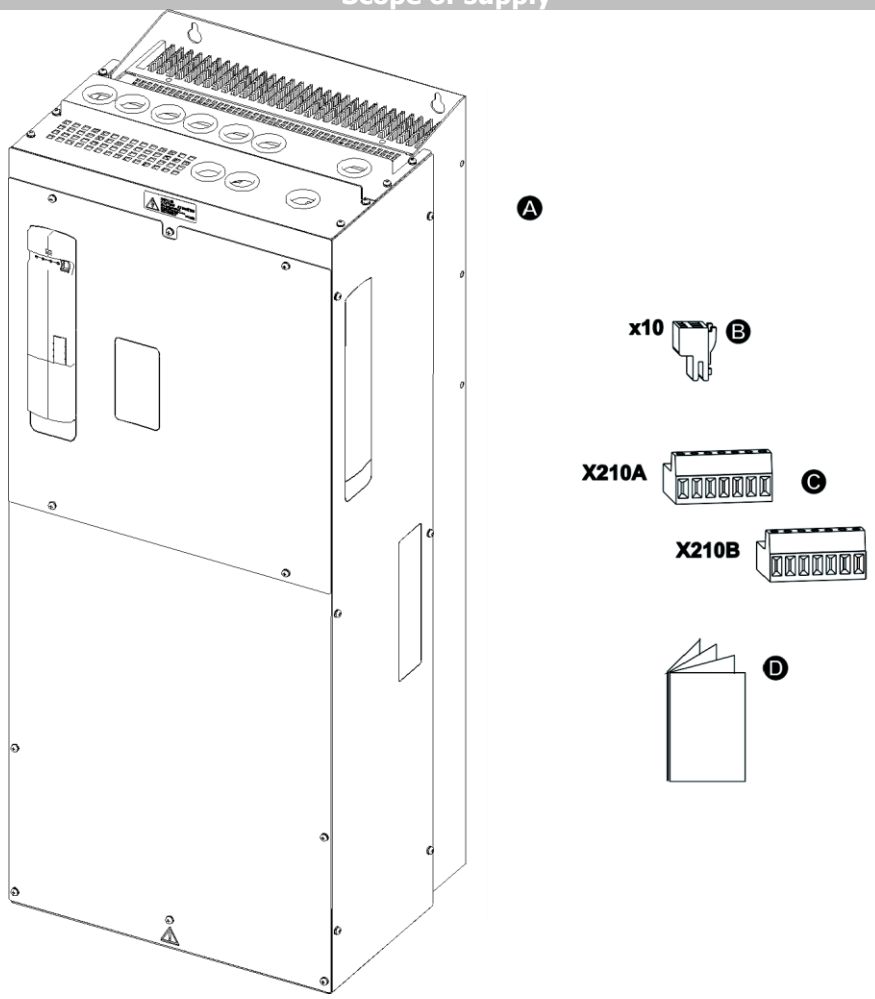


A	Frequency inverter The illustration shows an air-cooled frequency inverter as an example.
B	Terminal strip X10 (Phoenix ZEC 1.5/3ST5.0) Plug-in terminals for the relay output
C	Control terminals X210A / X210B (Wieland DST85 / RM3.5) Plug-in terminal for connection of the control signals
D	Quick Start Guide

Please check incoming goods for quality, quantity and type without delay. Obvious defects such as exterior damage of the packing and/or the unit must be notified to the sender within seven days for insurance reasons.

4.6 Size 8 ACU 410, ACU 510 and ACU 610 (160 through 400 kW)

Scope of supply



A	Frequency inverter The illustration shows an air-cooled frequency inverter as an example.
B	Terminal strip X10 (Phoenix ZEC 1.5/3ST5.0) Plug-in terminals for the relay output
C	Control terminals X210A / X210B (Wieland DST85 / RM3.5) Plug-in terminal for connection of the control signals
D	Quick Start Guide

Please check incoming goods for quality, quantity and type without delay. Obvious defects such as exterior damage of the packing and/or the unit must be notified to the sender within seven days for insurance reasons.

5 Technical data

CAUTION

Device defect and motor defect

The recommended motor shaft power indicated in the technical data applies to IE1 motors only. Ignoring the possible DC-link currents may decrease the motor product life and may damage the inverter.

- Always verify the applicable operation parameters with regard to the particular motor type and inverter type combination.
- Adapt software parameters if necessary.

5.1 General technical data

CE conformity	The ACU frequency inverters meet the requirements of the low voltage directive 2014/35/EU and DIN EN 61800-5-1.
EMC directive	For proper installation of the frequency inverter in order to meet the requirements of EN 61800-3, please comply with the installation instructions in these operating instructions.
Interference immunity	The ACU frequency inverters meet the requirements of EN 61800-3 for use in industrial environments.
UL Approval	The frequency inverters are also marked with the UL label according to UL508c / UL 61800-5-1, which proves that they also meet the requirements of the CSA Standard C22.2-No. 14. ACU 410 device series are UL-approved in sizes 1 through 8, ACU 210 devices are UL-approved in sizes 1 and 2. Excepted from this are ACU 410-51 (160 kW /200 kW-liquid cooled) devices in size 7.
Safety function	The function is described in application manual "Safe Torque Off STO".
Ambient temperature	Storage: -25 ... 55°C (for liquid cooling: drain the heat sink completely!) Transport: -25 ... 70°C (for liquid cooling: drain the heat sink completely!) Operation: 0…55°C; as from 40 °C power reduction should be considered.
Ambient pressure	70 ... 106 kPa
Environmental class	Operation: 3K3 (EN60721-3-3) Relative humidity Air cooling: 15…85%, no water condensation Liquid cooling: 15…95%, non-condensing For liquid cooling: Comply with the notes on “Heat sink condensation protection” in the “Operating Instructions Liquid Cooling Supplemental”. In addition, the following environmental conditions must be considered for operation according to DIN EN 60721-3-3: 3Z1 (negligible thermal radiation) 3B1 (no biological impact) 3C1 (chemically active substances, limits as per standard) 3S1 (mechanically active substances, no sand in air, limits as per standard) 3M4 (mechanical vibration and shocks, limits as per standard)
Ingress protection rating	IP20 if covers and connection terminals are used properly.
Altitude of installation	Up to 1000 m at rated specifications. Up to 4000 m at reduced power.
Storage	Storage according to EN 61800-5-1. After one year of storage, connect the device to mains voltage for 60 minutes.
Permitted grid types	The frequency inverter may be operated in TN, TT and IT grid types. Precautions must be taken for operation in IT grids, see Chapter 7 "Electrical installation". Operation in a corner-grounded TN grid shall not be permissible.
Overload capacity	Continuous operation 100 % IN Up to 150% IN for 60 s Up to 200% IN for 1 s Devices -01, -03 (0.25 & 0.37 kW): Up to 200% IN for 60 s Up to 200% IN for 1 s Overload capacity can be used every 10 minutes. For the individual overload capacity, refer to the technical data.

Vibration and shock resistance	
Sine	Accoding to DIN EN 60068-2-6 Fc
Shock / Half-Sine	According to DIN EN 60068-2-27 Ea
Max. permissible short-circuit current to be expected with mains supply	Up to 132 kW device power (size 7): 5 kA; As from 160 kW device power (size 7 and 8): ≥ 30 kA
Contamination level	The frequency inverters are designed for Pollution Degree 2.
Overvoltage category	The frequency inverters are designed for Overvoltage Category II.
Functions	– Control methods adjusted to motors and application (configuration). – Adjustable speed/torque control. – Various protection functions for motor and frequency inverter. – Positioning absolute or relative to a reference point. – Catching function. – Special brake control and load detection for lifting gear. – S-ramps for jerk limitation during acceleration and deceleration. – Technology (PI) controller. – Parameterizable Master-Slave operation via system bus. – Error memory. – Simplified and extended control via PC (commissioning, parameterization, data set backup, diagnosis with Scope).
Parameterization	– Freely programmable digital inputs and outputs. – Various logic modules for linking and processing of signals. – Four separate data sets incl. motor parameters.

If required by the customer, the switching frequency may be increased if the output current is reduced at the same time. Comply with the applicable standards and regulations for this operating point.

5.2 Technical Data – Control Electronic Equipment

Control terminal X210A			Control terminal X210B		
X210A.1	DC 20 V output (I_{max}=180 mA) or DC 24 V ±10% input for external power supply		X210B.1	Digital input [1]	
X210A.2	GND 20 V/ GND 24 V (ext.)		X210B.2	Digital input **STOB** (second shut-down path)	safety relevant
X210A.3	Digital input **STOA** (first shut-down path)	safety relevant	X210B.3	Digital output [1]	
X210A.4	Digital inputs [1]		X210B.4	Multifunction output [1] (voltage signal, proportional act. frequency, factory settings)	
X210A.5			X210B.5	Supply voltage DC 10 V for reference value potentiometer, (I_{max}=4 mA)	
X210A.6			X210B.6	Multifunction input [1] (reference speed 0 … +10 V, factory settings)	
X210A.7			X210B.7	Ground 10 V	

Relay output X10	
X10	Inverter error message [1]

[1] Control terminals are freely configurable.

- Check "Safe Torque Off": Contacts on X210A.3 and X210B.2 open.
- Release of frequency inverter: Contacts on X210A.3 and X210B.2 closed.

By default, the different configurations occupy the control terminals with certain settings. These settings can be adjusted to the specific application, and various functions can be assigned freely to the control terminals.

Technical data of control terminals
Digital inputs (X210A.3…X210B.2): Low Signal: DC 0…3 V, High Signal: DC 12…30 V, Input resistance: 2.3 kΩ, response time: 2 ms (STOA and STOB: 10 ms), PLC compatible, X210A.6 and X210A.7 additionally: Frequency signal: DC 0 V...30 V, 10 mA at DC 24 V, fmax=150kHz
Digital output (X210B.3): Low Signal: DC 0…3 V, High Signal: DC 12…30 V, Maximum output current: 50 mA, PLC compatible
Relay output (X10): Change-over contact, response time approx. 40 ms, Make contact AC 5 A / 240 V, DC 5 A (ohmic) / 24 V Break contact AC 3 A / 240 V, DC 1 A (ohmic) / 24 V
Multifunction output (X210B.4): Analog signal: DC 19…28 V, maximum output current: 50 mA, pulse-width modulated (fPWM= 116 Hz), Digital signal: Low Signal: DC 0…3 V, High Signal: DC 12…30 V, output current: 50 mA, PLC compatible, Frequency signal: Output voltage: DC 0…24 V, maximum output current: 40 mA, maximum output frequency: 150 kHz
Multifunction input (X210B.6): Analog signal: Input voltage: DC 0… 10 V (Ri=70 kΩ), input current: DC 0…20 mA (Ri=500 Ω), Digital signal: Low Signal: DC 0…3 V, High Signal: DC 12 V…30 V, response time: 4 ms, PLC compatible
Conductor cross-section: The signal terminals are suitable for the following cable sizes: with ferrule: 0.25…1.0 mm² without ferrule: 0.14…1.5 mm²

5.3 ACU 210 Size 1 (0.25 to 1.1 kW, 230 V)

Type							
ACU 210			-01	-03	-05	-07	-09
Size			1				
Output, motor side							
Recommended motor shaft power	P	kW	0.25	0.37	0.55	0.75	1.1
Output current	I	A	1.6	2.5	3.0	4.0	5,4 **5)**
Long-term overload current (60 s)	I	A	3.2	5.0	4.5	6.0	7.3
Short-time overload current (1 s)	I	A	3.2	5.0	6.0	8.0	8.0
Output voltage	U	V	Maximum input voltage, three-phase				
Protection	-	-	Short circuit / earth fault proof				
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency				
Switching frequency	f	kHz	2, 4 (default), 8, 16				
Output, braking resistor							
Min. braking resistance	R	Ω	100	100	100	100	100
Recommended braking resistor (U_{dBC} = 385 V)	R	Ω	430	300	230	160	115
Input, mains side							
Mains current **3)** 3ph 1ph/N/PE; 2ph	I	A	1,6 2.9	2,5 4.5	3 5.4	4 7.2	5.5 **1)** 9.5
Mains voltage	U	V	184 ... 264				
Mains frequency	f	Hz	45 ... 66				
Fuse 3ph 1ph/N; 2ph	I	A	6 6	6 10			10 16
UL type 250 VAC RK5, 3ph 1ph/N; 2ph	I	A	6 6	6 10			10 15
Mechanical							
Dimensions	HxWxD	mm	190 x 60 x 175				
Weight approx.	m	kg	1.2				
Ingress protection rating	-	-	IP20 (EN60529)				
Connection terminals	A	mm^2	0.2 ... 1.5				
Form of assembly	-	-	vertical				
Ambient conditions							
Energy dissipation (2 kHz switching frequency)	P	W	32	38	43	53	73
Coolant temperature	Tn	°C	0 ... 40 (3K3 DIN IEC 721-3-3)				

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	Switching frequency			
	2 kHz	**4 kHz**	**8 kHz**	**16 kHz**
0.25 kW	1.6 A	1.6 A	1.6 A	1.1 A
0.37 kW	2.5 A	2.5 A	2.5 A	1.7 A
0.55 kW	3.0 A	3.0 A	3.0 A	2.0 A
0.75 kW	4.0 A	4.0 A	4.0 A	2.7 A
1.1 kW	5.4 A **1)**	5.4 A **1) 5)**	5.4 A **1) 5)**	3.7 A **5)**

1) Connection requires a commutating choke.
3) Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")
4) Maximum output current = 9.5 A with single-phase and two-phase connection
5) Reduction of switching frequency in thermal limit range

5.4 ACU 210 Size 2 (1.5 to 3.0 kW, 230 V)

Type					
ACU 210			-11	-13	-15
Size			2		
Output, motor side					
Recommended motor shaft power	P	kW	1.5	2.2	3,0 [4]
Output current	I	A	7.0	9.5	12.5 [4] [5]
Long-term overload current (60 s)	I	A	10.5	14.3	16.2
Short-time overload current (1 s)	I	A	14.0	19.0	19.0
Output voltage	U	V	Maximum input voltage, three-phase		
Protection	-	-	Short circuit / earth fault proof		
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency		
Switching frequency	f	kHz	2, 4 (default), 8, 16		
Output, braking resistor					
Min. braking resistance	R	Ω	37	37	37
Recommended braking resistor (U_{dBC} = 385 V)	R	Ω	75	55	37
Input, mains side					
Mains current[3] 3ph 1ph/N; 2ph	I	A	7 13.2	9.5 16.5 [1]	10.5 [1] 16.5 [4]
Mains voltage	U	V	184 ... 264		
Mains frequency	f	Hz	45 ... 66		
Fuse 3ph 1ph/N; 2ph	I	A	10 16	16 20	16 20
UL type 250 VAC RK5, 3ph 1ph/N; 2ph	I	A	10 15	15 20	15 20
Mechanical					
Dimensions	HxWxD	mm	250 x 60 x 175		
Weight approx.	m	kg	1.6		
Ingress protection rating	-	-	IP20 (EN60529)		
Connection terminals	A	mm^2	0.2 ... 1.5		
Form of assembly	-	-	vertical		
Ambient conditions					
Energy dissipation (2 kHz switching frequency)	P	W	84	115	170
Coolant temperature	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)		

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	Switching frequency			
	2 kHz	4 kHz	8 kHz	16 kHz
1.5 kW	7.0 A	7.0 A	7.0 A	4.8 A
2.2 kW	9.5 A [1]	9.5 A [1]	9.5 A [1]	6.5 A
3.0 kW [1] [4]	12.5 A [1]	12.5 A [1] [5]	12.5 A [1] [5]	8.5 A [5]

[1] Connection requires a commutating choke.
[3] Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")
[4] Maximum output current = 9.5 A with single-phase and two-phase connection
[5] Reduction of switching frequency in thermal limit range

5.5 ACU 210 Sizes 3 and 4 (4.0 to 9.2 kW, 230 V)

Type						
ACU 210			-18	-19	-21	-22
Size			3		4	
Output, motor side						
Recommended motor shaft power	P	kW	4.0	5.5 **4)**	7.5 4)	9.2 4)
Output current	I	A	18.0	22.0	32.0	35.0
Long-term overload current (60 s)	I	A	26.3	30.3	44.5	51.5
Short-time overload current (1 s)	I	A	33.0	33.0	64.0	64.0
Output voltage	U	V	Maximum input voltage, three-phase			
Protection	-	-	Short circuit / earth fault proof			
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency			
Switching frequency	f	kHz	2, 4 (default), 8, 16			
Output, braking resistor						
Min. braking resistance	R	Ω	24	24	12	12
Recommended braking resistor (U_{dBC} = 385 V)	R	Ω	30	24	16	12
Input, mains side						
Mains current**3)** 3ph 1ph/N; 2ph	I	A	18 28 **1)**	20 **1)** - **4)**	28.2 **1)** - **4)**	35.6 **1)** - **4)**
Mains voltage	U	V	184 ... 264			
Mains frequency	f	Hz	45 ... 66			
Fuse 3ph 1ph/N; 2ph	I	A	25 35	25 - **4)**	35 - **4)**	50 - **4)**
Mechanical						
Dimensions	HxWxD	mm	250 x 100 x 200		250 x 125 x 200	
Weight approx.	m	kg	3.0		3.7	
Ingress protection rating	-	-	IP20 (EN60529)			
Connection terminals	A	mm^2	0.2 … 6		0.2 … 16	
Form of assembly	-	-	vertical			
Ambient conditions						
Energy dissipation (2 kHz switching frequency)	P	W	200	225	310	420
Coolant temperature	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)			

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	Switching frequency			
	2 kHz	**4 kHz**	**8 kHz**	**16 kHz**
4.0 kW	18.0 A **1)**	18.0 A **1)**	18.0 A **1)**	12.2 A
5.5 kW **4)**	23.0 A **1)**	22.7 A 1), 5)	22.0 A **1), 5)**	15.0 A **5)**
7.5 kW **4)**	32.0 A **1)**	32.0 A **1)**	32.0 A **1)**	21.8 A
9.2 kW **4)**	40.0 A **1)**	38.3 A **1), 5)**	35.0 A **1), 5)**	23.8 A **5)**

1) Connection requires a commutating choke.
3) Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")
4) Three-phase connection permissible only.
5) Reduction of switching frequency in thermal limit range

5.6 ACU 410 Size 1 (0.25 to 1.5 kW, 400 V)

Type								
ACU 410			-01	-03	-05	-07	-09	-11
Size			1					
Output, motor side								
Recommended motor shaft power	P	kW	0.25	0.37	0.55	0.75	1.1	1.5
Output current	I	A	1.0	1.6	1.8	2.4	3.2	3.8 **3)**
Long-term overload current (60 s)	I	A	2.0	3.2	2.7	3.6	4.8	5.7
Short-time overload current (1 s)	I	A	2.0	3.2	3.6	4.8	6.4	7.6
Output voltage	U	V	Maximum input voltage, three-phase					
Protection	-	-	Short circuit / earth fault proof					
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency					
Switching frequency	f	kHz	2, 4 (default), 8, 16					
Output, braking resistor								
Min. braking resistance	R	Ω	300	300	300	300	300	300
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	930	930	930	634	462	300
Input, mains side								
Power supply current **2)**	I	A	1.0	1.6	1.8	2.4	2.8 **1)**	3.3 **1)**
Mains voltage	U	V	320 ... 528					
Mains frequency	f	Hz	45 ... 66					
Fuses	I	A	6					
UL type 600 VAC RK5	I	A	6					
Mechanical								
Dimensions	HxWxD	mm	190 x 60 x 175					
Weight approx.	m	kg	1.2					
Ingress protection rating	-	-	IP20 (EN60529)					
Connection terminals	A	mm^2	0.2 ... 1.5					
Form of assembly	-	-	vertical					
Ambient conditions								
Energy dissipation (2 kHz switching frequency)	P	W	30	35	40	46	58	68
Coolant temperature	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)					

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	Switching frequency			
	2 kHz	**4 kHz**	**8 kHz**	**16 kHz**
0.25 kW	1.0 A	1.0 A	1.0 A	0.7 A
0.37 kW	1.6 A	1.6 A	1.6 A	1.1 A
0.55 kW	1.8 A	1.8 A	1.8 A	1.2 A
0.75 kW	2.4 A	2.4 A	2.4 A	1.6 A
1.1 kW	3.2 A **1)**	3.2 A **1)**	3.2 A **1)**	2.2 A
1.5 kW **1)**	3.8 A	3.8 A **3)**	3.8 A **3)**	2.6 A **3)**

1) Connection requires a commutating choke.
2) Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")
3) Reduction of switching frequency in thermal limit range

5.7 ACU 410 Size 2 (1.85 to 4.0 kW, 400 V)

Type						
ACU 410			-12	-13	-15	-18
Size			2			
Output, motor side						
Recommended motor shaft power	P	kW	1.85	2.2	3.0	4.0
Output current	I	A	4.2	5.8	7.8	9.0 [3)]
Long-term overload current (60 s)	I	A	6.3	8.7	11.7	13.5
Short-time overload current (1 s)	I	A	8.4	11.6	15.6	18.0
Output voltage	U	V	Maximum input voltage, three-phase			
Protection	-	-	Short circuit / earth fault proof			
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency			
Switching frequency	f	kHz	2, 4 (default), 8, 16			
Output, braking resistor						
Min. braking resistance	R	Ω	136	136	136	92
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	300	220	148	106
Input, mains side						
Power supply current [2)]	I	A	4.2	5.8	6.8 [1)]	7.8 [1)]
Mains voltage	U	V	320 ... 528			
Mains frequency	f	Hz	45 ... 66			
Fuses	I	A	6	10		
UL type 600 VAC RK5	I	A	6	10		
Mechanical						
Dimensions	HxWxD	mm	250 x 60 x 175			
Weight approx.	m	kg	1.6			
Ingress protection rating	-	-	IP20 (EN60529)			
Connection terminals	A	mm^2	0.2 ... 1.5			
Form of assembly	-	-	vertical			
Ambient conditions						
Energy dissipation (2 kHz switching frequency)	P	W	68	87	115	130
Coolant temperature	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)			

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	Switching frequency			
	2 kHz	**4 kHz**	**8 kHz**	**16 kHz**
1.85 kW	4.2 A	4.2 A	4.2 A	2.9 A
2.2 kW	5.8 A	5.8 A	5.8 A	3.9 A
3.0 kW	7.8 A [1)]	7.8 A [1)]	7.8 A [1)]	5.3 A
4.0 kW	9.0 A [1)]	9.0 A [1) 3)]	9.0 A [1) 3)]	6.1 A [3)]

[1)] Connection requires a commutating choke.
[2)] Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")
[3)] Reduction of switching frequency in thermal limit range

5.8 ACU 410 Sizes 3 and 4 (5.5 to 15.0 kW, 400 V)

Type							
ACU 410			-19	-21	-22	-23	-25
Size			3			4	
Output, motor side							
Recommended motor shaft power	P	kW	5.5	7.5	9.2	11.0	15.0
Output current	I	A	14.0	18.0	22.0 [3)]	25.0	32.0
Long-term overload current (60 s)	I	A	21.0	26.3	30.3	37.5	44.5
Short-time overload current (1 s)	I	A	28.0	33.0	33.0	50.0	64.0
Output voltage	U	V	Maximum input voltage, three-phase				
Protection	-	-	Short circuit / earth fault proof				
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency				
Switching frequency	f	kHz	2, 4 (default), 8, 16				
Output, braking resistor							
Min. braking resistance	R	Ω	48	48	48	32	32
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	80	58	48	48	32
Input, mains side							
Power supply current [2)]	I	A	14.2	15.8 [1)]	20.0 [1)]	26.0	28.2 [1)]
Mains voltage	U	V	320 ... 528				
Mains frequency	f	Hz	45 ... 66				
Fuses	I	A	16	25		35	
UL type 600 VAC RK5	I	A	20			30	40
Mechanical							
Dimensions	HxWxD	mm	250 x 100 x 200			250 x 125 x 200	
Weight approx.	m	kg	3.0			3.7	
Ingress protection rating	-	-	IP20 (EN60529)				
Connection terminals	A	mm2	0.2 ... 6			0.2 ... 16	
Form of assembly	-	-	vertical				
Ambient conditions							
Energy dissipation (2 kHz switching frequency)	P	W	145	200	225	240	310
Coolant temperature	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)				

Output current (Maximum current in continuous operation)				
Frequency inverter nominal power	**Switching frequency**			
	2 kHz	**4 kHz**	**8 kHz**	**16 kHz**
5.5 kW	14.0 A	14.0 A	14.0 A	9.5 A
7.5 kW	18.0 A [1)]	18.0 A [1)]	18.0 A [1)]	12.2 A
9.2 kW [1)]	23.0 A	22.7 A [3)]	22.0 A [3)]	15.0 A [3)]
11 kW	25.0 A	25.0 A	25.0 A	17.0 A
15 kW	32.0 A [1)]	32.0 A [1)]	32.0 A [1)]	21.8 A

[1)] Connection requires a commutating choke.
[2)] Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")
[3)] Reduction of switching frequency in thermal limit range

5.9 ACU 410 Size 5 (18.5 to 30.0 kW, 400 V)

Type					
ACU 410			-27	-29	-31
Size			5		
Output, motor side					
Recommended motor shaft power	P	kW	18.5	22.0	30.0
Output current	I	A	40.0	45.0	60.0
Long-term overload current (60 s)	I	A	60.0	67.5	90.0
Short-time overload current (1 s)	I	A	80.0	90.0	120.0
Output voltage	U	V	Maximum input voltage, three-phase		
Protection	-	-	Short circuit / earth fault proof		
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency		
Switching frequency	f	kHz	2, 4 (default), 8		
Output, braking resistor					
Min. braking resistance	R	Ω	16		
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	26	22	16
Input, mains side					
Power supply current [2]	I	A	42.0	50.0	58.0 [1]
Mains voltage	U	V	320 ... 528		
Mains frequency	f	Hz	45 ... 66		
Fuses	I	A	50		63
UL type 600 VAC RK5	I	A	50		60
Mechanical					
Dimensions	HxWxD	mm	250x200x260		
Weight approx.	m	kg	8		
Ingress protection rating	-	-	IP20 (EN60529)		
Connection terminals	A	mm^2	up to 25		
Form of assembly	-	-	vertical		
Ambient conditions					
Energy dissipation (2 kHz switching frequency)	P	W	445	535	605
Coolant temperature	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)		

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	Switching frequency		
	2 kHz	4 kHz	8 kHz
18.5 kW	40.0 A	40.0 A	40.0 A
22 kW	45.0 A	45.0 A	45.0 A
30 kW	60.0 A [1]	60.0 A [1]	60.0 A [1]

[1] Connection requires a commutating choke.
[2] Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")

5.10 ACU 410 Size 6 (37.0 to 65.0 kW, 400 V)

Type						
ACU 410			-33	-35	-37	-39
Size			6			
Output, motor side						
Recommended motor shaft power	P	kW	37.0	45.0	55.0	65.0
Output current	I	A	75.0	90.0	110.0	125.0
Long-term overload current (60 s)	I	A	112.5	135.0	165.0	187.5
Short-time overload current (1 s)	I	A	150.0	180.0	220.0	250.0
Output voltage	U	V	Maximum input voltage, three-phase			
Protection	-	-	Short circuit / earth fault proof			
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency			
Switching frequency	f	kHz	2, 4 (default), 8			
Output, braking resistor [5)]						
Min. braking resistance	R	Ω	7.5			
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	13	11	9	7.5
Input, mains side						
Power supply current [2)]	I	A	87.0	104.0	105.0 [1)]	120.0 [1)]
Mains voltage	U	V	320 ... 528			
Mains frequency	f	Hz	45 ... 66			
Fuses	I	A	100	125	125	125
UL type 600 VAC RK5	I	A	100	125	125	125
Mechanical						
Dimensions	HxWxD	mm	400x275x260			
Weight approx.	m	kg	20			
Ingress protection rating	-	-	IP20 (EN60529)			
Connection terminals	A	mm^2	up to 70			
Form of assembly	-	-	vertical			
Ambient conditions						
Energy dissipation (2 kHz switching frequency)	P	W	665	830	1080	1255
Coolant temperature for air cooling 6)	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)			

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	**Switching frequency**		
	2 kHz	**4 kHz**	**8 kHz**
37 kW	75.0 A	75.0 A	75.0 A
45 kW	90.0 A	90.0 A	90.0 A
55 kW	110.0 A [1)]	110.0 A [1)]	110.0 A [1)]
65 kW	125.0 A [1) 3)]	125.0 A [1) 3)]	125.0 A [1) 3)]

[1)] Connection requires a commutating choke.
[2)] Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")
[3)] Reduction of switching frequency in thermal limit range
[5)] As an option, the frequency inverter of this size is available without internal brake transistor.
[6)] Coolant temperature for liquid cooling: see "Operating Instructions Liquid Cooling Supplemental"

5.11 ACU 410 Size 7 (75.0 to 200.0 kW, 400 V)

Type								
ACU 410			-43	-45	-47	-49	-51	-53
Size			7					
Output, motor side								
Recommended motor shaft power	P	kW	75	90	110	132	160	200 [8]
Output current	I	A	150	180	210	250	305	380
Long-term overload current (60 s)	I	A	225	270	315	332	460	570
Short-time overload current (1 s)	I	A	270	325	375	375	550	680
Output voltage	U	V	Maximum input voltage, three-phase					
Protection	-	-	Short circuit / earth fault proof					
Rotary field frequency	f	Hz	0 ... 599, depending on switching frequency					
Switching frequency	f	kHz	2, 4 (default), 8					
Output, braking resistor (external) [5]								
Min. braking resistance	R	Ω	4.5		3.0		2.71	2.17
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	6.1	5.1	4.1	3.8	2.7	2.2
Input, mains side								
Power supply current [2]	I	A	143 [1]	172 [1]	208 [1]	249 [1]	302 [1]	377 [1]
Mains voltage	U	V	320 ... 528					
Mains frequency	f	Hz	45 ... 66					
Fuses	I	A	160	200	250	315	400	500
Fuses as per UL[6] Cooper Bussmann	Type		FWH-250A	FWH-300A	FWH-350A	FWH-400A	FWH-450A	FWH-500A
Mechanical								
Dimensions	HxWxD	mm	510 x 412 x 351/389 (for 160/200 kW)					
Weight approx.	m	kg	45		48		52	
Ingress protection rating	-	-	IP20 (EN60529)					
Connection terminals	A	mm^2	up to 2 x 95				up to 2 x 120	
Form of assembly	-	-	vertical					
Ambient conditions								
Energy dissipation (2 kHz switching frequency)	P	W	1600	1900	2300	2800	3400	4000
Coolant temperature for air cooling [7]	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)					

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	Switching frequency		
	2 kHz	4 kHz	8 kHz
75 kW	150 A	150 A	150 A
90 kW	180 A	180 A	180 A
110 kW	210 A	210 A	210 A [3]
132 kW	250 A	250 A	250 A [3]
160 kW	305 A	305 A	305 A [3]
200 kW	380 A	380 A	380 A [3]

[1] Connection requires a commutating choke.
[2] Mains current with relative mains impedance ≥ 1% (refer to Chapter 7 "Electrical installation")
[3] Reduction of switching frequency in thermal limit range
[5] As an option, the frequency inverter of this size is available without internal brake transistor.
[6] For UL-compliant fusing, use the specified Cooper Bussmann fuses. Do not use other fuses for UL-conforming fusing.
[7] Coolant temperature for liquid cooling: see "Operating Instructions Liquid Cooling Supplemental"
[8] Values in this column are valid for **liquid cooled** ACU 410-53 size 7 devices only

Liquid cooled ACU 410-53 size 7 devices reach rated power of up to 200 kW.

5.12 ACU 410 Size 8 (160.0...400.0 kW, 400 V)

Type								
ACU 410			-51	-53	-55	-57	-59	-61
Size			8					
Output, motor side								
Recommended motor shaft power	P	kW	160	200	250	315	355	400
Output current	I	$A_{eff.}$	305	380	475	595	645	735
Long-term overload current (60 s) [1]	I	$A_{eff.}$	460	570	715	895	970	1100
Short-term overload current (1 s) [2]	I	$A_{eff.}$	550	685	855	1070	1160	1330
Output voltage	U	$V_{eff.}$	Maximum input voltage, three-phase					
Protection	-	-	Short circuit / earth fault proof					
Rotary field frequency	f	Hz	±500; Depending on switching frequency					
Switching frequency	f	kHz	2, 4 (default), 8					
Output, braking resistor (external) [5]								
Min. braking resistance	R	Ω	2.71	2.17	1.20	0.80	0.80	0.80
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	2.7	2.2	1.50	1.00	1.00	1.00
Input, mains side								
Power supply current [6]	I	A	302	350	440	550	620	690
Mains voltage	U	V	320 ... 528					
Mains frequency	f	Hz	45 ... 66					
Fuses [7]	I	A	400	500	630	700	800	900
Fuses as per UL [8]	Type		170M5* 08 or 170M5* 58	170M5* 10 or 170M5* 60	170M5* 12 or 170M5* 62	170M5* 13 or 170M5* 63	170M5* 14 or 170M5* 64	170M5* 15 or 170M5* 65
Mechanical								
Dimensions	HxWxD	mm	1067 x 439 x 375					
Weight approx.	m	kg	120	120	120	140	140	140
Ingress protection rating	-	-	IP20 (EN60529)					
Connection terminals	A	mm^2	up to 2 x 240					
Form of assembly	-	-	vertical					
Ambient conditions								
Energy dissipation (2 kHz switching frequency)	P	W	3800	4500	5600	6300	6850	7900
Coolant temperature for air cooling [10]	T_n	°C	-25 ... 45 (3K3 DIN IEC 60721-3-3)					

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	Switching frequency		
	2 kHz	4 kHz	8 kHz
160 kW	305	305	305
200 kW	380	380	380
250 kW	475	475	475
315 kW	595	595	595
355 kW	645	645	645
400 kW	735	735	735

[1] Power reduction with torsional frequencies below 10 Hz [2] Only with torsional frequencies above 10 Hz
[5] As an option, the frequency inverter of this size is available without internal brake transistor.
[6] Rated value with recommended motor power, 400V mains voltage and mains inductance U_K=4%
[7] Semiconductor fuses recommended (e.g. Bussmann Type 170M)
[8] For UL-compliant fusing, use the specified Cooper Bussmann fuses. * is a placeholder for the mounting.
[10] Coolant temperature for liquid cooling: see "Operating Instructions Liquid Cooling Supplemental"

5.13 ACU 510 Size 8 (160.0...400.0 kW, 525 V)

Type								
ACU 510			-51	-53	-55	-57	-59	-61
Size			8					
Output, motor side								
Recommended motor shaft power	P	kW	160	200	250	315	355	400
Output current	I	$A_{eff.}$	230	290	360	450	490	560
Long-term overload current (60 s) [1]	I	$A_{eff.}$	345	435	540	675	735	840
Short-term overload current (1 s) [2]	I	$A_{eff.}$	420	520	650	810	880	1000
Output voltage	U	$V_{eff.}$	Maximum input voltage, three-phase					
Protection	-	-	Short circuit / earth fault proof					
Rotary field frequency	f	Hz	±500; Depending on switching frequency					
Switching frequency	f	kHz	2, 4 (default), 8					
Output, braking resistor (external) [5]								
Min. braking resistance	R	Ω	1.20	1.20	1.20	0.80	0.80	0.80
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	2.70	2.70	2.70	1.50	1.50	1.50
Input, mains side								
Power supply current [6]	I	A	215	270	335	420	470	525
Mains voltage [7]	U	V	525					
Mains frequency	f	Hz	50 (60)					
Fuses [8]	I	A	315	350	450	550	630	700
Mechanical								
Dimensions	HxWxD	mm	1067 x 439 x 375					
Weight approx.	m	kg	120	120	120	140	140	140
Ingress protection rating	-	-	IP20 (EN60529)					
Connection terminals	A	mm^2	up to 2 x 240					
Form of assembly	-	-	vertical					
Ambient conditions								
Energy dissipation (2 kHz switching frequency)	P	W	3800	4500	5600	6300	6850	7900
Coolant temperature for air cooling [11]	T_n	°C	-25 ... 45 (3K3 DIN IEC 60721-3-3)					

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	**Switching frequency**		
	2 kHz	**4 kHz**	**8 kHz**
160 kW	230	230	230
200 kW	290	290	290
250 kW	360	360	360
315 kW	450	450	450
355 kW	490	490	490
400 kW	560	560	560

[1] Power reduction with torsional frequencies below 10 Hz [2] Only with torsional frequencies above 10 Hz
[5] As an option, the frequency inverter of this size is available without internal brake transistor.
[6] Rated value with recommended motor power, 525 V mains voltage and mains inductance U_K=4%
[7] Note: in addition to AC 3x525V connection, AC 3x400V connection is required, see Chapter 7.7 "X13 connection in ACU 510 and ACU 610".
[8] Semiconductor fuses recommended (e.g. Bussmann Type 170M)
[11] Coolant temperature for liquid cooling: see "Operating Instructions Liquid Cooling Supplemental"

5.14 ACU 610 Size 8 (160.0...400.0 kW, 690 V)

Type								
ACU 610			-51	-53	-55	-57	-59	-61
Size			8					
Output, motor side								
Recommended motor shaft power	P	kW	160	200	250	315	355	400
Output current	I	$A_{eff.}$	180	230	280	350	370	450
Long-term overload current (60 s) [1]	I	$A_{eff.}$	270	350	420	530	600	675
Short-term overload current (1 s) [2]	I	$A_{eff.}$	330	420	510	630	720	750
Output voltage	U	$V_{eff.}$	Maximum input voltage, three-phase					
Protection	-	-	Short circuit / earth fault proof					
Rotary field frequency	f	Hz	±500; Depending on switching frequency					
Switching frequency	f	kHz	2, 4 (default), 8					
Output, braking resistor (external) [5]								
Min. braking resistance	R	Ω	3.00	3.00	3.00	1.80	1.80	1.80
Recommended braking resistor (U_{dBC} = 770 V)	R	Ω	5.00	5.00	5.00	3.00	3.00	3.00
Input, mains side								
Power supply current [6]	I	A	160	200	250	320	360	410
Mains voltage [7]	U	V	690 (for UL reduced: 600)					
Mains frequency	f	Hz	50 (60)					
Fuses [8]	I	A	250	315	350	450	500	550
Mechanical								
Dimensions	HxWxD	mm	1067 x 439 x 375					
Weight approx.	m	kg	120	120	120	140	140	140
Ingress protection rating	-	-	IP20 (EN60529)					
Connection terminals	A	mm^2	up to 2 x 240					
Form of assembly	-	-	vertical					
Ambient conditions								
Energy dissipation (2 kHz switching frequency)	P	W	3200	3950	4500	5500	6250	6900
Coolant temperature for air cooling [11]	T_n	°C	-25 … 45 (3K3 DIN IEC 721-3-3)					

Output current (Maximum current in continuous operation)

Frequency inverter nominal power	**Switching frequency**		
	2 kHz	**4 kHz**	**8 kHz**
160 kW	180	180	180
200 kW	230	230	230
250 kW	280	280	280
315 kW	350	350	350
355 kW	400	400	400
400 kW	450	436	410

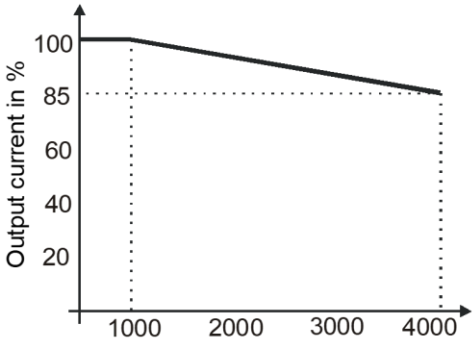
[1] Power reduction with torsional frequencies below 15 Hz [2] Only with torsional frequencies above 15 Hz
[5] As an option, the frequency inverter of this size is available without internal brake transistor
[6] Rated value with recommended motor power, 400V mains voltage and mains inductance U_K=4%
[7] Note that, in addition to AC 3x690V connection, AC 3x400V connection is required, see Chapter 7.7 "X13 connection in ACU 510 and ACU 610".
[8] Semiconductor fuses recommended (e.g. Bussmann Type 170M)
[9] For UL-compliant fusing, use the specified Cooper Bussmann fuses. * is a placeholder for the mounting.
[11] Coolant temperature for liquid cooling: see "Operating Instructions Liquid Cooling Supplemental"

5.15 Operation diagrams

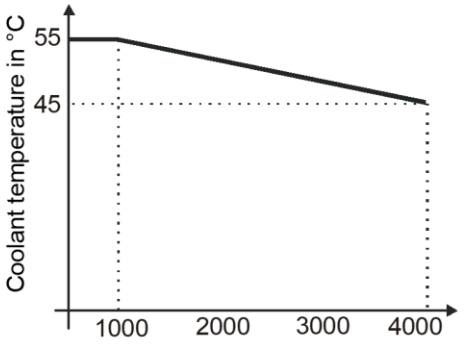
The technical data of the frequency inverters refer to the nominal point which was selected to enable a wide range of applications. A functionally and efficient dimensioning (derating) of the frequency inverters is possible based on the following diagrams.

Installation altitude

Power reduction (Derating),
5%/1000 m above sea level,
h_{max} = 4000 m

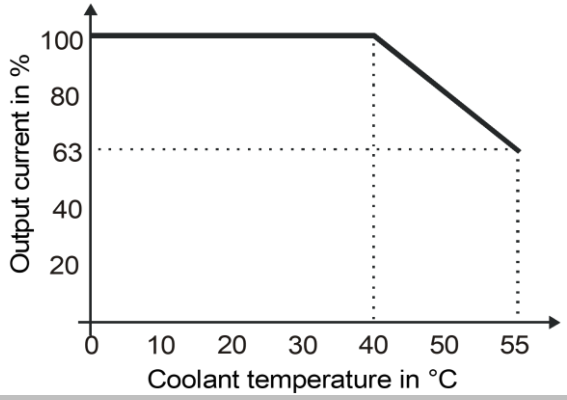


max. coolant temperature,
3.3 °C/1000 m above sea level,



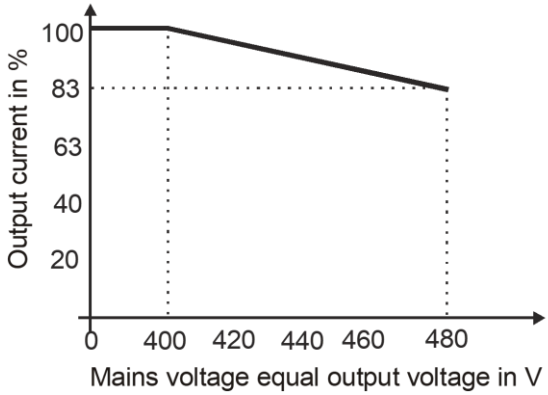
Coolant temperature

Power reduction (Derating)
2.5%/K upper 40 °C, T_{max} = 55 °C



Mains voltage

Reduction of output current at constant output power (Derating)
0.22%/ V upper 400 V, U_{max} = 480 V



6 Mechanical installation

The frequency inverters of degree of protection IP20 are designed, as a standard, for installation in electrical cabinets.
Apart from the air-cooled standard installation variant described in these Operating Instructions other installation variants are available:

- Feedthrough assembly for sizes 1 through 8, see "Installation Instructions – Feedthrough Assembly"
- ColdPlate for sizes 1 through 5, see "Installation Instructions – ColdPlate"
- Liquid cooling for sizes 6 through 8, see "Operating Instructions Liquid Cooling Supplemental"

- During installation, comply with the installation and the safety instructions and note the device specifications.

WARNING

Inappropriate handling of the device may result in serious physical injuries or major material damage.

- To avoid serious physical injuries or major material damage, only qualified persons are allowed to Work at the device.

WARNING

Risk of short circuit and fire!

During assembly, make sure that no foreign particles (e.g. chips, dust, wires, screws, tools) can get inside the frequency inverter. Otherwise there is the risk of short circuits and fire.

- The frequency inverter complies with IP20 ingress protection rating only if the covers, components and terminals are mounted properly.
- Overhead installation or installation in horizontal position is not permissible.

In devices with liquid cooling the coolant hoses must be connected after the mechanical installation procedure. Comply with instructions in the "Operating Instructions Liquid Cooling Supplemental" document.

6.1 Air circulation

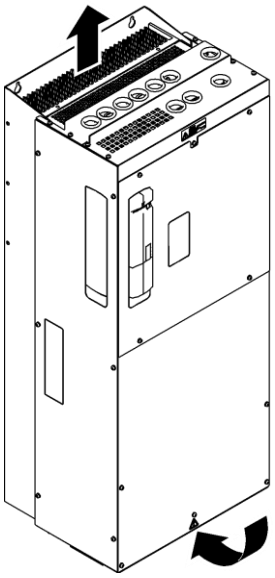
CAUTION

Risk of short circuit and fire!

Insufficient air circulation may result in major material damage, which may in turn result in physical injuries.

- Mount the devices with sufficient clearance to other components so that the cooling air can circulate freely.
- Avoid soiling by grease and air pollution by dust, aggressive gases, etc.
- Fan inlet and outlet openings must not be covered.

For air cooling:

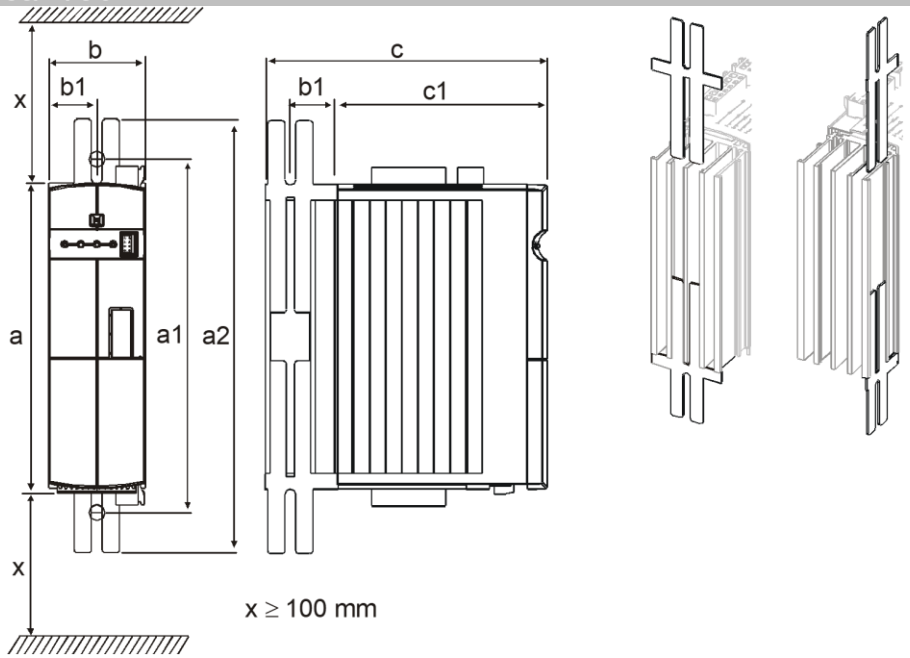


For cooling the air-cooled frequency inverters, air is taken in through openings in the bottom plate. The air coming from below heats up and escapes through openings in the top of the case. The illustration shows the air flow from below for size 8 frequency inverter.

6.2 Sizes 1 and 2: ACU 210 (up to 3.0 kW) and 410 (up to 4.0 KW)

The frequency inverter is mounted in a vertical position on the assembly panel by means of the standard fittings. The following illustration shows the different mounting possibilities.

Standard installation



For assembly the long side of the fixing plate is inserted in the heat sink and screwed to the assembly panel.

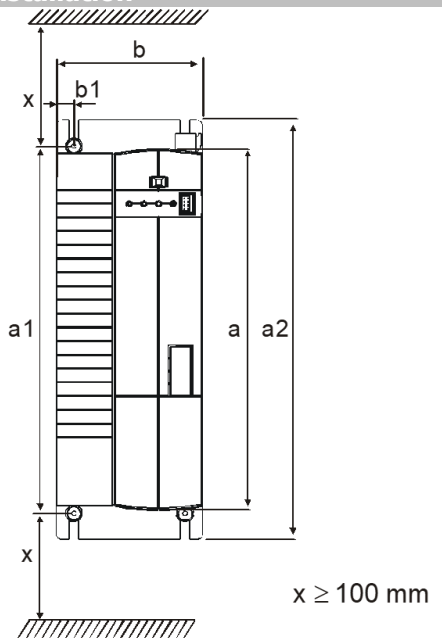
The dimensions of the device and the installation dimensions are those of the standard device without optional components and are given in millimeters.

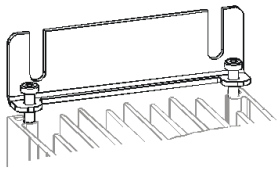
Dimensions [mm]					Assembly dimensions [mm]			
ACU		a	b	c	a1	a2	b1	c1
210	**0.25 kW ... 1.1 kW**	190	60	178	210 ... 230	260	30	133
	1.5 kW ... 3.0 kW	250	60	178	270 ... 290	315	30	133
410	**0.25 kW ... 1.5 kW**	190	60	178	210 ... 230	260	30	133
	1.85 kW ... 4.0 kW	250	60	178	270 ... 290	315	30	133

6.3 Sizes 3 and 4: ACU 210 (4.0 to 9.2 kW) and 410 (5.5 to 15.0 kW)

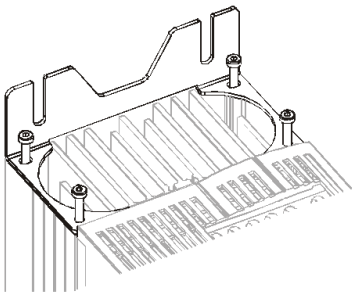
The frequency inverter is mounted in a vertical position on the assembly panel by means of the standard fittings. The following illustration shows the standard fitting.

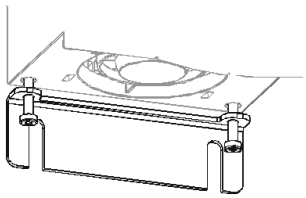
Standard installation



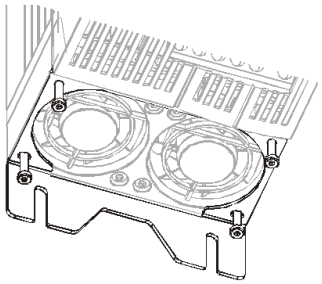


fixing bracket top
(fixing with screws **M4x20**)





fixing bracket bottom
(fixing with screws **M4x60**)



For assembly the two fixing brackets are screwed to the heat sink of the frequency inverter and the assembly panel.

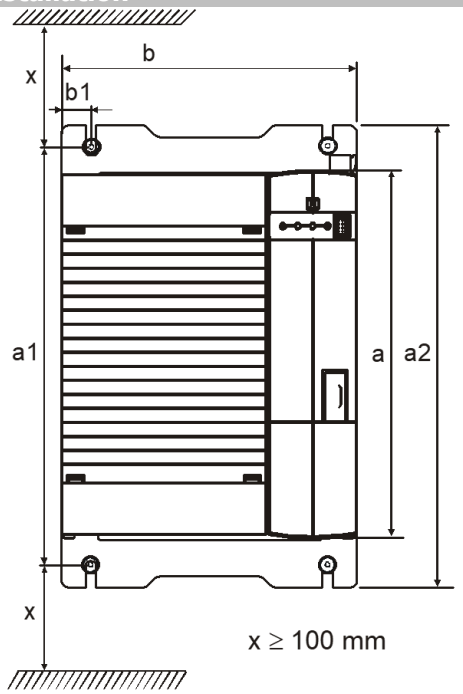
The frequency inverters are provided with fixing brackets, which are fitted using four thread-cutting screws. The dimensions of the device and the installation dimensions are those of the standard device without optional components and are given in millimeters.

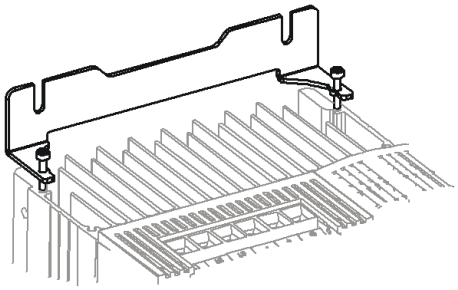
Dimensions [mm]					Assembly dimensions [mm]			
ACU		a	b	c	a1	a2	b1	c1
210	**4.0 ... 5.5 kW**	250	100	200	270 ... 290	315	12	133
	7.5 ... 9.2 kW	250	125	200	270 ... 290	315	17.5	133
410	**5.5 ... 9.2 kW**	250	100	200	270 ... 290	315	12	133
	11.0 ... 15.0 kW	250	125	200	270 ... 290	315	17.5	133

6.4 Size 5: ACU 410 (18.5 to 30.0 kW)

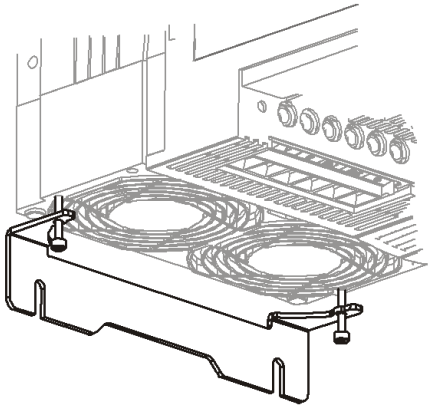
The frequency inverter is mounted in a vertical position on the assembly panel by means of the standard fittings. The following illustration shows the standard fitting.

Standard installation





fixing bracket top
(fixing with screws **M4x20**)



fixing bracket bottom
(fixing with screws **M4x70**)

For assembly the two fixing brackets are screwed to the heat sink of the frequency inverter and the assembly panel.

The frequency inverters are provided with fixing brackets, which are fitted using four thread-cutting screws. The dimensions of the device and the installation dimensions are those of the standard device without optional components and are given in millimeters.

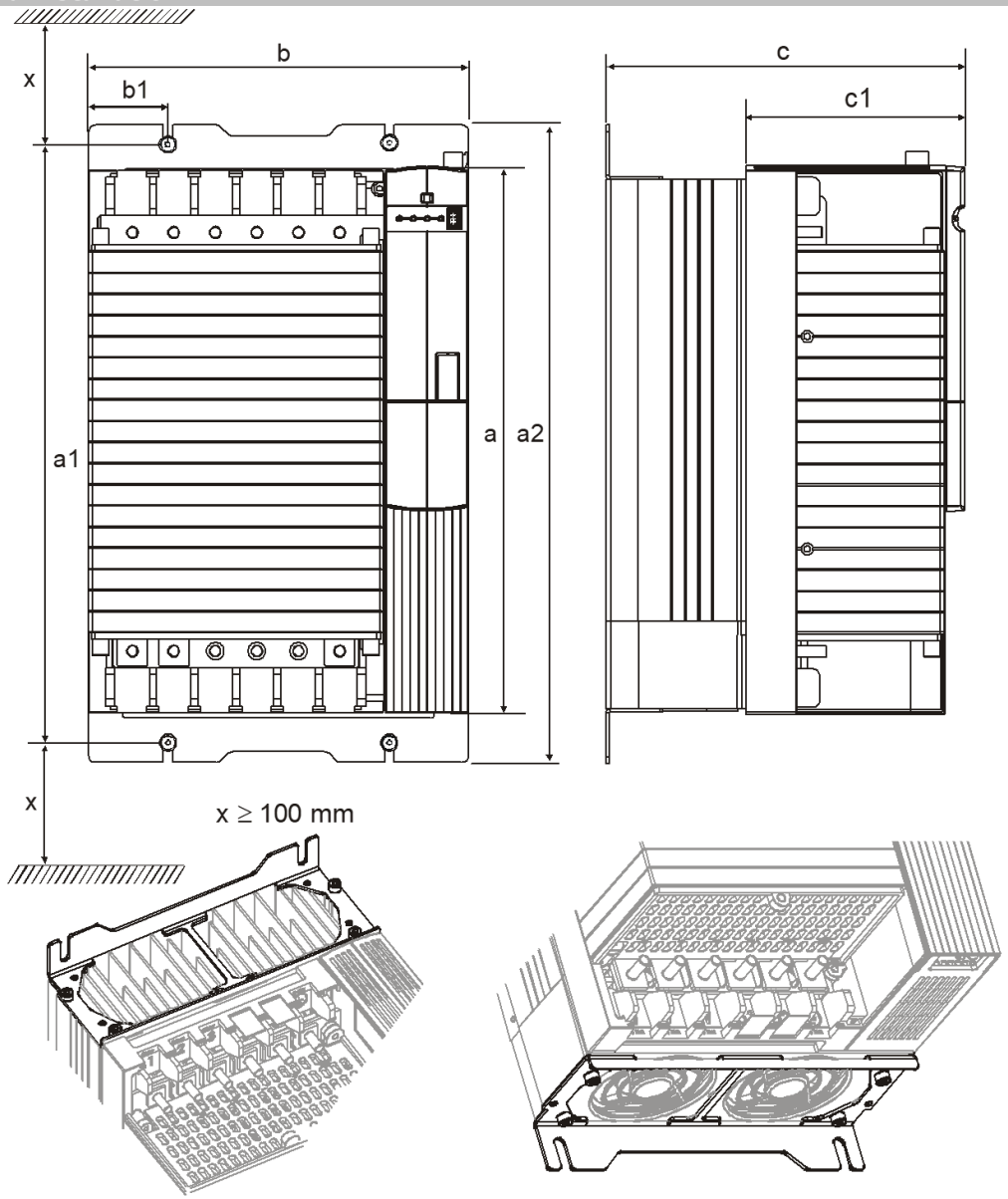
Dimensions [mm]					Assembly dimensions [mm]			
ACU		a	b	c	a1	a2	b1	c1
410	**18.5...30.0 kW**	250	200	260	270 ... 290	315	20	160

6.5 Size 6: ACU 410 (37.0 to 65.0 kW)

For mechanical installation of liquid-cooled size 6 frequency inverters see "Operating Instructions Liquid Cooling Supplemental".

The frequency inverter is mounted in a vertical position on the assembly panel by means of the standard fittings. The following illustration shows the standard fitting.

Standard installation



fixing braket top
(fixing with screws **M5x20**)

fixing braket bottom
(fixing with screws **M5x20**)

For assembly the two fixing brackets are screwed to the heat sink of the frequency inverter and the assembly panel.

The frequency inverters are provided with fixing brackets, which are fitted using four thread-cutting screws. The dimensions of the device and the installation dimensions are those of the standard device without optional components and are given in millimeters.

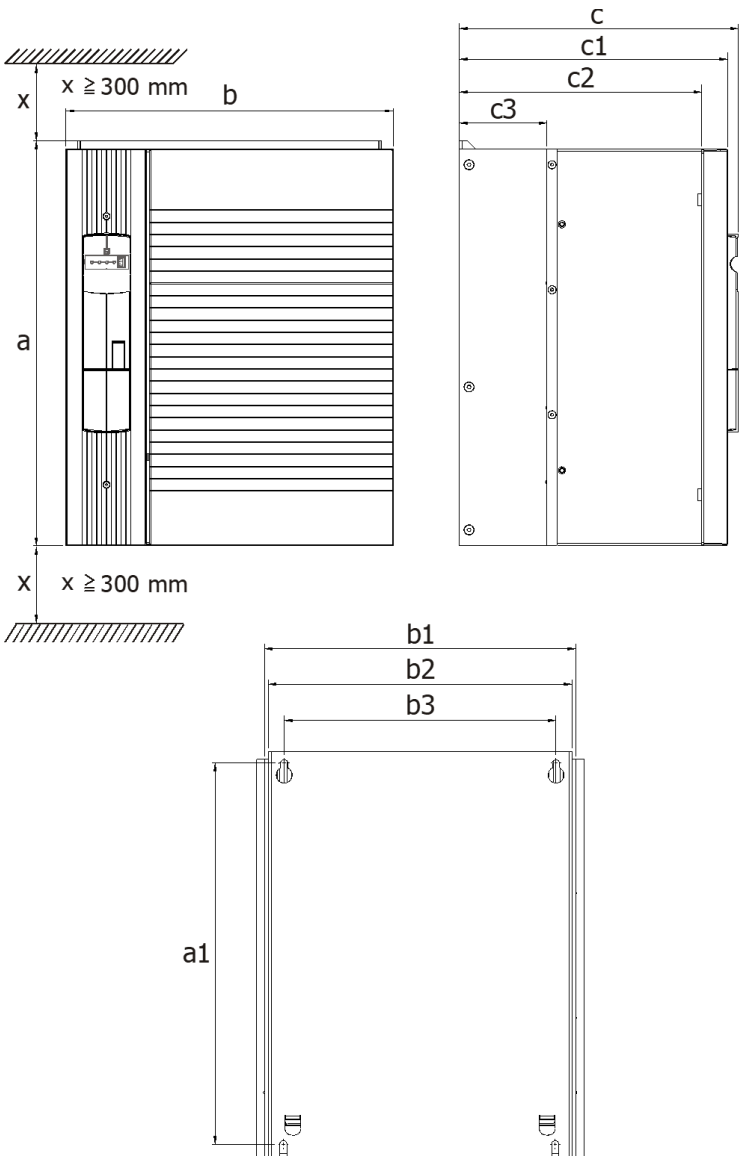
Dimensions [mm]					Assembly dimensions [mm]			
ACU		a	b	c	a1	a2	b1	c1
410	**37...65 kW**	400	275	260	425 ... 445	470	20	160

6.6 Size 7: ACU 410 (75.0 to 160.0 kW)

The illustration shows an example for mechanical installation of air-cooled frequency inverters. The dimensions and fitting elements correspond to those of liquid-cooled size 7 devices.

The frequency inverter is mounted in a vertical position on the assembly panel. The following illustration shows the standard fitting.

Standard installation

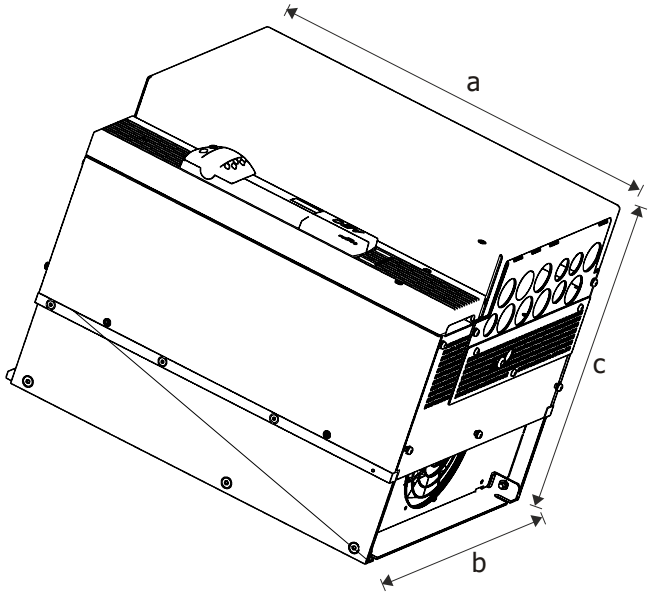


The diameter of the fixing holes is 9 mm.
For assembly the back wall of the frequency inverter is screwed to the assembly panel.
The dimensions of the device and the installation dimensions are those of the standard device without optional components and are given in millimeters.

Dimensions [mm]					Assembly dimensions [mm]						
ACU		**a**	**b**	**c**	**a1**	**b1**	**b2**	**b3**	**c1**	**c2**	**c3**
410	**75...132 kW**	510	412	351	480	392	382	342	338	305	110
410	**160 kW**	510	412	389	480	392	382	342		305	110

The illustration shows an example of air-cooled frequency inverters of size 7 and 160 kW version.

ACU 410 160kW

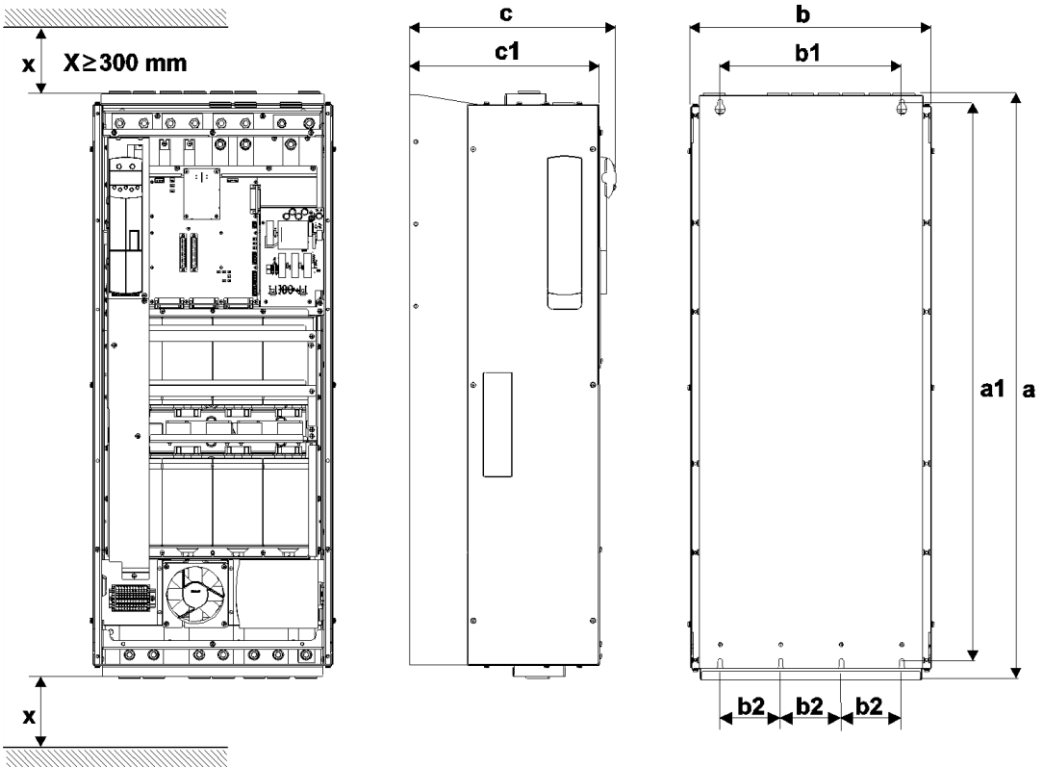


6.7 Size 8: ACU 410, 510 and 610 (160.0 to 400.0 kW)

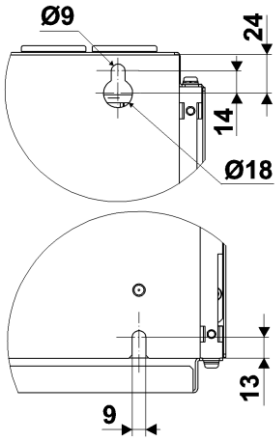
The illustration shows an example for mechanical installation of air-cooled frequency inverters. The dimensions and fitting elements correspond to those of liquid-cooled size 8 devices.

The frequency inverter is mounted in a vertical position on the assembly panel. The following illustration shows the standard fitting.

Standard installation



The diameter of the fixing holes is 9 mm.
Screw the rear wall of the frequency inverter heat sink to the assembly panel.



Dimensions in mm					Assembly dimensions in mm			
ACU	**kW**	a	b	c	a1	b1	b2	c1
410 **510** **610**	160.0...400.0	1063	439	376	1017	330	110	345

7 Electrical installation

WARNING

Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

- The electrical installation must be carried out by qualified electricians according to the general and regional safety and installation directives.
- The documentation and device specification must be complied with during installation.
- Before any assembly or connection work, discharge the frequency inverter. Verify safe isolation from power supply.
- Do not connect inappropriate voltage sources. The nominal voltage of the frequency inverter must correspond to the supply voltage.
- The frequency inverter must be connected to ground potential.
- Do not remove any covers of the frequency inverter while power supply is on.

The connecting cables must be protected externally, considering the maximum voltage and current values of the fuses. The mains fuses and cable cross-sections are to be selected according to EN 602041 and DIN VDE 0298 Part 4 for the nominal operating point of the frequency inverter. According to UL/CSA, the frequency inverter is suitable for operation at a supply network of a maximum of 480 VAC which delivers a maximum symmetrical current of 5000 A (effective value) if protected by fuses of class RK5. Only use copper cables with a temperature range of 60 / 75 °C.

The fuses must be chosen depending on the individual application. The values recommended in the technical data apply for the continuous rated operation without overload.

The frequency inverters are to be grounded properly, i.e. large connection area and with good conductivity. The leakage current of the frequency inverters may exceed AC 3.5 mA or DC 10 mA. According to EN 61800-5-1 a permanent connection must be provided. The protective conductor cross-section required for grounding the fixing plate must be selected according to the size of the unit. In these applications, the cross-section must correspond to the recommended cross-section of the wire.

CAUTION

Improperly mounted covers

IP20 ingress protection rating is only achieved with terminals plugged and with properly mounted covers. Improperly mounted covers lead to ingress of dirt or foreign objects into the housing of the device and might lead to malfunctions.

- Take care to mount all covers correctly and properly.
- Insert all terminal connectors and mount all covers before starting operation.

Special connection variants are possible apart from the standard connection variant described in these Operating Instructions:

- Parallel connection (see "Application Manual – Parallel Connection")
- DC supply (if you have any questions on this, contact BONFIGLIOLI Customer Service.)

In devices ACU 510 and ACU 610 of size 8, reconnection of the DC power supply unit is required to ensure proper cooling. Please contact BONFIGLIOLI Customer Service.

Connection conditions

- The frequency inverter is suited for connection to the public or industrial supply mains according to the technical data. If the transformer output of the supply mains is ≤ 500 kVA, a mains commutation choke is only necessary for the frequency inverters identified in the technical data. The other frequency inverters are suitable for connection without a mains commutating choke with a relative mains impedance ≥ 1%.
- It must be checked, based on the specifications of EN 61000-3-2, if the devices can be connected to the public supply means without taking additional measures. The frequency inverters ≤ 9.2 kW with integrated EMC filter comply with the emission limits of the product standard EN 61800-3 up to a motor cable length of 10 m, without additional measures being required. Increased requirements in connection with the specific application of the frequency inverter are to be met by means of optional components. Commutating chokes and EMC filters are optionally available for the series of devices.
- Operation on an unearthed mains (IT mains) is admissible when using devices specifically constructed for this purpose. Please contact BONFIGLIOLI for details.
- Interference-free operation with residual current device is guaranteed at a tripping current ≥ 30 mA if the following points are observed:
  - One-phase power supply (L1/N): Pulse current and alternating current sensitive residual current devices (Type A acc. to EN 61800-5-1)
  - Two-phase power supply (L1/L2) or Three-phase power supply (L1/L2/L3): All-current sensitive residual current devices (Type B acc. to EN 61800-5-1)
  - Use EMC filters with reduced leakage current or, if possible, do not use EMC filters at all.
  - The length of the shielded motor cable is ≤ 10 m and there are no additional capacitive components between the mains or motor cables and PE.

NOTICE

Unexpected current

Please note (according to EN 61800-5-1): This product may cause direct current in the protective earth conductor.

- Where residual current devices (RCD) or residual current monitors (RCM) are used as a protection against direct or indirect contact, only RCDs / RCMs of Type B are permissible on the power supply side of this product.

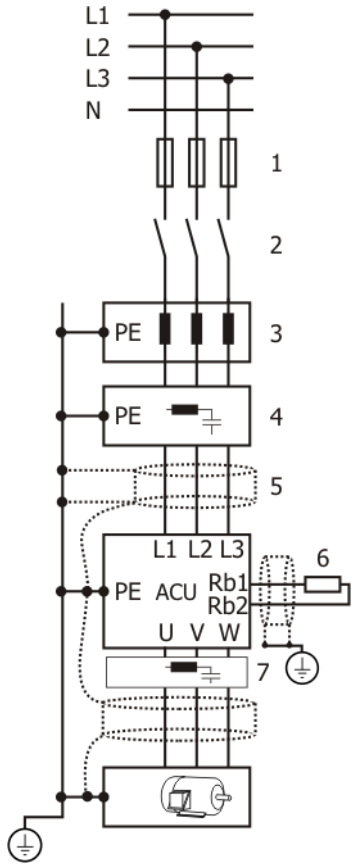
- The fuses to be used are to be selected depending on the specific application. The safety recommendations in the Technical Data are valid for continuous operation without overload.

7.1 EMC information

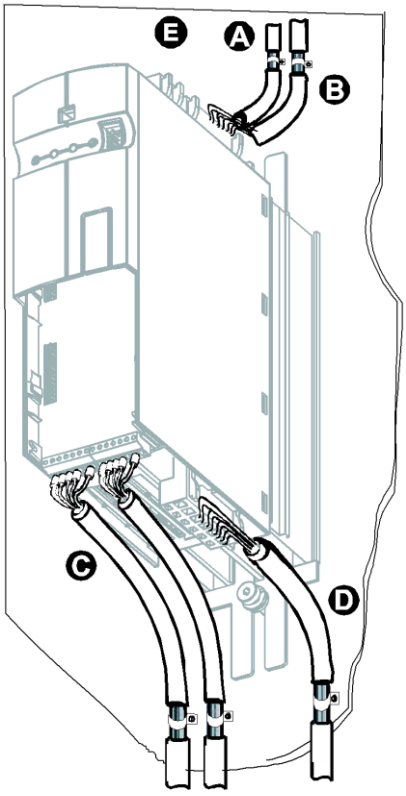
The frequency inverters are designed according to the requirements and limit values of product standard EN 61800-3 with an interference immunity factor (EMI) for operation in industrial applications. Electromagnetic interference is to be avoided by expert installation and observation of the specific product information.

Measures

- Install the frequency inverters and commutating chokes on a metal mounting panel. Ideally, the mounting panel should be galvanized, not painted.
- Provide proper equipotential bonding within the system or plant. Plant components such as electrical cabinets, control panels, machine frames must be connected by means of PE cables, i.e. sufficient area and with good conductivity.
- The shield of the control cables is to be connected to ground potential properly, i.e. with good conductivity, on both sides (shield clamp). Mount shield clamps for cable shields close to the unit.
- Connect the frequency inverter, the commutating choke, external filters and other components to an earthing point via short cables.
- Excessive cable length and loosely suspended cabling must be avoided.
- Contactors, relays and solenoids in the electrical cabinet are to be provided with suitable interference suppression components.



1 fuse
2 circuit breaker
3 line choke (optional)
4 input filter (optional)
5 cable shield
6 braking resistor (optional)
7 output filter (optional)



A Mains connection

The length of the mains supply cable is not limited. However, it must be installed separate from the control, data and motor cables.

B DC-link connection

The frequency inverters are to be connected to the same mains potential or a common direct voltage source. Cables longer than 300 mm are to be shielded. The shield must be connected to the mounting panel on both sides.

C Control connection

Keep control and signal cables physically separate from the power cables. Analog signal lines are to be connected to the shield potential on one side. Install sensor cables separate from motor cables.

D Motor and braking resistor

The shield of the motor cable is to be connected to ground potential properly on both sides. On the motor side use a metal compression gland. On the frequency inverter side an appropriate shield clamp is to be used. The signal cable used for monitoring the motor temperature must be kept separate from the motor cable. Connect the shield of this line on both sides. If a braking resistor is used, the connection cable must also be shielded, and the shield is to be connected to earth potential on both sides.

E Relay

The relay enables using high-energy signals.

Line choke

Line chokes reduce mains harmonics and reactive power. In addition, a longer service life of the frequency inverter is possible. When using a line choke, note that line chokes may reduce the maximum output voltage of the frequency inverter.

The line choke must be installed between the mains connection and the input filter.

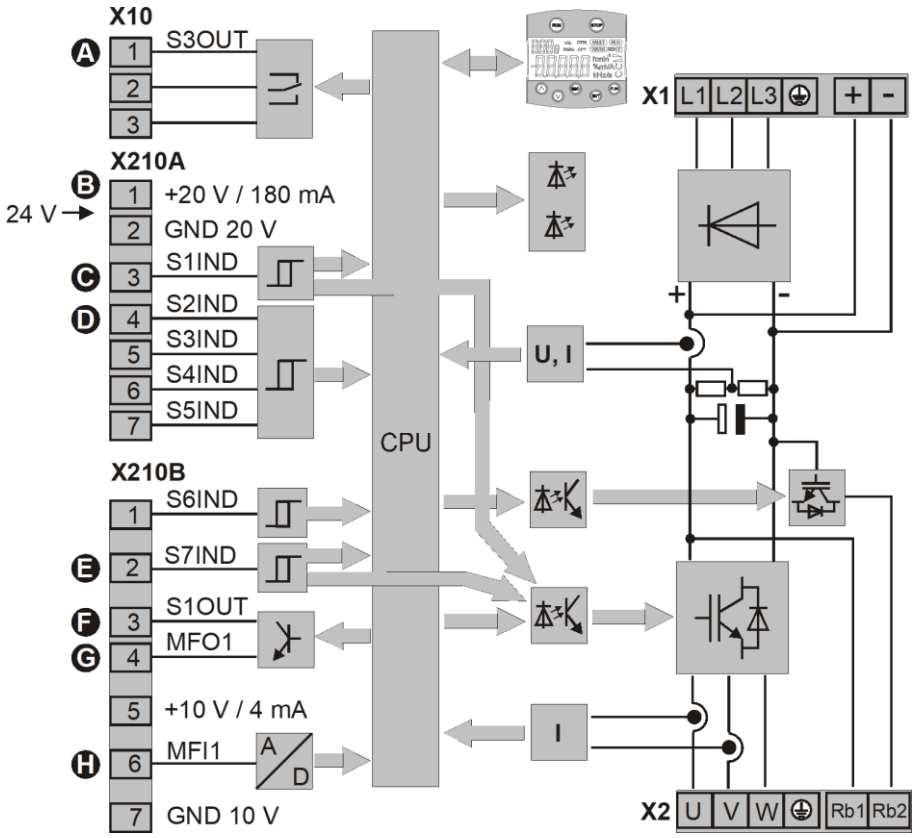
Input filter

Input filters reduce grid-bound, high-frequency radio interference voltage.

- Install the input filter on the mains side upstream of the frequency inverter.

The frequency inverters meet the requirements of the low voltage directive 2014/35/EU and the requirements of the EMC Directive 2014/30/EU. The EMC product standard EN 61800-3 relates to the drive system. The documentation provides information on how the applicable standards can be complied if the frequency inverter is a component of the drive system. The declaration of conformity is to be issued by the supplier of the drive system.

7.2 Block diagram



A Relay connection S3OUT

Change-over contact, response time approx. 40 ms,
Make contact AC 5 A / 240 V, DC 5 A (ohmic) / 24 V
Break contact AC 3 A / 240 V, DC 1 A (ohmic) / 24 V

B Voltage output/input

Bidirectional, DC 20 V voltage output (I_{max}=180 mA) or input for external power supply DC 24 V ±10%

C Digital input S1IND/STOA

Digital signal, STOA (1st shut-down path for safety function STO – "Safe Torque Off"), response time: approx. 10 ms (On), 10 µs (Off), U_{max} = DC 30 V, 10 mA at DC 24 V, PLC compatible

D Digital inputs S2IND ... S6IND

Digital signal: Response time approx. 2 ms, U_{max} = DC 30 V, 10 mA at 24 V, PLC compatible, frequency signal: DC 8...30 V, 10 mA at DC 24 V, f_{max} = 150 kHz

E Digital input S7IND/STOB

Digital signal, STOB (2nd shut-down path for safety function STO – "Safe Torque Off"), response time: approx. 10 ms (on), 10 µs (off), U_{max} = DC 30 V,
10 mA at DC 24 V, PLC compatible

F Digital output S1OUT

Digital signal, DC 24 V, I_{max} = 50 mA, PLC compatible, overload and short-circuit proof

G Multifunction Output MFO1

Analog signal: DC 24 V, I_{max} = 50 mA, pulse-width modulated, f_{PWM} = 116 Hz,
Digital signal: DC 24 V, I_{max} = 50 mA, PLC compatible,
Frequency signal: DC 0...24 V, I_{max} = 40 mA, f_{max} = 150 kHz, overload and short-circuit proof

H Multifunction input MFI1

Analog signal: Resolution 12 bit, DC 0...10 V (Ri = 70 kΩ), 0...20 mA (Ri = 500 Ω),
Digital signal: Response time approx. 4 ms, U_{max} = DC 30 V, 4 mA at DC 24 V, PLC compatible

7.3 Optional components

7.3.1 Expansion / Communication modules

Due to modular hardware components, the frequency inverters can be integrated in the automation concept easily. The standard and optional modules are recognized during the initialization, and the controller functionality is adjusted automatically. For the information required for installation and handling of the optional modules, refer to the corresponding documentation.

WARNING

Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The discharge time is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

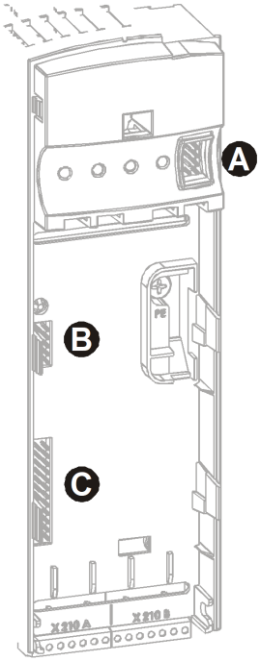
- The hardware modules at slots B and C may only be assembled and disassembled after the frequency inverter has been disconnected safely from power supply.
- The unit may only be connected with the power supply switched off.
- Verify safe isolation from power supply.

NOTICE

Deactivation of system bus interface in the EM extension module!

If two optional components with CAN-Protocol controller are installed, the system bus interface in the EM extension module is deactivated!

Hardware modules



Ⓐ Control unit KP500

Connection of the optional control unit KP500 or an interface adapter KP232.

Ⓑ Communication module CM

Slot for connection to various communication protocols:

- CM-232: RS232 interface
- CM-485: RS485 interface
- CM-PDP: Profibus-DP interface
- CM-CAN: CANopen interface
- Other communication modules, see Chapter 1.1 "Instructions".

Ⓒ Extension module EM

Slot for customer-specific adaptation of the control inputs and outputs to various applications:

- EM-ENC: extended speed sensor evaluation
- EM-RES: Resolver evaluation
- EM-ABS: Absolute encoder evaluation
- EM-IO, analog and digital inputs and outputs
- EM-SYS: System Bus

(system bus in combination with CM-CAN communication module upon request)

7.3.2 Shield sheets

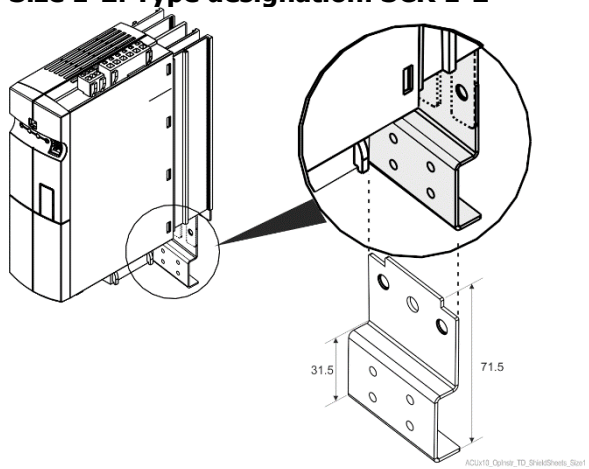
With an optional shield sheet, the shields of motor cables can be connected to PE potential in order to improve the EMC and EMI characteristics.

Shield sheet for motor cables

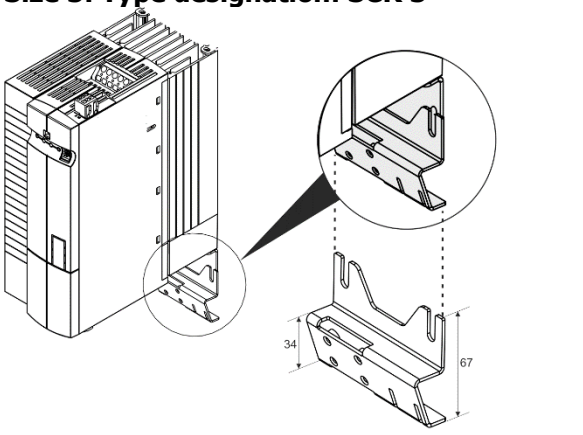
The applicable shield sheets depend on the device size.

The dimensions in the figures are given in mm.

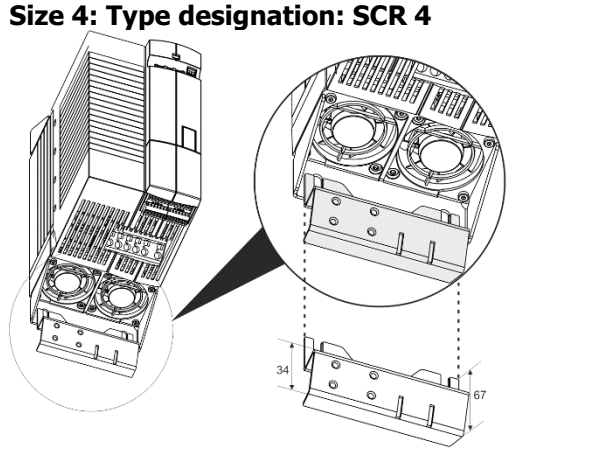
Size 1-2: Type designation: SCR 1-2



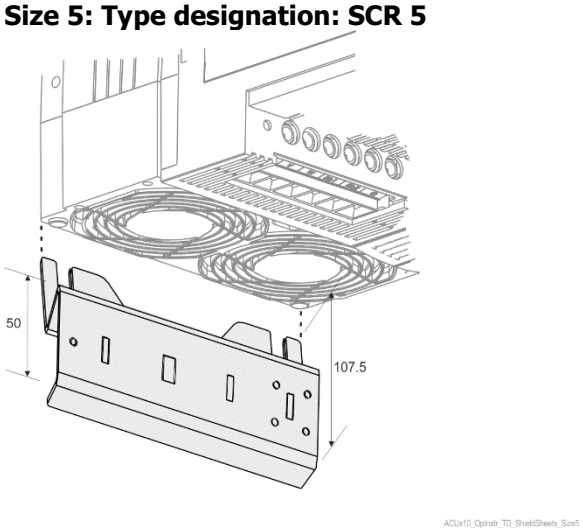
Size 3: Type designation: SCR 3



Size 4: Type designation: SCR 4



Size 5: Type designation: SCR 5



7.4 Connection of Unit

7.4.1 Dimensioning of conductor cross-section

The connecting cables must be protected externally, considering the maximum voltage and maximum current values of the fuses. The line fuses and cable cross-sections must be dimensioned according to EN 602041 and DIN VDE 0298 Part 4 for the nominal operating point of the frequency inverter.

The fuses must be chosen depending on the individual application. The values recommended in the technical data apply for the continuous rated operation without overload.

The cable dimensions should be selected according to the current load and voltage drop to be expected. Select the cable cross-section of the cables such that the voltage drop is as small as possible. If the voltage drop is too great, the motor will not reach its full torque. Also comply with any additional national and application-specific regulations and the separate UL instructions. For typical mains fuses, refer to chapter 5 "Technical data".

According to EN61800-5-1, the cross-sections of the PE conductor shall be dimensioned as follows:

Mains cable	Protective conductor
Mains cable up to 10 mm²	Install two protective conductors of the same size as the mains cable, or one protective conductor of a size of 10 mm².
Mains cable 10…16 mm²	Install one protective conductor of the same size as the mains feeder.
Mains cable 16…35 mm²	Install one protective conductor of a size of 16 mm².
Mains cable > 35 mm²	Install one protective conductor of half the size of the mains feeder.

The following tables provide an overview of typical cable cross-sections (copper cable with PVC insulation, 30 °C ambient temperature, continuous mains current max. 100% rated input current, installation variant C). Actual mains cable cross-section requirements may deviate from these values depending on actual operating conditions.

7.4.1.1 Typical cross-sections Size 1 through 7 (0.25 kW … 132 kW)

The following tables provide an overview of typical cable cross-sections (copper cable with PVC insulation, 30 °C ambient temperature, continuous mains current max. 100% rated input current, installation variant B2). Actual mains cable cross-section requirements may deviate from these values depending on actual operating conditions.

230 V: One-phase (L/N) and two-phase (L1/L2) connection

210		Mains cable	PE-conductor	Motor cable
-01 -03 -05 -07 -09	0.25 kW 0.37 kW 0.55 kW 0.75 kW 1.1 kW	1.5 mm²	2x1.5 mm² or 1x10 mm²	1.5 mm²
-11 -13 -15	1.5 kW 2.2 kW 3 kW	2.5 mm²	2x2.5 mm² or 1x10 mm²	1.5 mm²
-18	4 kW	4 mm²	2x4 mm² or 1x10 mm²	4 mm²

230 V: Three-phase connection (L1/L2/L3)

210		Mains cable	PE-conductor	Motor cable
-01 -03 -05 -07 -09 -11 -13 -15	0.25 kW 0.37 kW 0.55 kW 0.75 kW 1.1 kW 1.5 kW 2.2 kW 3 kW	1.5 mm²	2x1.5 mm² or 1x10 mm²	1.5 mm²
-18 -19	4 kW 5.5 kW	4 mm²	2x4 mm² or 1x10 mm²	4 mm²
-21	7.5 kW	6 mm²	2x6 mm² or 1x10 mm²	6 mm²
-22	9.2 kW	10 mm²	1x10 mm²	10 mm²

400V: Three-phase connection (L1/L2/L3)

NOTICE

Different conductor cross-sections

Liquid-cooled devices ACU 410-51 of size 7 can reach a rated power of 200 kW.

- Consider the correct conductor cross-sections for the rated power.

410		Mains cable	PE-conductor	Motor cable
-01 -03 -05 -07 -09 -11 -12 -13 -15 -18	*0.25 kW* *0.37 kW* *0.55 kW* *0.75 kW* *1.1 kW* *1.5 kW* *1.85* *2.2 kW* *3 kW* *4 kW*	1.5 mm²	2x1.5 mm² or 1x10 mm²	1.5 mm²
-19 -21	*5.5 kW* *7.5 kW*	2.5 mm²	2x2.5 mm² or 1x10 mm²	2.5 mm²
-22 -23	*9.2 kW* *11 kW*	4 mm²	2x4 mm² or 1x10 mm²	4 mm²
-25	*15 kW*	6 mm²	2x6 mm² or 1x10 mm²	6 mm²
-27	*18.5 kW*	10 mm²	1x10 mm²	10 mm²
-29 -31	*22 kW* *30 kW*	16 mm²	1x16 mm²	16 mm²
-33	*37 kW*	35 mm²	1x16 mm²	25 mm²
-35	*45 kW*	50 mm²	1x25 mm²	35 mm²
-37	*55 kW*	50 mm²	1x25 mm²	50 mm²
-39	*65 kW*	70 mm²	1x35 mm²	70 mm²
-43	*75 kW*	70 mm²	1x50 mm²	95 mm²
-45	*90 kW*	95 mm²	1x70 mm²	2x70 mm²
-47	*110 kW*	2x70 mm²	1x70 mm²	2x70 mm²
-49	*132 kW*	2x70 mm²	1x70 mm²	2x70 mm²

7.4.1.2Typical cross-sections Size 8 (160 kW...400 kW)

The following tables provide an overview of typical cable cross-sections (copper cable with PVC insulation, 30 °C ambient temperature, continuous mains current max. 100% rated input current, installation variant C). Actual mains cable cross-section requirements may deviate from these values depending on actual operating conditions.

400V: Three-phase connection (L1/L2/L3)

410		Mains cable	PE-conductor	Motor cable
-51	*160 kW*	150 mm²	95 mm²	185 mm²
-53	*200 kW*	240 mm²	120 mm²	240 mm²
-55	*250 kW*	2x120 mm²	120 mm²	2x120 mm²
-57	*315 kW*	2x150 mm²	150 mm²	2x150 mm²
-59	*355 kW*	2x185 mm²	185 mm²	2x185 mm²
-61	*400 kW*	2x240 mm²	240 mm²	2x240 mm²

525V: Three-phase connection (L1/L2/L3)

510		Mains cable	PE-conductor	Motor cable
-51	*160 kW*	95 mm²	70 mm²	120 mm²
-53	*200 kW*	150 mm²	95 mm²	150 mm²
-55	*250 kW*	185 mm²	120 mm²	240 mm²
-57	*315 kW*	2x120 mm²	120 mm²	2x120 mm²
-59	*355 kW*	2x120 mm²	120 mm²	2x120 mm²
-61	*400 kW*	2x150 mm²	150 mm²	2x150 mm²

690V: Three-phase connection (L1/L2/L3)

610		Mains cable	PE-conductor	Motor cable
-51	*160 kW*	70 mm²	At least 35 mm²	70 mm²
-53	*200 kW*	95 mm²	70 mm²	120 mm²
-55	*250 kW*	120 mm² or 2x70 mm²	95 mm²	150 mm² or 2x70 mm²
-57	*315 kW*	185 mm² or 2x70 mm²	120 mm²	240 mm² or 2x95 mm²
-59	*355 kW*	240 mm² or 2x95 mm²	120 mm²	240 mm² or 2x95 mm²
-61	*400 kW*	2x120 mm²	120 mm²	2x120 mm²

7.4.2 Mains connection

DANGER

Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.

CAUTION

Device damage possible!

Routing the lines inappropriately may lead to device damage.

- The control, mains and motor lines must be kept physically separate from one another.
- The cables connected to the frequency inverters may not be subjected to high-voltage insulation tests unless appropriate circuitry measures are taken before.

- The mains fuses and cable cross-sections are to be selected according to EN 602041 and DIN VDE 0298 Part 4 for the nominal operating point of the frequency inverter.
- According to UL/CSA, approved Class 1 copper lines with a temperature range of 60/75 °C and matching mains fuses are to be used for the power cables.
- The electrical installation is to be done according to the device specifications and the applicable standards and directives.

7.4.3 Motor connection

DANGER

Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.

CAUTION

Device damage possible!

Routing the lines inappropriately may lead to device damage.

- The control, mains and motor lines must be kept physically separate from one another.
- The cables connected to the frequency inverters may not be subjected to high-voltage insulation tests unless appropriate circuitry measures are taken before.

Bonfiglioli Vectron GmbH recommends using shielded cables for the connection of the motor and the braking resistor to the frequency inverter. The shield is to be connected to PE potential properly, i.e. with good conductivity, on both sides. The control, mains and motor lines must be kept physically separate from one another.

- Comply with the applicable limits stipulated in the relevant national and international directives as regards the application, the length of the motor cable and the switching frequency.

7.4.3.1 Length of motor cables, without filter

Without an installed output filter the specified lengths of the motor cables must not be exceeded.

Permissible length of motor cable without output filter		
Frequency inverter	**unshielded cable**	**shielded cable**
0.25 kW ... 1.5 kW	50 m	25 m
1.85 kW ... 4.0 kW	100 m	50 m
5.5 kW ... 9.2 kW	100 m	50 m
11.0 kW ... 15.0 kW	100 m	50 m
18.5 kW ... 30.0 kW	150 m	100 m
37.0 kW ... 65.0 kW	150 m	100 m
75.0 kW ... 132.0 kW	150 m	100 m
160.0 kW ... 400.0 kW	150 m	100 m

Frequency inverters ≤ 9.2 kW with integrated EMC filter comply with the emission limits stipulated in EN 61800-3 if the motor cable is no longer than 10 m. Frequency inverters ≤ 9,2 kW of size 3 with integrated EMC filter comply with EN 61800-3 if the motor cable is no longer than 20 m. Customer-specific requirements can be met using an optional filter.

7.4.3.2 Motor cable length, with output filter dU/dt

Longer motor cables can be used after taking appropriate technical measures, e.g. use of low-capacitance cables and output filters. The following table contains recommended values for the use of output filters.

Motor cable length with output filter		
Frequency inverter	**unshielded cable**	**shielded cable**
0.25 kW ... 1.5 kW	upon request	upon request
1.85 kW ... 4.0 kW	150 m	100 m
5.5 kW ... 9.2 kW	200 m	135 m
11.0 kW ... 15.0 kW	225 m	150 m
18.5 kW ... 30.0 kW	300 m	200 m
37.0 kW ... 65.0 kW	300 m	200 m
75.0 kW ... 132.0 kW	300 m	200 m
160.0 kW ... 400.0 kW	300 m	200 m

7.4.3.3 Motor cable length, with sinus filter

Motor cables can be much longer if sinus filters are used. By conversion in sinus-shaped currents, high-frequency portions which might limit the cable length are filtered out.

- Also consider the voltage drop across the cable length and the resulting voltage drop at the sinus filter. The voltage drop results in an increase of the output current. Check that the frequency inverter can deliver the higher output current. This must be considered in the projecting phase already.
- If the motor cable length exceeds 300 m, please consult BONFIGLIOLI.

7.4.3.4 Group drive

- In the case of a group drive (several motors at one frequency inverter), the total length shall be divided across the individual motors according to the value given in the table. Please note that group drive with synchronous servomotors is not possible.
- Use a thermal monitoring element on each motor (e.g. PTC resistor) in order to avoid damage.

7.4.3.5 Speed sensor connection

- Install sensor cables physically separate from motor cables. Comply the sensor manufacturer's specifications.
- Connect the shield close to the frequency inverter and limit the length to the necessary minimum.

7.4.4 Connection of a braking resistor

Install a braking resistor if feedback of regenerative energy is expected. Overvoltage shutdowns can be avoided by this.

DANGER

Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.

WARNING

Hot surface

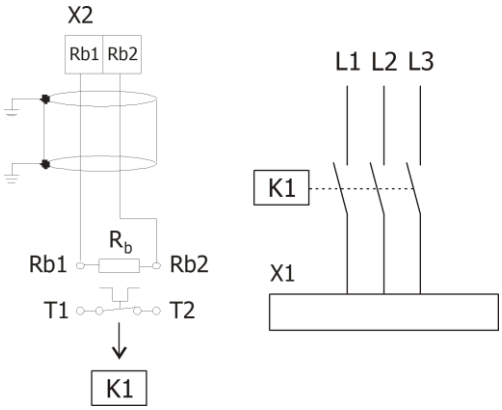
The surface of the braking resistor may reach a high temperature during operation and may remain hot for some time after operation.

- Do not touch the braking resistor while the frequency inverter is in operation or ready for operation. Non-compliance may result in burns.
- Install a safeguard to prevent touching or provide a warning sign.
- Do not install the braking resistor near inflammable or heat-sensitive materials.
- Do not cover the braking resistor.

Bonfiglioli Vectron GmbH recommends using a temperature switch. Depending on the resistor selected, the temperature switch is integrated as a standard or available as an option. The temperature switch disconnects the frequency inverter from mains supply if the braking resistor is overloaded.
Using braking resistors without temperature switches may result in critical situations.

Braking resistors are connected via terminal X2.

- Limit the length of the braking resistor cables to the necessary minimum.



7.5 Connection by size

7.5.1 Sizes 1 and 2: ACU 210 (up to 3.0 kW) and 410 (up to 4.0 kW)

Frequency inverters are connected to mains via plug-in terminal X1. The motor and braking resistor are connected to the frequency inverter via plug-in terminal X2. IP20 ingress protection rating (EN60529) is only guaranteed with the terminals plugged.

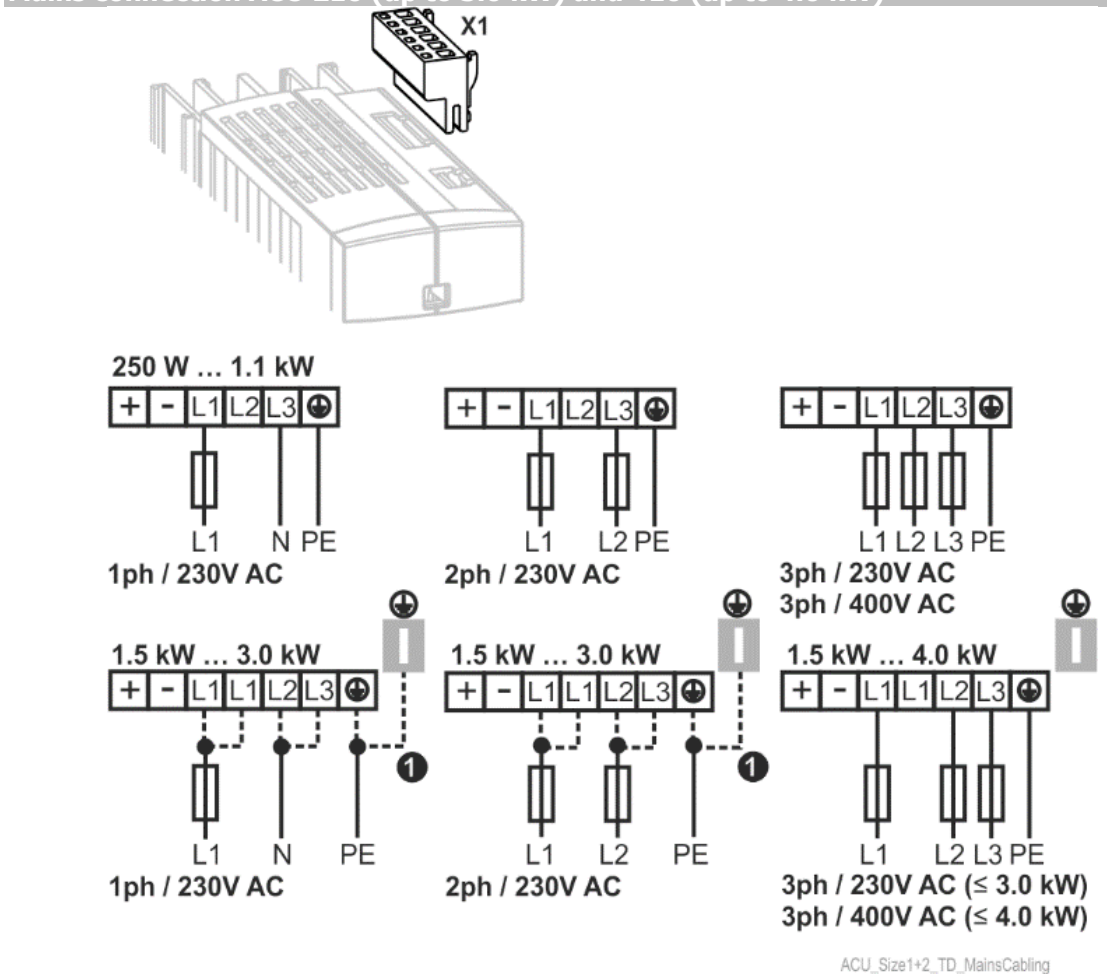
DANGER

Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

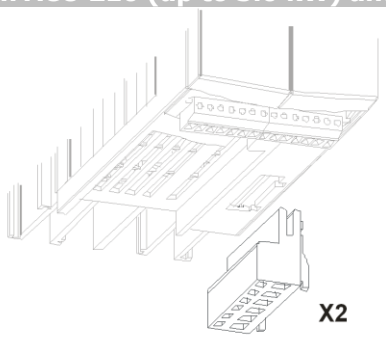
- Only connect and disconnect the reverse-polarity protected plug-in terminals X1 and X2 when no power is applied.
- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.

Mains connection ACU 210 (up to 3.0 kW) and 410 (up to 4.0 kW)

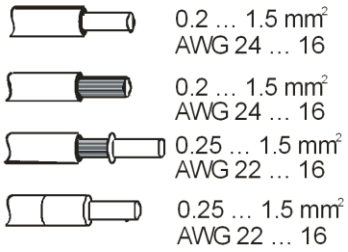


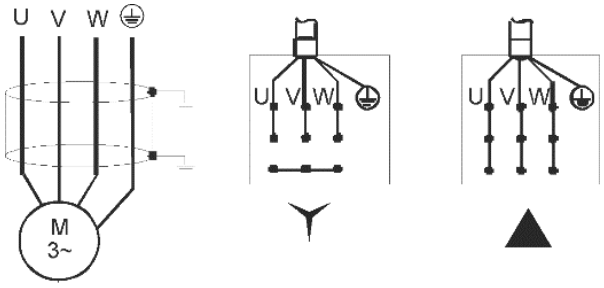
❶ With a mains current above 10 A, the mains power connection 230 V 1ph/N/PE and the mains power connection 230 V 2ph/N/PE are to be done on two terminals.

Motor connection ACU 210 (up to 3.0 kW) and 410 (up to 4.0 kW)

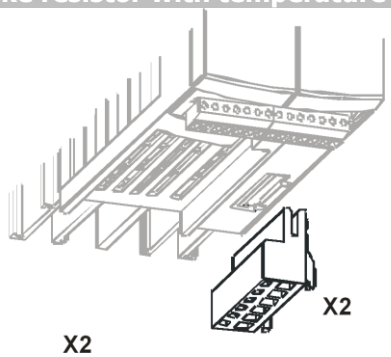


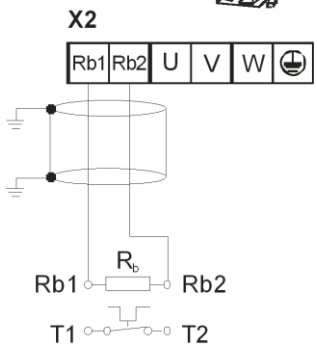
Phoenix ZEC 1,5/ .. ST7,5



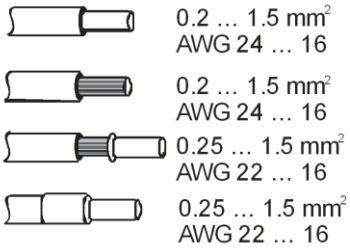


Connection of brake resistor with temperature switch





Phoenix ZEC 1,5/ .. ST7,5



7.5.2 Sizes 3 and 4: ACU 210 (4.0 to 9.2 kW) and 410 (5.5 to 15.0 kW)

Frequency inverters are connected to mains via terminal X1. The motor and braking resistor are connected to the frequency inverter via terminal X2.

DANGER

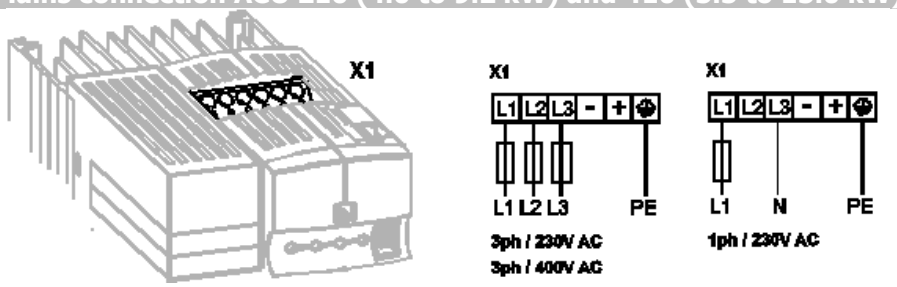
Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time.

Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

- Switch off power supply before connecting or disconnecting the mains cable to/from terminal X1, the motor cables and the brake resistor to/from terminal X2.
- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.

Mains connection ACU 210 (4.0 to 9.2 kW) and 410 (5.5 to 15.0 kW)



4.0 kW … 9.2 kW
6qmm / RM7,5

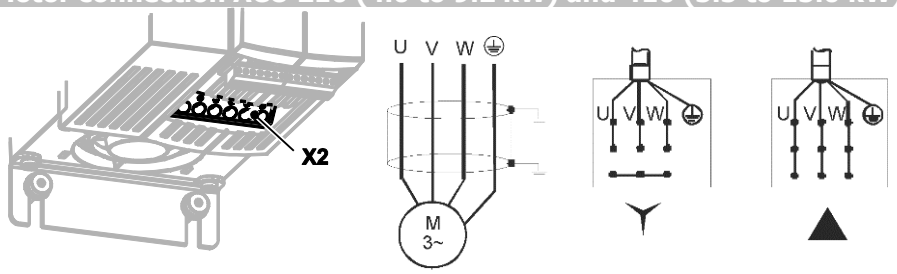
0.2 … 6 mm²	AWG 24 … 10
0.2 … 6 mm²	AWG 24 … 10
0.25 … 4 mm²	AWG 22 … 12
0.25 … 4 mm²	AWG 22 … 16

11 kW … 15 kW
16qmm / RM10+15

0.2 … 16 mm²	AWG 24 … 6
0.2 … 16 mm²	AWG 24 … 6
0.25 … 10 mm²	AWG 22 … 8
0.25 … 10 mm²	AWG 22 … 8

ACU 210-18 (4.0 kW): one-phase and three-phase connection possible
ACU 210-19 (5.5 kW) and higher: three-phase connection possible

Motor connection ACU 210 (4.0 to 9.2 kW) and 410 (5.5 to 15.0 kW)



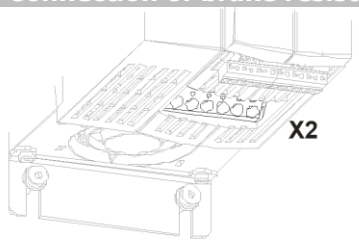
4.0 kW … 9.2 kW
6qmm / RM7,5

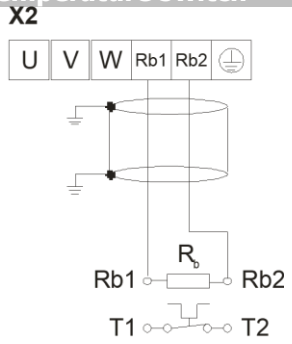
0.2 … 6 mm²	AWG 24 … 10
0.2 … 6 mm²	AWG 24 … 10
0.25 … 4 mm²	AWG 22 … 12
0.25 … 4 mm²	AWG 22 … 16

11.0 kW … 15.0 kW
16qmm / RM10+15

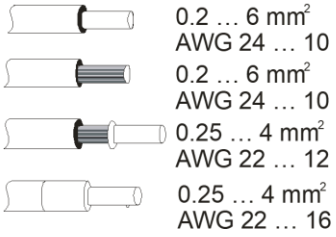
0.2 … 16 mm²	AWG 24 … 6
0.2 … 16 mm²	AWG 24 … 6
0.25 … 10 mm²	AWG 22 … 8
0.25 … 10 mm²	AWG 22 … 8

Connection of brake resistor with temperature switch

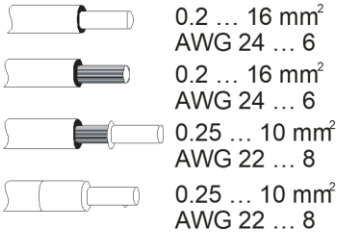




4.0 kW … 9.2 kW
6qmm / RM7,5



11.0 kW … 15.0 kW
16qmm / RM10+15



7.5.3 Size 5 ACU 410 (18.5 to 30.0 kW)

Frequency inverters are connected to mains via terminal X1. The motor and braking resistor are connected to the frequency inverter via terminal X2.

DANGER

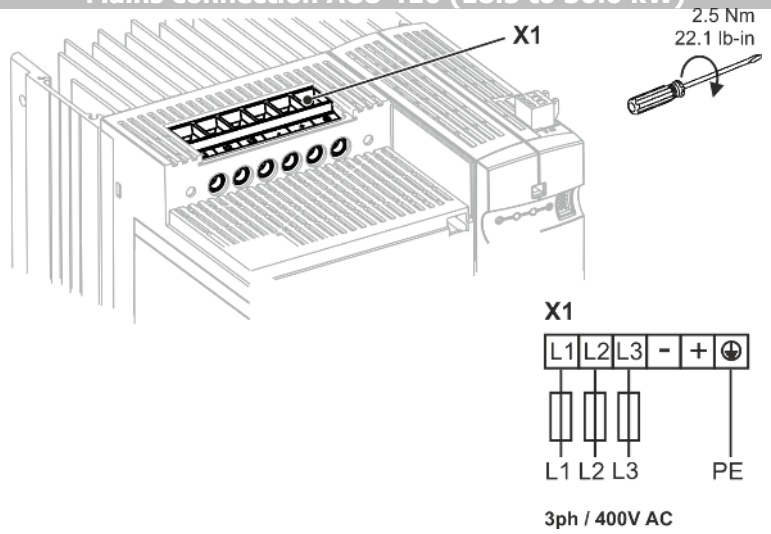
Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time.

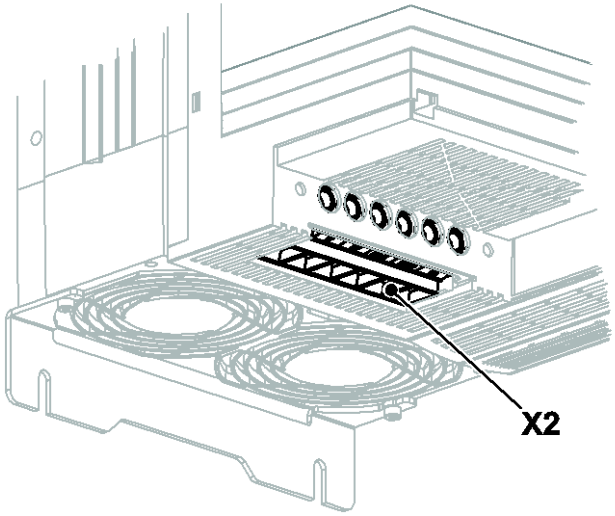
Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

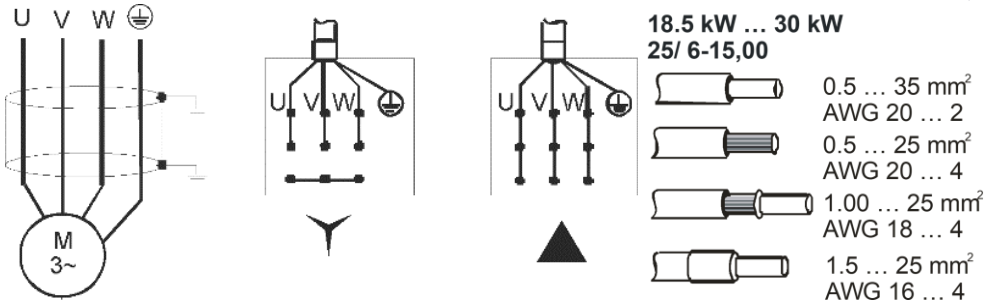
- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.
- Switch off power supply before connecting or disconnecting the mains cable to/from terminal X1, the motor cables and the brake resistor to/from terminal X2.

Mains connection ACU 410 (18.5 to 30.0 kW)

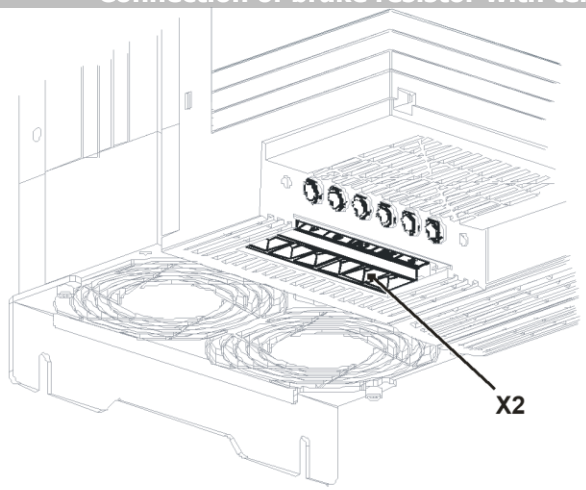


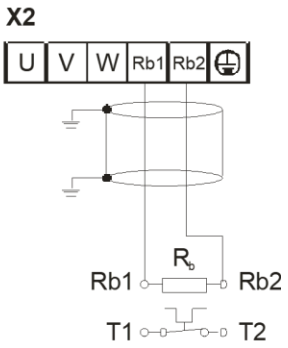
Motor connection ACU 410 (18.5 to 30.0 kW)

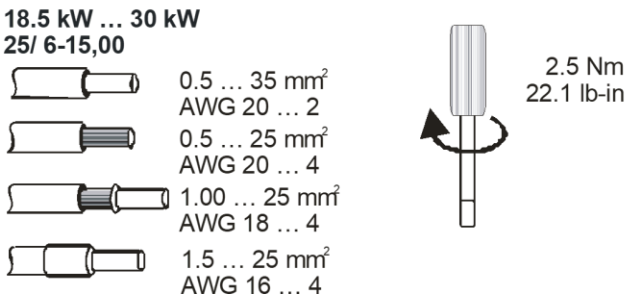




Connection of brake resistor with temperature switch







7.5.4 Size 6 ACU 410 (37.0 to 65.0 kW)

DANGER

Dangerous voltage!

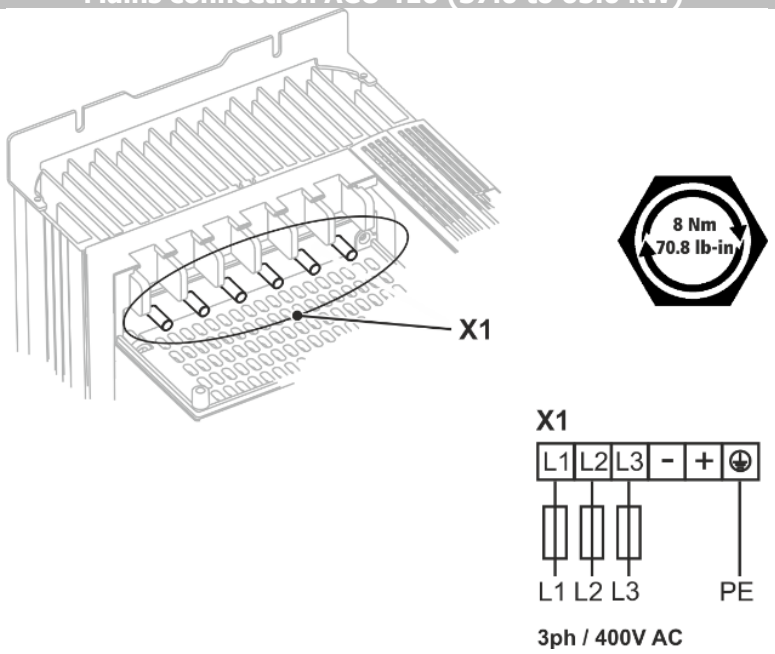
When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time.

Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

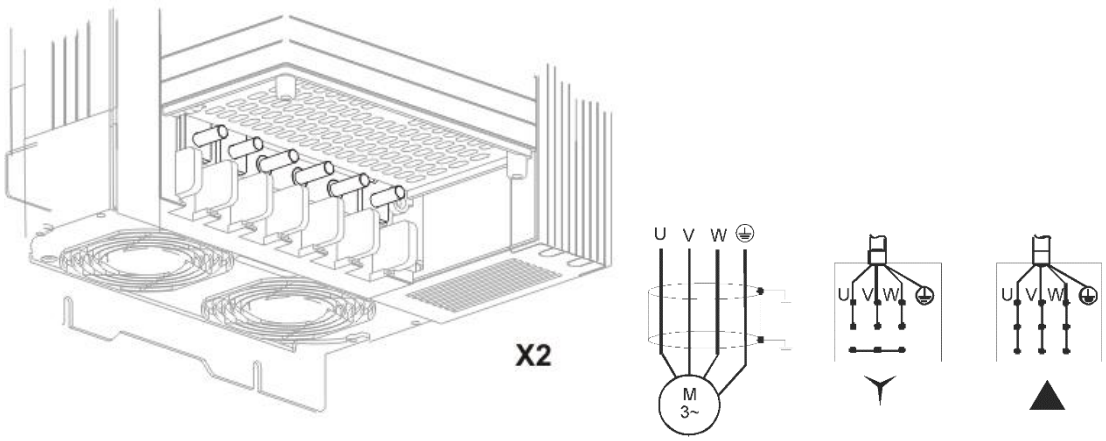
- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.
- Switch off power supply before connecting or disconnecting the mains cable to/from terminal X1, the motor cables and the brake resistor to/from terminal X2.

The following illustrations show the air-cooled variant of an ACU 410 frequency inverter size 6 as an example. Illustrations of the corresponding liquid-cooled device are given in the "Operating Instructions Liquid Cooling Supplemental". The electrical interfaces for both variants are basically the same.

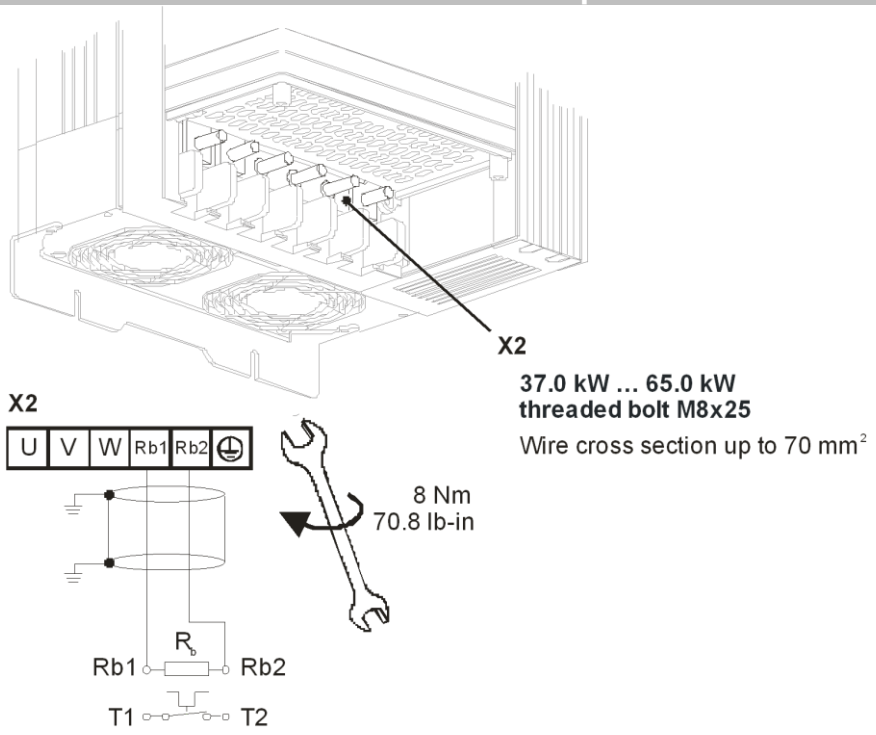
Mains connection ACU 410 (37.0 to 65.0 kW)



Motor connection ACU 410 (37.0 to 65.0 kW)



Connection of brake resistor with temperature switch



Optionally, devices of this size are available without brake chopper. These devices are designed without connecting terminals for the braking resistor.

7.5.5 Size 7 ACU 410 (75.0 to 160.0 kW)

DANGER

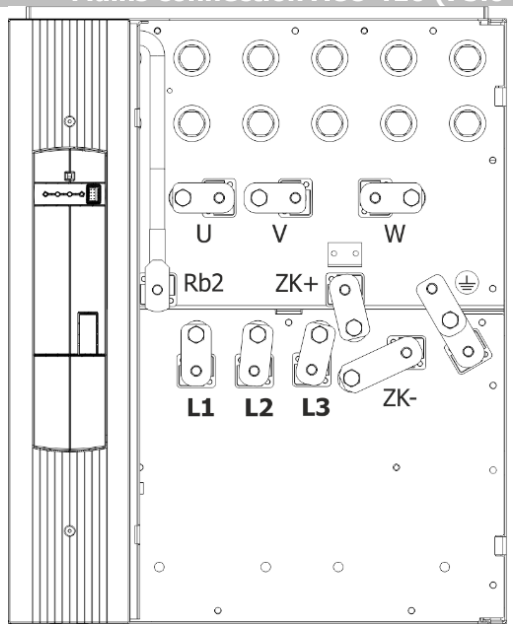
Dangerous voltage!

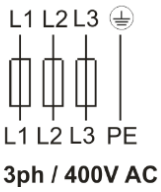
When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time.

Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.
- Switch off power supply before connecting or disconnecting the mains cable to/from terminal X1, the motor cables and the brake resistor to/from terminal X2.

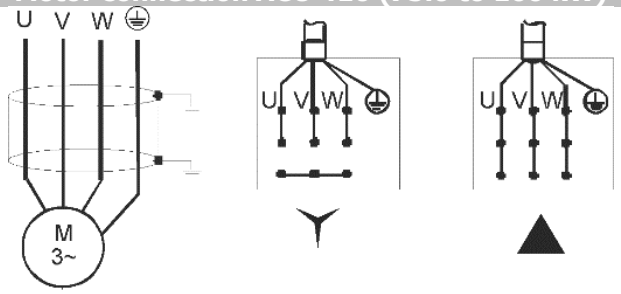
Mains connection ACU 410 (75.0 to 160 kW)





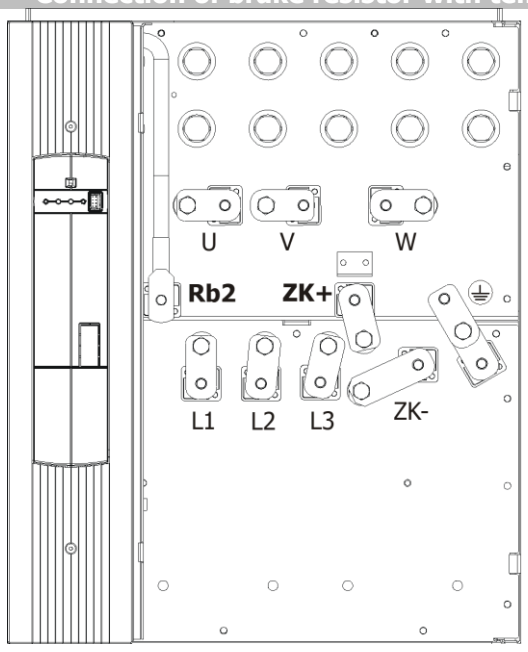
Threaded bolt M8x20

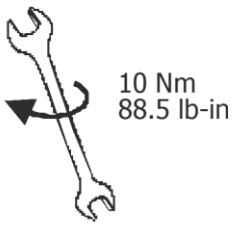
Motor connection ACU 410 (75.0 to 160 kW)

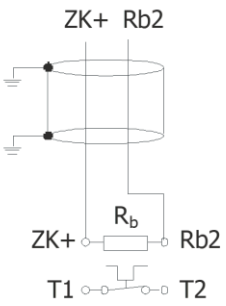


Threaded bolt M8x20

Connection of brake resistor with temperature switch







Threaded bolt M8x20

Optionally, devices of this size are available without brake chopper. These devices are designed without connecting terminals for the braking resistor.

7.5.6 Size 8 ACU 410 / ACU 510 / ACU 610 (160.0 to 400.0 kW)

DANGER

Dangerous voltage!

When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The time to wait is at least 3 minutes in the case of sizes 1 through 7 and at least 10 minutes in the case of size 8.

- Disconnect the frequency inverter from mains voltage and protect it against being energized unintentionally.
- Verify safe isolation from power supply.
- Switch off power supply before connecting or disconnecting the mains cable to/from terminal X1, the motor cables and the brake resistor to/from terminal X2.

WARNING

Dangerous voltage!

Devices of size 8 feature cable routing covers at the top and at the bottom of the housing. Mounting the covers is strictly mandatory! Leaving covers unmounted can result in risk of death and severe injury due to missing touch protection. It will further result in loss of IP20 protection, loss of warranty and in performance deterioration due to ingress of dust and dirt.

- Mount the cable routing covers according to the document VEC510.

CAUTION

Improperly mounted covers

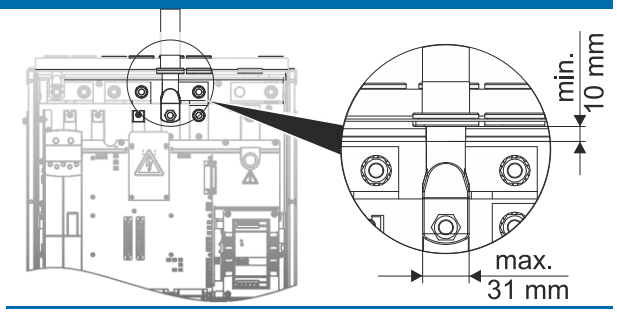
IP20 ingress protection rating is only achieved with terminals plugged and properly mounted covers. Improperly mounted covers lead to ingress of dirt or foreign objects into the housing of the device and might lead to malfunctions.

- Take care to mount all covers correctly and properly.
- Insert all terminal connectors and mount all covers before starting operation.

NOTICE

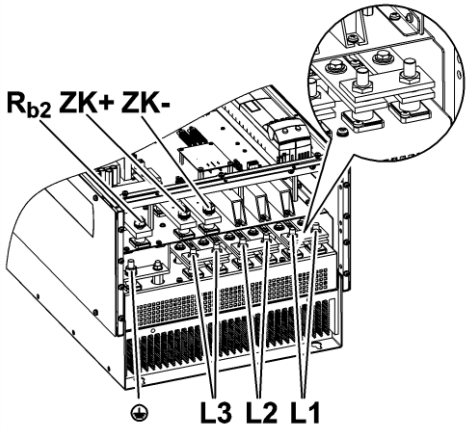
When connecting to mains, note:

- Max. width of cable lugs: 31 mm
- Min. length of insulation under cable gland: 10 mm

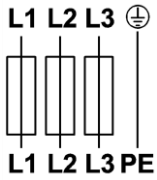


Mains connection ACU 410 / ACU 510 /ACU 610 (160.0 through 400.0 kW)

Mains connection 3 phases:

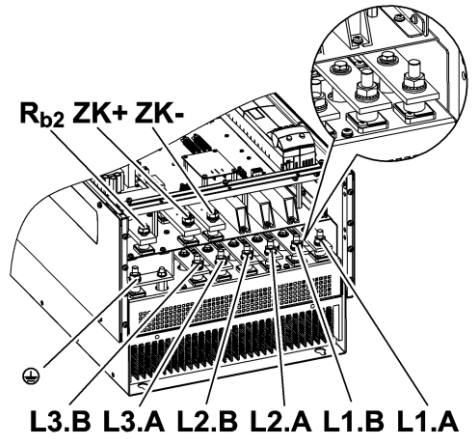


Threaded bolt M10x20

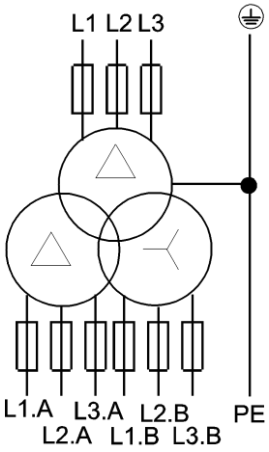


ACU 410: 3ph/400V AC
ACU 510: 3ph/525V AC
ACU 610: 3ph/690V AC

Mains connection 6 phases:



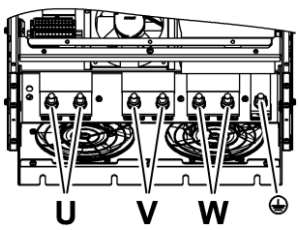
Threaded bolt M10x20

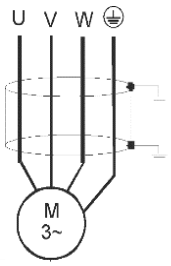


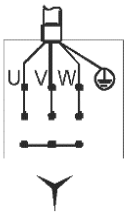
ACU 410: 6ph/400V AC
ACU 510: 6ph/525V AC
ACU 610: 6ph/690V AC

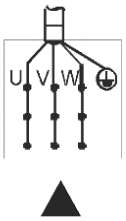
6-phase connection must be done via the same mains feeders and a suitable transformer (e.g. one d and one y winding on secondary side) which shifts all phases by 30° to one another. Alternatively, two transformers can be used (one with d-winding, one with y-winding on secondary side).

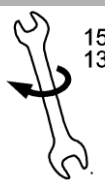
Motor connection ACU 410 (160.0 to 400.0 kW)





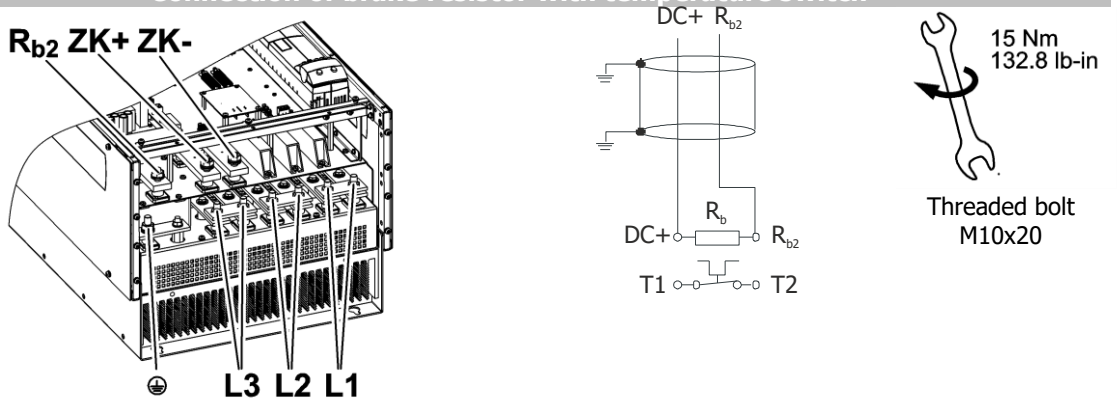






Threaded bolt M10x20

Connection of brake resistor with temperature switch



7.6 Control terminals

CAUTION

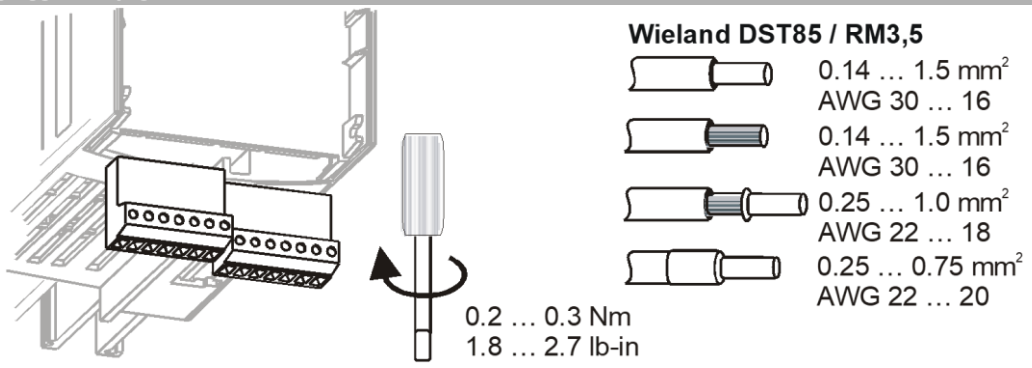
Live voltage

The control terminals may be energized.

- The unit may only be connected with the power supply switched off.
- Verify safe isolation from power supply.
- Switch off power supply before connecting or disconnecting the control inputs and outputs. Otherwise, components may be damaged.

The control and software functionality is freely configurable to ensure a reliable and economical operation. The operating instructions describe the factory settings of the standard connections in the relevant *Configuration* **30** as well as the software parameters to be set up.

Control terminals



Control terminal X210A

Term.	Description
1	- voltage output 20 V, I_{max}=180 mA [1] or - input for external power supply DC 24 V ±10%
2	GND 20 V and GND 24 V (ext.)
3	Digital input STOA (1. shut-down path for "Safe Torque Off" function), U_{max}=DC 30 V, 10 mA at DC 24 V, input resistance: 2.3 kΩ, PLC compatible, response time approx. 10 ms
4	Digital input S2IND, U_{max}=DC 30 V, 10 mA at DC 24 V, Input resistance: 2.3 kΩ, PLC compatible, response time approx. 2 ms
5	Digital input S3IND, U_{max}=DC 30 V, 10 mA at DC 24 V, Input resistance: 2.3 kΩ, PLC compatible, response time approx. 2 ms
6	Digital input S4IND, U_{max}=DC 30 V, 10 mA at DC 24 V, Input resistance: 2.3 kΩ, PLC compatible, Frequency signal: 0...30 V, 10 mA at 24 V, f_{max}=150 kHz
7	Digital input S5IND, U_{max}=DC 30 V, 10 mA at DC 24 V, Input resistance: 2.3 kΩ, PLC compatible, Frequency signal: 0...30 V, 10 mA at 24 V, f_{max}=150 kHz

[1] The power output on terminal X210A.1 may be loaded with a maximum current of I_{max}= 180 mA. The maximum current available is reduced by the digital output S1OUT and multifunction output MFO1.

Control terminal X210B	
Term.	**Description**
1	Digital input S6IND, U_{max}=DC 30 V, 10 mA at 24 V, input resistance: 2.3 kΩ, PLC compatible, response time approx. 2 ms
2	Digital input STOA (2nd shut-down path for "Safe Torque Off" function), U_{max}=30 V, 10 mA at DC 24 V, input resistance: 2.3 kΩ, PLC-compatible, response time approx. 10 ms
3	Digital output S1OUT, U=24 V, I_{max}=50 mA, overload and short-circuit proof
4	Multifunction output MFO1, Analog signal: U= 24 V, I_{max} = 50 mA, pulse-width modulated, f_{PWM} = 116 Hz, Digital signal: U=24 V, I_{max}=50 mA, overload and short-circuit proof, Frequency signal: 0...24 V, I_{max}=50 mA, f_{max}=150 kHz
5	Reference output 10 V, I_{max}=4 mA
6	Multifunction input MFI1, Analog signal: resolution 12 Bit, 0...+10 V (Ri=70 kΩ), 0…20 mA (Ri = 500 Ω), Digital signal: response time approx. 4 ms, U_{max}=30 V, 4 mA at 24 V, PLC compatible
7	Ground / GND 10 V

	Level:
Digital inputs (X210A.3 … X210B.2)	Low: 0 V … 3 V, High: 12 V … 30 V
Digital output (X210B.3)	

7.6.1 External DC 24 V power supply

NOTICE

Device damage possible

The digital inputs and the DC 24 V terminal of the electronic control equipment can withstand external voltage up to DC 30 V. Higher voltages may destroy the unit.

- Avoid higher voltage levels.
- Use suitable external power supply units with a maximum output current of DC 30 V or use appropriate fuses to protect the unit.

The bidirectional control terminals X210A.1/ X210A.2 can be used as a voltage output or voltage input. By connecting an external power supply of DC 24 V ±10% to terminals X210A.1/X210A.2, the function of inputs and outputs as well as the communication can be maintained.

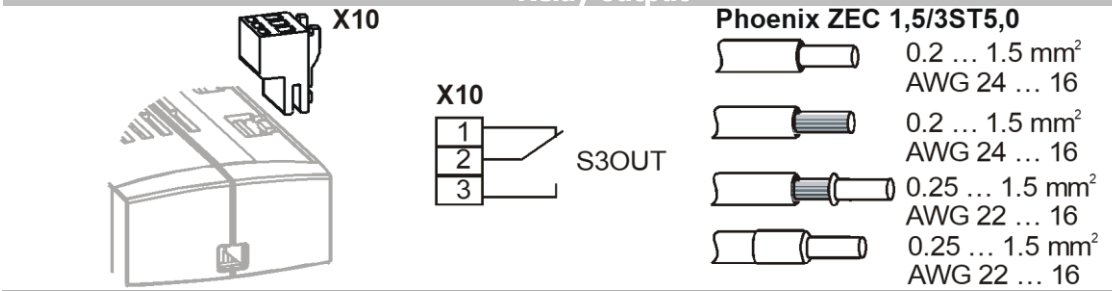
Requirements to be met by external power supply	
Input voltage range	DC 24 V ±10%
Rated input current	Max. 1.0 A (typically 0.45 A)
Peak inrush current	Typically: < 20 A
External fuse	Via standard fuse elements for rated current, characteristic: slow
Safety	Safety extra low voltage (SELV) according to EN 61800-5-1

The application manual "Safe Torque Off STO" must be complied with, particularly if the safety function described there is used.

7.6.2 Relay output

By default, the freely programmable relay output is linked to the monitoring function (factory setting). The logic link to various functions can be freely configured via the software parameters. Connection of the relay output is not absolutely necessary for the function of the frequency inverter.

Relay output

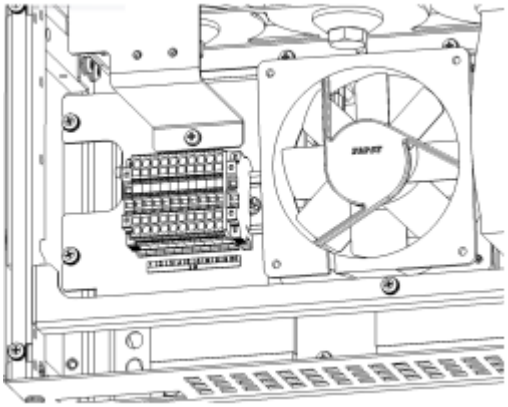


Control terminal X10

Term.	Description
1 ... 3	Relay output, floating change-over contact, response time approx. 40 ms, maximum contact load: make contact: AC 5 A / 240 V, DC 5 A (ohmic) / 24 V break contact: AC 3 A / 240 V, DC 1 A (ohmic) / 24 V

7.7 X13 connection in ACU 510 and ACU 610

When an ACU 510 or ACU 610 device is used, connection of AC 3x400 V at X13 is required. The illustration shows the X13 terminal on an air-cooled device as an example.



Auxiliary voltage terminal X13

1 … 6	Not used
7	⏚ PE
8	L1
9	L2
10	L3

Connection

Connected load	≥ 1.2 kW
Supply voltage	400 V +- 10 %
Supply frequency	50 / 60 Hz

7.8 Motor Thermo-Contact

The ACU frequency inverters can evaluate the thermal switch of motor. By default, terminal X210B.1 (S6IND) is configured as an input for this evaluation. Connect the thermal switch to the digital input and the DC 24 V supply unit X210A.1. For parameterization, refer to Sections 14.6 "Motor temperature" and 16.4.5 "Thermocontact".

7.9 Wiring control terminals

WARNING

Safety functions failure

If the digital inputs S1IND/STOA and S2IND are driven by the same signal, safe disconnection of energy supply to the motor as per the STO safety function ("Safe Torque OFF") is not guaranteed.

- Note the correct signal routing.

The control hardware and the software of the frequency inverter are freely configurable to a great extent. Certain functions can be assigned to the control terminals, and the internal logic of the software modules can be freely selected.

Thanks to the modular design, the frequency inverter can be adapted to a great range of different driving tasks.

The demands made of the control hardware and software are well known in the case of standard driving tasks. This control terminal logic and internal function assignments of the software modules are available in standard configurations. These assignments can be selected via *Configuration* **30.** The configurations are described in the following section.

The ACU devices of the ACTIVE Cube series feature the integrated STO function ("Safe Torque Off"). If this function is not required, the "Controller release" signal must be connected to inputs S1IND/STOA and S7IND/STOB.
Inputs S1IND/STOA and S7IND/STOB are connected in series.

7.10 Configurations overview

Refer to following table in order to learn which combinations of functions and control methods are possible. Configurations "Standard", "Technology Controller" and "Torque Control" will be described in the following sections. For configurations "Electronic Gear", "Positioning" and "Brake Control", please refer to the corresponding application manuals.

Configurations:

Function	V/f	SynRM Speed Cntrld	Sensorless vector	Speed controlled	Servo	Sensorless vector
Standard	110	310	410	210	510	610
Technology control-ler	111		411	211	511	611
Electronic gear with position controller [1)]	115		415	215	515	
Electronic gear + index controller [1)]	116			216	516	
Torque control		330	430	230	530	630
Positioning [2)]			440	240	540	640
Brake control [3)]	160		460	260	560	

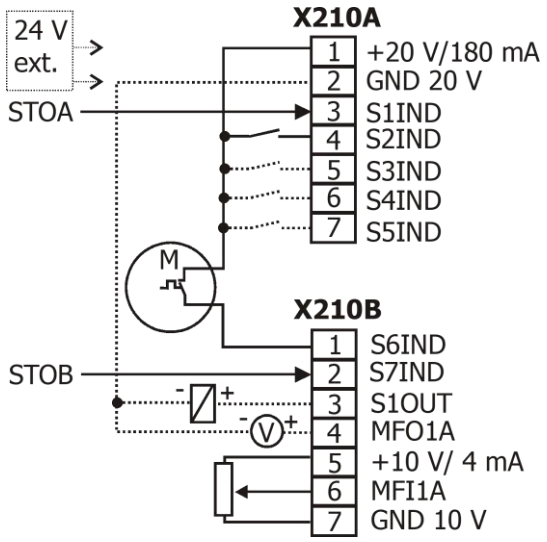
Refer to the following manuals:

1) Application manual: Electronic Gear, Position Control and Index Control
2) Application Manual: Positioning
3) Application Manual: Hoisting Gear Drives and Load Estimation

Control methods 2xx can be used with **HTL** encoders (with or without reference pulse) at basic device or an extension module.
In order to use control methods 2xx with **TTL** encoders, an extension module is required.
An extension module EM-RES for evaluation of resolver signals is required for operation of a synchronous machine (control method 5xx).
An extension module EM-ABS for signal evaluation is required for operation with absolute encoders (Hiperface, EnDat2.1, SSI).

7.10.1 Config 110 – Sensorless Control

Configuration 110 contains the functions for variable-speed control of a 3-phase machine in a wide range of standard applications. The motor speed is set according to the selected ratio of the reference frequency to the necessary voltage.

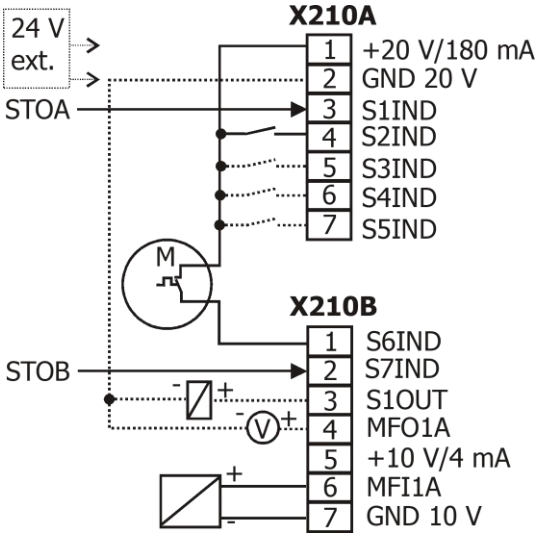


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1. shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input STOA (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10 V
X210B.7	Ground 10 V

7.10.2 Config 111 – Sensorless Control with Tec. Controller

Configuration 111 extends the functionality of the sensorless control by software functions for easier adaptation to the customer's requirements in different applications. The Technology Controller enables flow rate, pressure, level or speed control.



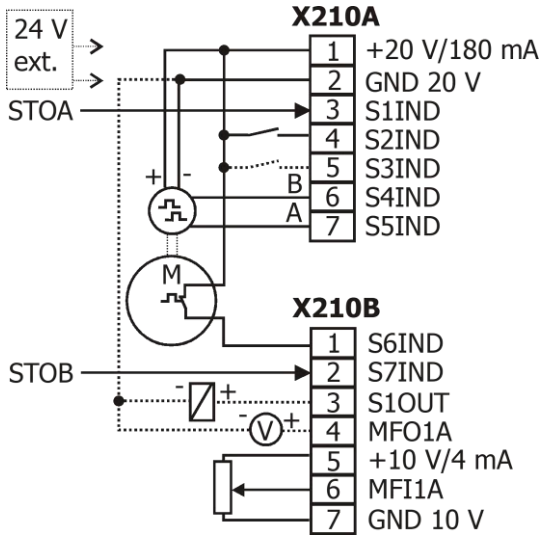
Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Fixed Percent Change-Over 1
X210A.5	Fixed Percent Change-Over 2
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.3 Config 210 – FOC, Speed Controlled

Control methods 2xx can be used with **HTL** encoders (with or without reference pulse) at basic device or an extension module.
In order to use control methods 2xx with **TTL** encoders, an extension module is required.
An extension module EM-ABS for signal evaluation is required for operation with absolute encoders (Hiperface, EnDat2.1, SSI).

Configuration 210 contains the functions for speed-controlled, field-oriented control of a 3-phase machine with speed sensor feedback. The necessary speed sensor feedback results in a precise speed and torque performance.

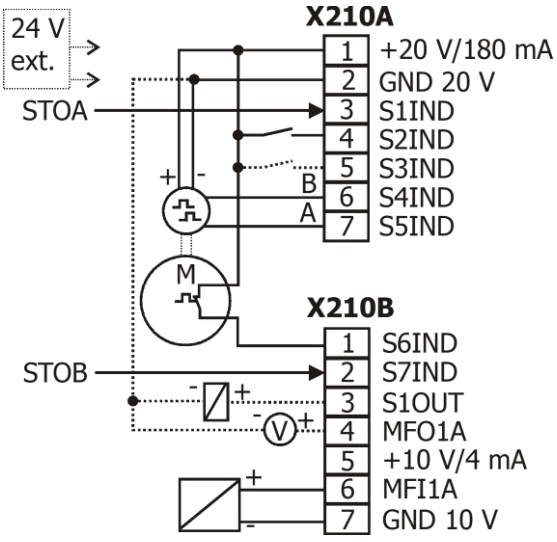


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Speed sensor track B
X210A.7	Speed sensor track A

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10V
X210B.7	Ground 10 V

7.10.4 Config 211 – FOC with Tec. Controller

Configuration 211 extends the functionality of the speed-controlled, field-oriented control of Configuration 210 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.

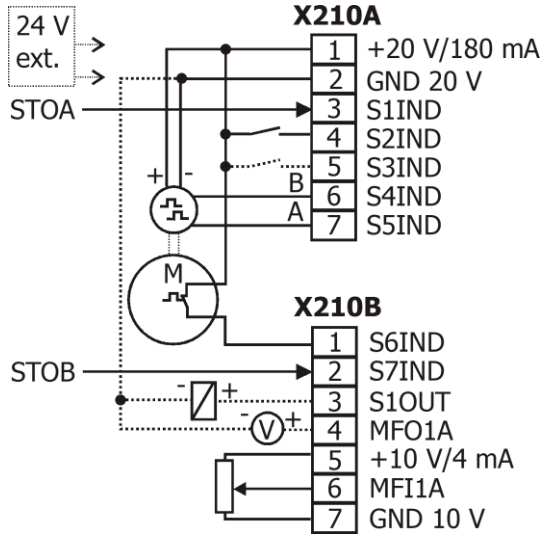


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Fixed Percent Change-Over 1
X210A.5	no function assigned
X210A.6	Speed sensor track B
X210A.7	Speed sensor track A

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.5 Config 230 – FOC, Speed and Torque Controlled

Configuration 230 extends the functionality of Configuration 210 by functions for torque-dependent, field-oriented control. The reference torque is represented as a percentage and it is transmitted into the corresponding operational performance of the application. Change-over between variable-speed control and torque-dependent control is done jerk-free during operation.

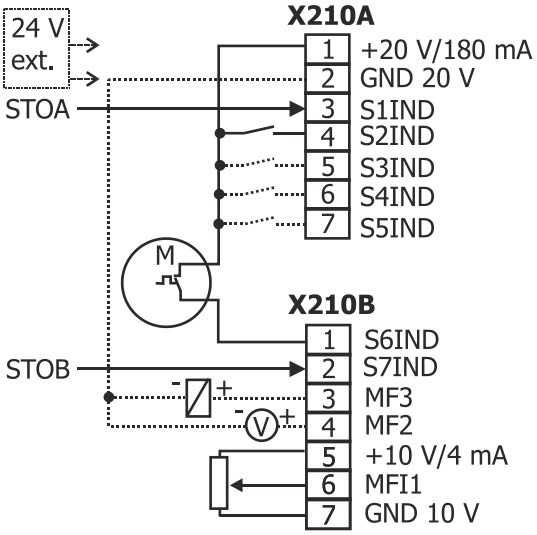


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	n-/M change-over control function
X210A.6	Speed sensor track B
X210A.7	Speed sensor track A

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0...+10 V or reference torque as percentage
X210B.7	Ground 10 V

7.10.6 Config 310 – Speed Control (Sensorless), SynRM

Configuration 310 contains the functions for the control of a synchronous reluctance motor. The synchronous reluctance machines are typically operated in open loop. Also refer to chapter 18.4 for details.

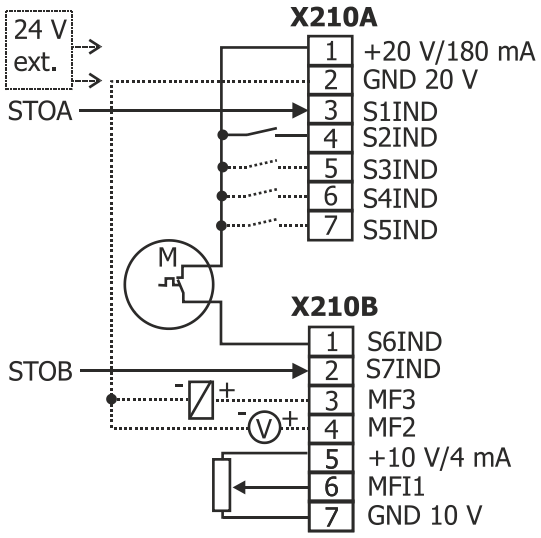


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	Start of anti-clockwise operation
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor thermal contact
X210B.2	Digital input STOB (2nd shutdown path of safety function STO)
X210B.3	Run Signal [1)]
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10 V
X210B.7	Ground 10 V

7.10.7 Config 330 – Switchable Speed and Torque Ctrl (Sensorless), SynRM

Configuration 330 extends the functionality of the configuration 310 for a synchronous reluctance motor by torque control functionality. The synchronous reluctance machines are typically operated in open loop. Also refer to chapter 18.4 for details.

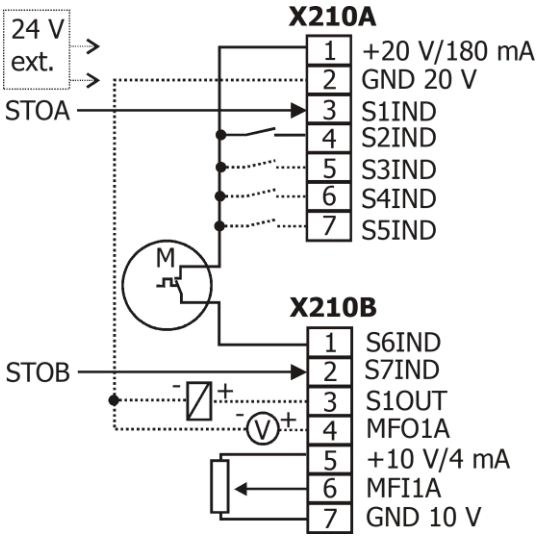


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	n-/M change-over control function
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor thermal contact
X210B.2	Digital input STOB (2nd shutdown path of safety function STO)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10 V [1)]
X210B.7	Ground 10 V

7.10.8 Config 410 – Sensorless FOC

Configuration 410 contains the functions for sensorless, field-oriented control of an asynchronous machine. The current motor speed is determined from the present currents and voltages in combination with the machine parameters. Separate control of torque and flux-forming current enables a high drive dynamism at a high load moment.

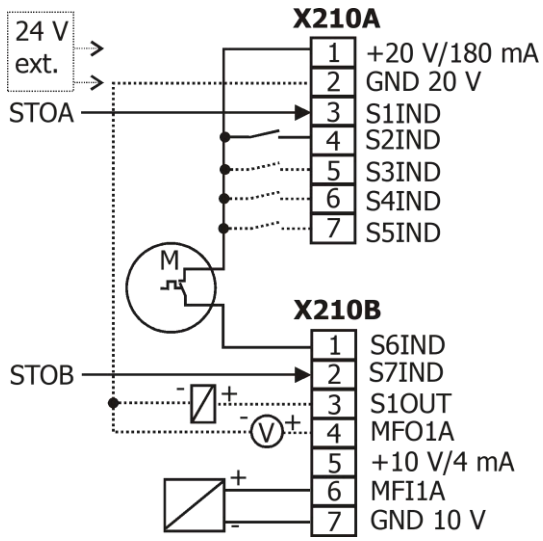


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10 V
X210B.7	Ground 10 V

7.10.9 Config 411 –Sensorless FOC with Technology Controller

Configuration 411 extends the functionality of the sensorless field-oriented control of Configuration 410 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.

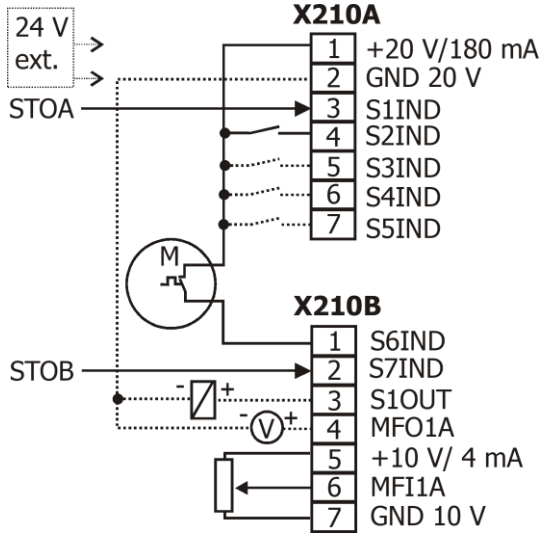


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Fixed Percent Change-Over 1
X210A.5	no function assigned
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.10 Config 430 – Sensorless FOC, Speed and Torque Ctrl

Configuration 430 extends the functionality of the sensorless field-oriented control of Configuration 410 by a Torque Controller. The reference torque is represented as a percentage and it is transmitted into the corresponding operational performance of the application. Change-over between variable-speed control and torque-dependent control is done jerk-free during operation.



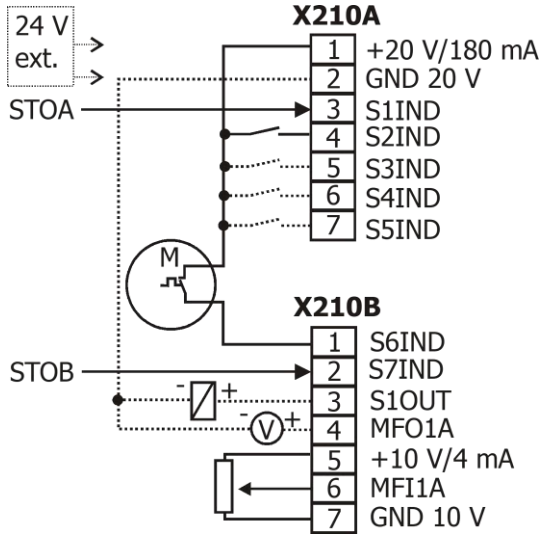
Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	n-/M change-over control function
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0...+10 V or reference torque as percentage
X210B.7	Ground 10 V

7.10.11 Config 510 – FOC of Synch. Machine, Speed Controlled

An extension module EM-RES for evaluation of resolver signals is required for operation of a synchronous machine (control method 5xx).
An extension module EM-ABS for signal evaluation is required for operation with absolute encoders (Hiperface, EnDat2.1, SSI).
For connection of the resolver or absolute encoder, also refer to operating instructions of extension module.

Configuration 510 contains the functions for speed-controlled, field-oriented control of a synchronous machine with resolver feedback. The separate control of torque and flux-forming current enables high drive dynamism with a high load moment. The necessary resolver feedback results in a precise speed and torque performance.



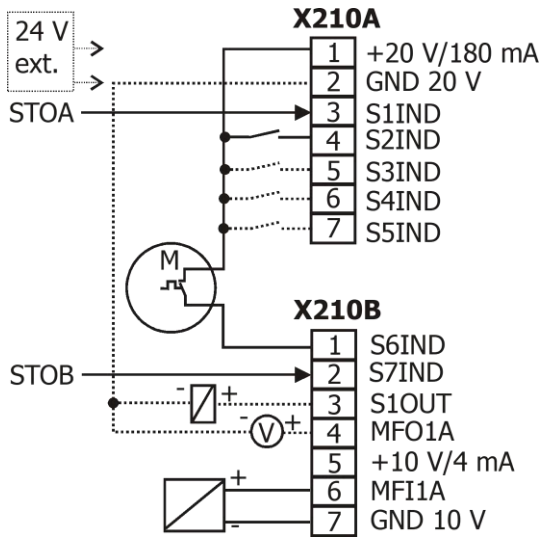
Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10V
X210B.7	Ground 10 V

7.10.12 Config 511 –FOC of Synch. Machine w/ Tec. Controller

An extension module EM-RES for evaluation of resolver signals is required for operation of a synchronous machine (control method 5xx).
An extension module EM-ABS for signal evaluation is required for operation with absolute encoders (Hiperface, EnDat2.1, SSI).
For connection of the resolver or absolute encoder, also refer to operating instructions of extension module.

Configuration 511 extends the functionality of the field-oriented control of a synchronous machine of Configuration 510 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.



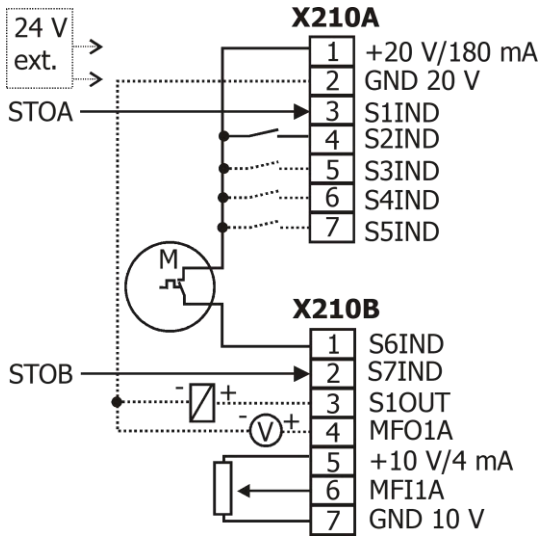
Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shut-down path of STO safety function)
X210A.4	Fixed Percent Change-Over 1
X210A.5	no function assigned
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input STOB (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.13 Config 530 – FOC of a Sync. Mach. Speed and Torque Controlled

An extension module EM-RES for evaluation of resolver signals is required for operation of a synchronous machine (control method `5xx`).
An extension module EM-ABS for signal evaluation is required for operation with absolute encoders (Hiperface, EnDat2.1, SSI).
For connection of the resolver or absolute encoder, also refer to operating instructions of extension module.

Configuration 530 extends the functionality of Configuration 510 by functions for torque-dependent, field-oriented control. The reference torque is represented as a percentage and it is transmitted into the corresponding operational performance of the application. Change-over between variable-speed control and torque-dependent control is done jerk-free during operation.

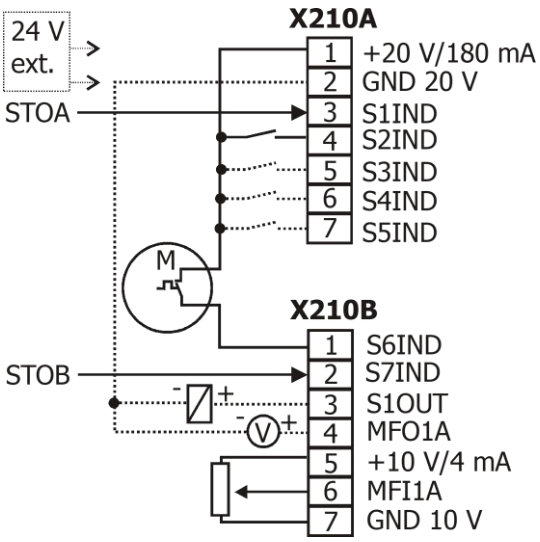


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	n-/M change-over control function
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0...+10 V or reference torque as percentage
X210B.7	Ground 10 V

7.10.14 Config 610 – Sensorless FOC of Sync. Machine, Speed Controlled

Configuration 610 contains the functions for sensorless field-oriented control of a synchronous machine without resolver feedback. The separate control of torque and flux-forming current enables high drive dynamism with a high load moment. The missing resolver feedback results in slightly lower dynamism and speed quality compared to Configuration 510.

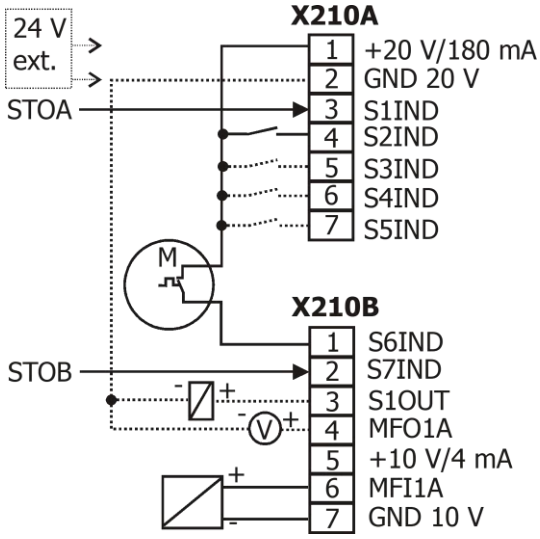


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10 V
X210B.7	Ground 10 V

7.10.15 Config 611 – Sensorless FOC of Sync. Machine with Tec Contrllr

Configuration 611 extends the functionality of the sensorless field-oriented control of a synchronous machine of Configuration 610 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.

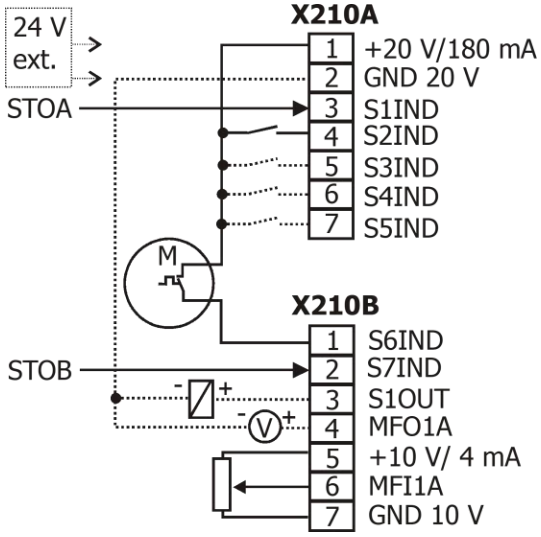


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Fixed Percent Change-Over 1
X210A.5	no function assigned
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.16 Config 630 – Sensorless FOC of Sync. Mach Speed & Torque Ctrlld

Configuration 630 extends the functionality of the sensorless field-oriented control of Configuration 610 by a Torque Controller. The reference torque is represented as a percentage and it is transmitted into the corresponding operational performance of the application. Change-over between variable-speed control and torque-dependent control is done jerk-free during operation.



Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shut-down path of STO safety function)
X210A.4	Start of clockwise operation
X210A.5	n-/M change-over control function
X210A.6	Data Set Change-Over 1
X210A.7	Data Set Change-Over 2

Control terminal X210B	
X210B.1	Motor therm. contact
X210B.2	Digital input **STOB** (2nd shut-down path of STO safety function)
X210B.3	Run Signal
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0...+10 V or reference torque as percentage
X210B.7	Ground 10 V

7.11 Installation notes according to UL508c / UL 61800-5-1

NOTICE

No branch circuit protection

Integral solid state short circuit protection does not provide branch circuit protection.

- Branch circuit protection must be provided in accordance with the Manufacturer Instructions, National Electrical Code and any additional local codes.

For an installation according to UL508c / UL 61800-5-1 the motor must be supervised regarding the thermal behavior. The connection and the parameter settings for the temperature motor supervision is described in chapter 16.4.5 "Thermocontact".
Thermal motor protection as per UL508c / UL 61800-5-1 can be realized in devices marked with "TM included" under the rating plate.
Overload protection operates over 100% of the full load current rating of the motor. The drive parameter shall be set at no more than the full load current rating of the motor. Motor overtemperature protection is provided.
Drives without inscription "TM included" on name plate only: "Motor overtemperature sensing is not provided by the drive". For installation as per UL508c / UL 61800-5-1,

- the mains feeder may be protected using approved fuses only. For approved fuses, refer to Chapter 5 "Technical data".
- the maximum temperatures specified in Chapter 5 "Technical data" must not be exceeded.
- only copper cables with a rated current of 60/75°C may be used.
- the devices may only be used in "Pollution Degree 2" environments.

For connection and parameterization of the thermal motor evaluation, refer to Chapter 14.6 "Motor temperature", 16.4.5 "Thermocontact" and 19.5 "Motor circuit breaker".
According to UL508c / UL 61800-5-1, warnings and markings/labels must not be removed.

Short-circuit current rating

For Size 1 to 6

Suitable for use on a circuit capable of delivering not more than 5,000 rms symmetrical amperes, 480 V AC maximum when protected by K5 Class Fuses.

For Size 7

Suitable for use on a circuit capable of delivering not more than 10,000 rms symmetrical amperes, 480 V AC maximum when protected by RK5 Class Fuses or R/C (JFHR2) Semiconductor Fuse, Type FWH-xxxA, manufactured by Cooper Bussmann LLC.

For Size 8 -51, -53, -55

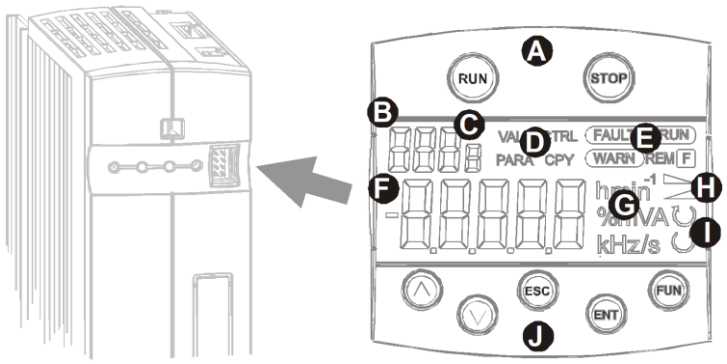
Suitable For Use On A Circuit Capable Of Delivering Not More Than 18 kA rms Symmetrical Amperes, 480 V AC Maximum when protected by Semiconductor fuses Types 170M5* made by Cooper Bussmann LLC.

For Size 8 -57, -59, -61

Suitable For Use On A Circuit Capable Of Delivering Not More Than 30 kA rms Symmetrical Amperes, 480 V AC Maximum when protected by Semiconductor fuses Types 170M5* made by Cooper Bussmann LLC.

8 Control unit KP500

The optional KP500 control unit is a practical tool for controlling the frequency inverter and setting and displaying the frequency inverter parameters.
The control unit is not absolutely necessary for the operation of the frequency inverter and can be plugged on when required.

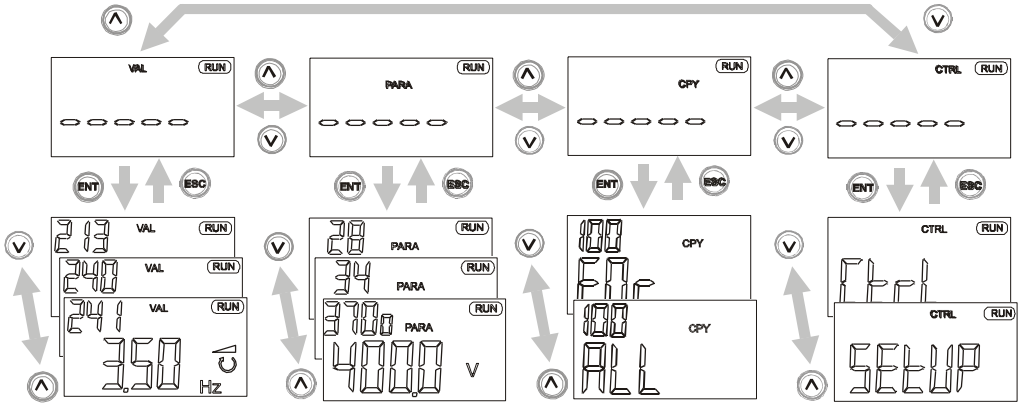


Buttons		
A	RUN	Used for starting the drive and opening the CTRL menu. Press the RUN key to open the motor potentiometer function.
	STOP	Used for opening the CTRL menu, stopping the drive and acknowledging faults
J	▲ ▼	Navigate in menu structure and select parameters. Increase or reduce parameter values.
	ENT	Open parameters or switch within the menu structure. Confirm the selected function or parameter.
	ESC	Used for aborting parameters or switching back to the previous menu within the menu structure. Cancel the function or reset parameter value.
	FUN	Used for switching over the key function, access to special functions.

Display		
B	Three-digit 7-segment display to show the parameter number.	
C	One-digit 7-segment display for display of the active data record, direction of rotation etc.	
D	Display selected menu branch:	
	VAL	Show actual values.
	PARA	Select parameters and adjust parameter values.
	CTRL	Select a function for adjustment and/or display via the operating unit: SEtUP Guided commissioning. CtrL motor potentiometer and jog function.
	CPY	Copy parameters via the control unit: ALL All parameter values are copied. Act Active parameter values are copied only. FOr Control unit memory is formatted and deleted.
E	Status and operating messages:	
	WARN	Warning about a critical operating behavior.
	FAULT	Message indicating that the unit was switched off due to a fault.
	RUN	Flashing: signalizes readiness for operation Lighting signalizes operation and release of the power part
	REM	Active remote control via interface connection.
	F	Function switch-over with the FUN key.
F	Five-digit 7-segment display for display of parameter value and sign.	
G	Physical unit of parameter value displayed.	
H	Active acceleration or deceleration ramp.	
I	Current direction of rotation of the drive.	

8.1 Menu structure

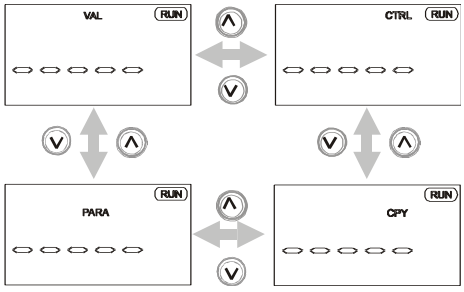
The menu structure of the control unit is arranged as shown in the following illustration. Use the arrow keys as well as ESC and ENT to navigate through the menu. The software contains the full set of information and enables a flexible use of the parameter setting and control options.



8.2 Main Menu

The various parameters and information of the frequency inverter can be displayed by means of the control unit. The different functions and parameters are grouped together in four menu branches. From any point in the menu structure you can return to the main menu by pressing the ESC key either continuously or repeatedly.

In the following description of the key functions, a plus (+) between the key symbols indicates that the keys have to be pressed at the same time.
A comma (,) between the key symbols indicates that the keys have to be pressed one after the other.



Menu branch – VAL
Display of actual values

Menu branch – PARA
Display and edit parameters

Menu branch – CPY
Copy parameters

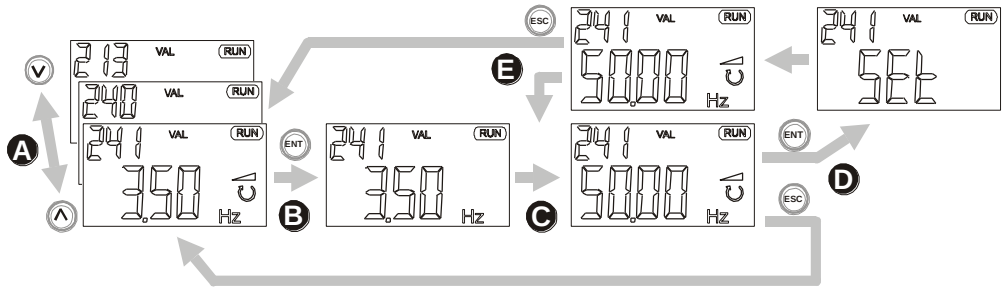
Menu branch – CTRL
Select control and test functions

Use the arrow keys to select the required menu branch. The selected menu branch is displayed (flashing).
Select the menu branch by pressing the ENT key. The first parameter or the first function in the selected menu branch will be displayed.
If you press the ESC key you will return to the main menu of the control unit.

Buttons	
▲ ▼	Navigate through the menu structure and select a menu branch
ENT	Open the selected menu branch
ESC	Quitting the menu branch and return to the main menu.

8.3 Actual Value Menu (VAL)

In the VAL menu branch, the control unit displays a variety of actual values, depending on the configuration selected and the options installed. The parameters and basic software functions linked to the corresponding actual value are documented in the operating instructions.



A	Use the arrow keys to select the required number from the actual values displayed in numerical order. When you have reached the highest parameter number, the smallest parameter number is displayed once you press the ▲ button. When you have reached the smallest parameter number, the highest parameter number is displayed once you press the ▼. In the current data set, the data set related actual value parameters are displayed, including the corresponding data set number. The seven-segment display shows data record 0 if the actual values in the four data sets are identical.

Buttons	
▲ + ▼	Display the actual value parameter upon startup.
FUN , ▲	Display last actual value parameter (highest number).
FUN , ▼	Display first actual value parameter (lowest number).

B	Use the ENT key to select the actual value. The parameter is displayed including its current value, unit and the active data set.

C	During commissioning, operation and error analysis, it is possible to monitor each actual value parameter specifically. Some of the actual value parameters are arranged in the four available data sets. If the parameter values in the four data records are identical, the actual value is displayed in data record 0. If the actual values in the four data set are different, diFF is displayed in data set 0.

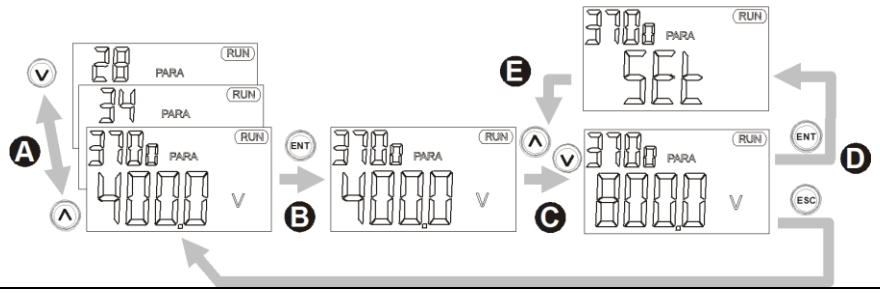
Buttons	
▲ , ▼	Switch to another of the data set in the case of related actual values.
FUN , ▲	Determine minimum value and display it permanently.
FUN , ▼	Determine and display minimum actual value permanently.
FUN , ENT	Display of mean value of the actual value during the monitoring period.

D	Use the ENT key to save the selected actual value as a parameter displayed at switch-on. The message SEt (with parameter number) is displayed for a short time. When the frequency inverter is switched on the next time, this actual value will be displayed automatically.

E	After saving the parameter, you can monitor and display the value again. Use the ESC key to switch to the parameter selection of the VAL menu branch.

8.4 Parameter Menu (PARA)

The parameters to be configured during the guided commissioning procedure were selected from common applications and can be supplemented as required by further settings in the PARA menu branch. The parameters and basic software functions linked to the corresponding actual value are documented in the operating instructions.



A	Use the arrow keys to select the required number from the parameters displayed in numerical order. The parameter number is displayed with the active data set (flashes). When you have reached the highest parameter number, the smallest parameter number is displayed once you press the ▲ button. When you have reached the smallest parameter number, the highest parameter number is displayed once you press the ▼. In the case of parameter numbers > 999, the first digit will be displayed in hexadecimal form (999, A00 … B5 … C66). In the current data set, the related parameters are displayed, including the corresponding data set number. The seven-segment display shows data set 0 if the parameter values in the four data sets are identical.	
	Buttons	
	▲ + ▼	Change to the last parameter edited.
	FUN , ▲	Display of last parameter (highest number).
	FUN , ▼	Display of first parameter (lowest number).

B	Use the ENT key to select the parameter. The parameter is displayed including its value, unit and the active data set. If settings are edited in data set 0, the parameter values are changed in the four data sets.	

C	Use the arrow keys to adjust the parameter value or to select an operation mode. The adjustment possibilities you have depend on the parameter. Keep the arrow keys pressed for a while to change the displayed values quickly. If you release the keys again, the speed at which the values change is reduced again. If the parameter value starts to flash, the speed at which the values change is reset to the initial value again.	
	Buttons	
	▲ + ▼	Set parameter to factory setting.
	FUN , ▲	Set parameter to highest value.
	FUN , ▼	Set parameter to smallest value.
	FUN , ENT	Change of the data set in the case of data set related parameters.

D	Use the ENT key to save the parameter. For a short time, the message SEt including the parameter number and the data set is displayed. To leave the parameter unchanged, press the ESC key.	
	Messages	
	Err1: EEPrO	Parameter has not been saved.
	Err2: StOP	Parameter can only be read (i.e. not edited) when the unit is in operation.
	Err3: Error	Other error.

E	After saving the parameter, you can edit the value again or return to the parameter selection menu by pressing the ESC key.

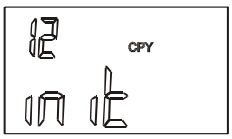
8.5 Copy Menu (CPY)

With the copy function of the control unit you can copy parameter values from the frequency inverter to a non-volatile memory of the control unit (upload) and store (download) them to a frequency inverter again.
The copy function makes the parameterization of recurring applications much easier. The function archives all parameter values, regardless of access control and value range. The memory space available in the control unit for the files is dynamically scaled to match the scope of the data.

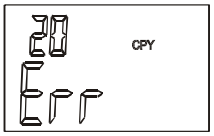
The Copy Menu (CPY) is accessible in control level 3. The control level can be adjusted, if necessary, via parameter *Control Level* **28**.

8.5.1 Reading the Stored Information

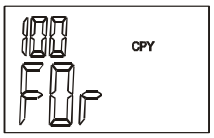
When you open the CPY menu branch, the data stored in the control unit are read out. This process takes a few seconds. During this time, init and a progress indicator will be displayed. After the initialization in the copy menu, the function can be selected.



If the information stored in the control unit is not valid, the initialization is stopped and an error message is displayed.
In this case, the memory in the control unit must be formatted as follows:

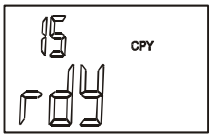


- Use the ENT key to confirm the error message.
- Use the arrow keys to select the function FOr.
- Use the ENT key to confirm the selection.



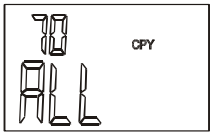
During the formatting process, FCOPY and a progress indicator are displayed.

The process takes a few seconds. When the process is complete, the message rdY is displayed.



- Confirm the message by pressing the ENT key.

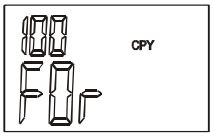
Now, you can select the copy function as described in the following.



8.5.2 Menu structure

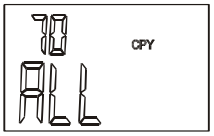
The copy menu CPY contains three main functions. Use the arrow keys to select the required function. Select the source and the destination for the process. The memory space available in the non-volatile memory of the control unit is displayed as a percentage on the three-digit seven-segment display.

Function – FOr



Use the function For to format and delete the memory in the control unit. This may be necessary if a new control unit is used for the first time.

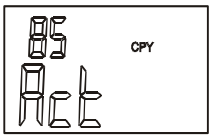
Function – ALL



All readable and writable parameter values are transferred.

- Confirm this selection by pressing the ENT key and continue by selecting the source.

Function – Act



The active parameter values of the frequency inverter are copied to the control unit only. The number of active parameter values depends in the current or selected configuration of the frequency inverter.
When copying the data from the control unit to the frequency inverter, all stored parameter values are transmitted, like in the case of the ALL function.

- For the copy operation, confirm the selection Act by pressing the ENT button and selecting the source.

8.5.3 Selecting the Source

The parameters of the ALL and Act sub-function in the CPY menu branch can be parameterized to meet the requirements of the specific application. The available memory space of the control unit is shown on the seven-segment display.

- Use the arrow keys to select the data source (Src.) for the copy operation (upload). The data sets of the frequency inverter (Src. x) or the files of the control unit (Src. Fy) can be used as the data source.
- Confirm the data source selected by pressing the ENT key and continue by selecting the target.

Display	Description
Src. 0	The data of the four data sets of the frequency inverter are copied.
Src. 1	The data of data set 1 of the frequency inverter are copied.
Src. 2	The data of data set 2 of the frequency inverter are copied.
Src. 3	The data of data set 3 of the frequency inverter are copied.
Src. 4	The data of data set 4 of the frequency inverter are copied.
Src. E	An empty data set for deletion of a file in the control unit.
Src. F1	File 1 is transferred from the memory of the control unit. [1)]
Src. F2	File 2 is transferred from the memory of the control unit. [1)]
Src. F3	File 3 is transferred from the memory of the control unit. [1)]
Src. F4	File 4 is transferred from the memory of the control unit. [1)]
Src. F5	File 5 is transferred from the memory of the control unit. [1)]
Src. F6	File 6 is transferred from the memory of the control unit. [1)]
Src. F7	File 7 is transferred from the memory of the control unit. [1)]
Src. F8	File 8 is transferred from the memory of the control unit. [1)]

[1)] Empty files not yet filled with data will not be offered as signal source. The memory of the control unit is managed dynamically (Chapter 8.5 "Copy Menu (CPY)").

8.5.4 Selecting the Destination

Select the destination (dSt.) of the copy operation (application-specific). The data source is transferred to the selected target (download).

- Use the arrow keys to select the destination (dSt.) of the copied data (download). Depending on the data source selected, either the data sets of the frequency inverter (dSt. x) or still empty files of the control unit (dSt. F y) are available as the target.
- Confirm your selection by pressing the ENT key. The copy operation will start and COPY will be displayed.

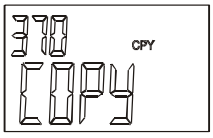
Display	Description
dSt. 0	The four data sets of the frequency inverter are overwritten.
dSt. 1	The data are copied to data set 1 of the frequency inverter.
dSt. 2	The data are copied to data set 2 of the frequency inverter.
dSt. 3	The data are copied to data set 3 of the frequency inverter.
dSt. 4	The data are copied to data set 4 of the frequency inverter.
dSt. F1	The data are copied to file 1 of the control unit. [1)]
dSt. F2	The data are copied to file 2 of the control unit. [1)]
dSt. F3	The data are copied to file 3 of the control unit. [1)]
dSt. F4	The data are copied to file 4 of the control unit. [1)]
dSt. F5	The data are copied to file 5 of the control unit. [1)]
dSt. F6	The data are copied to file 6 of the control unit. [1)]
dSt. F7	The data are copied to file 7 of the control unit. [1)]
dSt. F8	The data are copied to file 8 of the control unit. [1)]

[1)] Already existing files will not be offered as copy target.

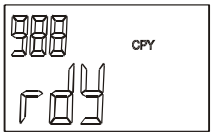
8.5.5 Copy Operation

Before the parameter settings are transferred to the frequency inverter, the individual parameter values are checked.
The value range and the parameter settings can differ according to the power range of the frequency inverter. Parameter values which are outside of the value range will trigger a copy error message. In case a device error is triggered as a result of copying, the device error will only be displayed once the copying has been completed.

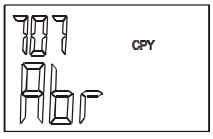
While the copy operation is in process, the message COPY and, as a progress indicator, the number of the currently copied parameter will be displayed.
In the case of the Act function, the active parameter values are copied only. Using the ALL function, parameters which are not relevant to the selected configuration are copied, too.



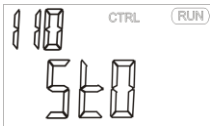
Depending on the configuration selected (ALL or Act), the copy operation will be completed after approx. 100 seconds and the message rdY will be displayed.
Press the ENT key to switch to the copy menu. Use the ESC key to switch to the target selection menu.



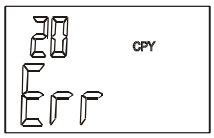
If the ESC key is pressed during the copy operation, the copy operation is aborted before the transmission of the data is complete. The message Abr and the number of the last parameter which was copied are displayed.
Press the ENT key to return to the selection in the copy menu. Use the ESC key to switch to the target selection menu.



8.5.6 Error messages



The copy function archives all parameters, regardless of the access control and the value range. Some of the parameters are only writable if the frequency inverter is not in operation. The controller enable input (S1IND, S7IND) may not be activated during the copy operation, otherwise the data transmission is aborted. The message **StO** and the number of the last parameter which was copied are displayed. If the controller enable input is deactivated again, the aborted copy operation is continued.



The data transmission from the selected source to the destination is continuously monitored by the copy function. If an error occurs, the copy operation is aborted and the message **Err** and an error code are displayed.

Error messages		
Key		**Meaning**
0	1	Write error in memory of control unit;repeat the copy operation. If error message is displayed again, format the memory.
	2	Read error in memory of control unit;repeat the copy operation. If error message is displayed again, format the memory.
	3	The size of the memory of the control unit was not determined correctly. If this error occurs repeatedly, replace the control unit.
	4	Not enough memory; the data are incomplete. Delete the incomplete file and date no longer needed from the control unit.
	5	The communication has been disturbed or interrupted; repeat the copy function, delete the incomplete file if necessary.
1	0	Invalid identification of a file in the operating unit; delete faulty file and format memory if necessary.
	2	The memory space of the selected target file is occupied; delete file or use different target file in the operating unit.
	3	The source file to be read in the control unit is empty; only files containing reasonable data should be selected as a source.
	4	Defective file in the control unit; delete defective file and format memory if necessary.
2	0	The memory in the control unit is not formatted; format the memory via the FOr function in the copy menu.
3	0	Error during reading of a parameter from the frequency inverter;check connection between the control unit and the frequency inverter and repeat reading operation.
	1	Error during writing of a parameter in the frequency inverter; Check connection between the control unit and the frequency inverter and repeat the writing operation.
	2	Unknown parameter type; delete faulty file and format memory if necessary.
4	0	The communication has been disturbed or interrupted; repeat the copy function, delete the incomplete file if necessary.

8.6 Reading Data From Control Unit

"Parameter transmission" enables the transmission of parameter values from the control unit KP 500 to the frequency inverter. In this operation mode, all other functions of the control unit are disable, except for the COPY function. Transmission from the frequency inverter to the control unit is also disabled.

Activation of the control unit KP 500 for parameter transfer is prepared via parameter *Program* **34**. The control unit KP 500 must be connected to the frequency inverter.

Program 34	Function
111 - Parameter transmission	Control unit P 500 is prepared for parameter transmission. A connected frequency inverter can receive data from the control unit.
110 - Standard operation	Resetting of control unit KP 500 to standard operation mode.

Parameter transmission mode can be activated on the control unit KP 500 only if at least 1 file is stored in the control unit. Otherwise, the error message "**F0A10**" will be displayed as soon as activation is attempted.

8.6.1 Activation

The control unit KP 500 can be configured both via the keys of the KP 500 and via any available CM communication module. For configuration and activation of the KP 500 control unit, proceed as follows:

Activation via keyboard of control unit

- In the parameter menu PARA, use the arrow keys to select parameter *Program* **34**, and confirm your selection by pressing the ENT key.
- Use the arrow keys to set value 111 – Parameter transmission and confirm your selection by pressing the ENT key.

  Now the control unit is ready for activation.

Before data transmission, the control unit must be initialized:

- Unplug the control unit from the frequency inverter and connect again to the same or another frequency inverter.

  The initialization is started. During the time of initialization, **init** and a progress indicator are displayed. After initialization, the control unit KP°500 is ready for transfer of data to the frequency inverter.

Adjustment of parameter *Program(ming)* **34** to value 111 – Parameter transmission, can be undone via the control unit, provided that the control unit has not been initialized yet.

- In Parameter *Program(ming)* **34** use the arrow keys to set the value 110 – Normal operation again and confirm by pressing the **ENT** key.

Activation via communication module CM

Activation of the control unit through a communication connection is possible only if the frequency inverter is fitted with an optional communication module CM, and communication takes place via this module. The control unit must be connected to the frequency inverter.

- Establish connection to frequency inverter.
- Start communication and select parameter *Program* **34** via the communication interface.
- Via the communication interface, enter value 111 in parameter *Program* **34** and confirm this value.
- Via the communication interface in parameter *Program* **34**, enter 123 and confirm this value.

  The frequency inverter is re-initialized. The display of the control unit reads **rESEt**. After that, the unit is initialized.

8.6.2 Data transfer

In order to transmit a file from the control unit to the frequency inverter, proceed as follows:

- Connect control unit KP 500 to the frequency inverter.

  After initialization, the data sources available for transmission are displayed.
- Use the arrow keys to select the data source (Src. Fy) for the transmission to the frequency inverter.

  The files stored in the control unit are available as data sources.

The files stored in the control unit contain all information and parameters stored according to the selected copy function ALL or Act (see Chapter 8.5 "Copy Menu (CPY)") in the control unit.

- Confirm your selection by pressing the ENT key.

  The copy process is started. While the copy operation is in process, COPY and, as a progress indicator, the number of the currently copied parameter will be displayed.
  As soon as the copy operation is complete, the control unit will be re-initialized.

8.6.3 Resetting to Normal Operation

A control unit KP°500 activated for parameter transmission can be reset to full functionality (standard operation) via a specific key code on the control unit or via each available communication module CM.

Resetting on control unit

- Press RUN and STOP keys on control unit simultaneously for approx. 1 second.
  When the process is complete, – – – – – is displayed briefly. Then the top menu level of the control unit is available.
- In the parameter menu PARA, use the arrow keys to select parameter *Program* **34**, and confirm your selection by pressing the ENT key.
- Use the arrow keys to set value 110 – Normal operation and confirm your selection by pressing the ENT key.

The control unit is set to normal operation.

Resetting via communication module CM and/or using control software VPlus

Resetting of the control unit through a communication connection is possible only if the frequency inverter is fitted with an optional communication module CM, and communication takes place via this module.

- Establish connection to frequency inverter.
- Start communication and select parameter *Program* **34** via the communication connection.
- Via the communication connection, enter value 110 in parameter *Program* **34** and confirm this value.
- Via the communication connection enter value 123 in parameter *Program* **34** and confirm this value by pressing Enter.

  The frequency inverter is reset. The display of the control unit reads rESEt.

After resetting, the control unit is available again with full functionality.

8.7 Control Menu (CTRL)

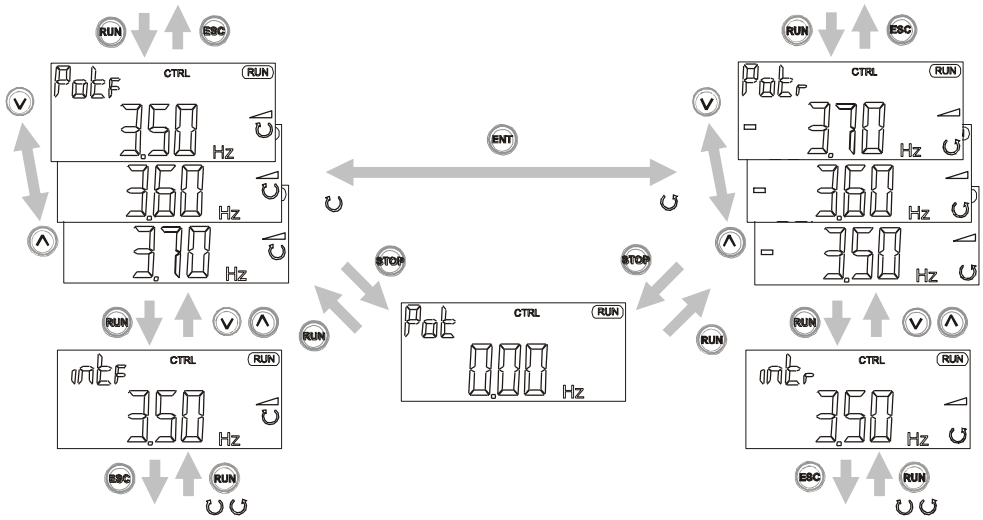
In order to be able to control the drive via the control unit, the digital inputs S1IND/STOA and S7IND/STOB must be connected for enabling the output.

In the CTRL menu branch, various functions are available which make commissioning easier and enable the control of the inverter via the control unit.
The frequency inverters can be controlled by means of the control unit and/or a communication module. If you want to control the frequency inverter via an optional communication module, the necessary adjustments can be made via parameter *Local/Remote* **412**. Via this parameter, you can specify which functions will be available to the controller. Depending on the operation mode selected, only some of the control menu functions are available. Refer to chapter 19.3 "Bus controller" for a detailed description of parameter *Local/Remote* **412**.

8.8 Controlling the Motor via the Control Unit

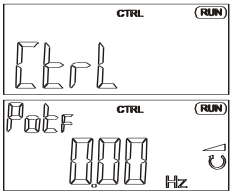
The operating unit enables control of the connected motor in accordance with the selected operating mode of the parameter *Local/Remote* **412**.

In order to be able to control the drive via the control unit, the digital inputs S1IND/STOA (STOA/terminal X210A.3) and S7IND/STOB (STOB/terminal X210B.2) must be connected for enabling the output. These are the inputs for the shut-down paths of the ST= safety function "Safe Torque Off".

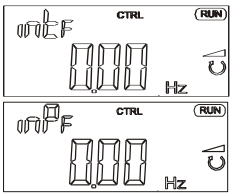


: When the RUN key was pressed, the drive was in operation already.

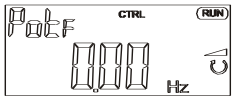
The CTRL menu branch can be accessed via the navigation within the menu structure. The **CtrL** function contains sub-functions which are displayed according to the operating point of the frequency inverter.
Pressing the RUN key leads to a direct change from anywhere within the menu structure to the motorpoti function PotF for clockwise rotation or Potr for anticlockwise rotation.



If the drive is already running, the display reads **intF** (forward, clockwise) / intr (backward, anticlockwise) for the internal reference value function or inPF (forward, clockwise) / inPr (backward, anticlockwise) for the "Motorpoti (KP)" function.
The function „Motorpoti (KP)" enables linking to other reference sources in the reference frequency channel. Refer to Chapter 15.10.2 "Motorpoti (KP)".

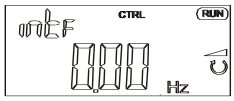


Motor potentiometer function Pot



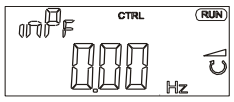
Using the arrow keys, you can adjust the output frequency of the frequency inverter from the *Minimum Frequency* **418** to the *Maximum Frequency* **419**. The acceleration corresponds to the factory settings (`2 Hz/s`) for parameter *Ramp Keypad-Motorpoti* **473**. Parameters *Acceleration (Clockwise)* **420** and *Deceleration (Clockwise)* **421** are considered in the case of low acceleration values.

Internal reference value function int



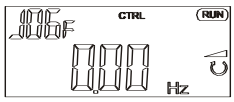
The drive is in operation, i.e. output signals are present at the frequency inverter and the current actual value is displayed. Press an arrow key to switch to the motor potentiometer function Pot. The current frequency value is taken over in the motor potentiometer function Pot.

Motor potentiometer function (KP) inP clockwise



Using the arrow keys, you can adjust the output frequency from *Minimum Frequency* **418** to *Maximum Frequency* **419**. The frequency value adjusted via the control unit can be linked to other reference values via the *Reference Frequency Source* **475** (Chapter 15.4 "Frequency reference channel" and 15.10.2 "Motorpoti (KP)").

JOG-Frequency JOG



This function is useful for manual setup and positioning of a machine. The frequency of the output signal is set to the entered value if the FUN key is pressed.

- Press FUN key to switch from the internal reference value int or the motor potentiometer function Pot to parameter *JOG-Frequency* **489**.
- While keeping the FUN key pressed, press the arrow keys to adjust the required frequency.

  (The last frequency value set will be saved in parameter *JOG-Frequency* **489**.)
- Release the FUN key to stop the drive.

  (The display returns to the previous function Pot or int. or inP if function "Motorpoti (KP)" is activated).

CAUTION

Unexpected system behavior

If you press the `ENT` key, the Sense of Rotation is changed independent of the signal on the terminals Clockwise S2IND or Anticlockwise S3IND.

If the *Minimum Frequency* **418** is set to `0.00` Hz, the sense of rotation of the motor changes as soon as the sign of the reference frequency value changes.

- Note the correct operation.

Key functions	
ENT	Reversal of the sense of rotation independent of the control signal on the terminals Clockwise S2IND or Anticlockwise S3IND.
ESC	Cancel function and return to the menu structure.
FUN	Switch from internal reference value int or motor potentiometer function Pot to JOG-Frequency; the drive will start. Release the key to switch to the sub-function and stop the drive.
RUN	Start drive; alternative to control signal S2IND or S3IND.
STOP	Stop drive; alternative to control signal S2IND or S3IND.

9 Commissioning of frequency inverter

NOTICE

If filters (e.g. dU/dt filters or sine filters) are used between the frequency inverter and machine, the following must be noted.
For configurations with sensor feedback (2xx, 5xx):

- Carry out the installation with the filter connected. Note the filter manufacturer's specifications concerning permissible switching frequencies. During setup note that the filter may be overloaded thermally.

For configurations without sensor feedback (1xx, 4xx, 6xx):

- Carry out the installation without connected filters. After setup, connect the filters between the frequency inverter and the motor.

NOTICE

In liquid-cooled devices:

- Vent the cooling circuit.
- Initiate the cooling circuit.

See instructions in the "Operating Instructions Liquid Cooling Supplemental" document.

9.1 Switching on Mains Voltage

After completion of the installation work, make sure to check all control and power connections again before switching on the mains voltage. When all electrical connections are correct, make sure that the frequency inverter is not enabled (control inputs S1IND/STOA and S7IND/STOB open). After power-up, the frequency inverter carries out a self-test and the relay output (X10) reports "Fault".
After a few seconds, the self-test is complete, the relay (X10) picks up and signals "no fault ".
If the unit is in "as-delivered" condition or after resetting the unit to the factory settings, the guided commissioning procedure is started automatically. On the control unit, the "`SetUP`" menu from the menu branch `CTRL` is displayed.

9.2 Setup Using the Control Unit

The guided commissioning of the frequency inverter determines all parameter settings relevant to the required application. The available parameters were selected based on known standard drive applications. This facilitates the selection of the important parameters. After successful completion of the SETUP routine, the actual value *Actual Frequency* **241** from the VAL menu branch is displayed on the control unit. Now, the user should check whether further parameters are relevant for the application.

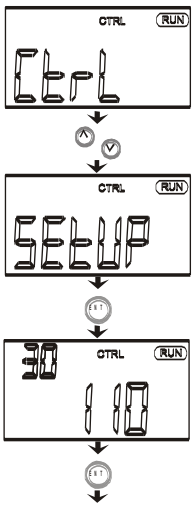
The guided commissioning contains the function for parameter identification. The parameters are determined by way of measurement and set accordingly. Guided commissioning must be carried out when the machine is cold, since a part of the machine data depends on the operating temperature.

NOTICE

For control of a synchronous machine and setting parameter *Configuration* **30** to "510 - FOC Syn. Speed Controlled , you will have to cancel the guided commissioning first by pressing the ESC key after the "SEtUP" message and set parameter *Offset* **382**.

- To do this, proceed according to the operating instructions for the extension module EM-RES or EM-ABS-01 installed.

When the unit is in "as-delivered" condition, the guided commissioning procedure is started automatically. After successful commissioning, the guided commissioning can be carried out again later via the sub-menu CTRL.



- Use the ENT key to switch to the CTRL sub-menu.
- In the CTRL sub-menu, select the menu item "SetUP" and confirm by pressing the ENT key.
- Use the ENT button to select parameter *Configuration* **30.**

The available configurations are displayed automatically depending on the selected *Control Level* **28**.

- Use the arrow keys to enter the number of the required configuration. (for a description of the configurations, refer to the following chapter)

  If the setup was changed, the hardware and software functionality will be configured. The message "SEtUP" is displayed again.

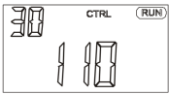
- Confirm this message by pressing the ENT key in order to continue the commissioning procedure.

- Switch to the next parameter.
- After initialization, confirm the selected configuration by pressing the ENT key.
- Continue the guided commissioning procedure according to the following chapters.

9.2.1 Configuration

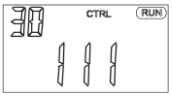
Configuration **30** determines the assignment and basic function of the control inputs and outputs as well as the software functions. The software of the frequency inverter offers several configuration options. These differ with respect to the way in which the drive is controlled. Analog and digital inputs can be combined and complemented by optional communication protocols as further reference value sources. The Operating Instructions describe the configurations and relevant parameters on the third *Control Level* **28** (Set parameter *Control Level* **28** to value 3). Please also comply with the following manuals:

Manual	Configuration
Application Manual – Electronic Gear	(**x15, x16**)
Application Manual: Positioning	(**x40**)
Application Manual – Hoisting Gear Drives	(**x60**)



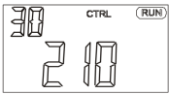
Configuration 110, sensor-less control (SLC)

Configuration 110 contains the functions for variable-speed control of a 3-phase machine in a wide range of standard applications. The motor speed is set according to the V/f characteristic in accordance with the voltage/frequency ratio.



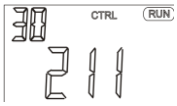
Configuration 111, SLC w. Technology Controller

Configuration 111 extends the functionality of the sensorless control by software functions for easier adaptation to the customer's requirements in different applications. The Technology Controller enables flow rate, pressure, level or speed control.



Configuration 210, FOC Speed Controlled

Configuration 210 contains the functions for speed-controlled, field-oriented control of a 3-phase machine with speed sensor feedback. The separate control of torque and flux-forming current enables high drive dynamism with a high load moment. The necessary speed sensor feedback results in a precise speed and torque performance.

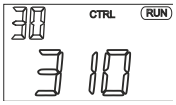


Configuration 211, FOC w. Technology Controller

Configuration 211 extends the functionality of Configuration 210 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.

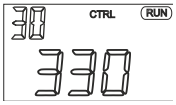
Configuration 230, FOC N or M Controlled

Configuration 230 extends the functionality of Configuration 210 by functions for torque-dependent, field-oriented control. The reference torque is represented as a percentage and it is transmitted into the corresponding operational performance of the application. Change-over between variable-speed control and torque-dependent control is done jerk-free during operation.



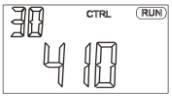
Configuration 310 – Speed Control, Synchronous reluctance machine

Configuration 310 contains the functions for the control of a synchronous reluctance motor. The synchronous reluctance machines are typically operated in open loop.



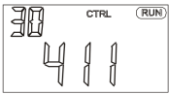
Configuration 330 – Switchable Speed and torque control, Synchronous reluctance machine

Configuration 330 extends the functionality of the configuration 310 for a synchronous reluctance motor by torque control functionality. The synchronous reluctance machines are typically operated in open loop.



Configuration 410, sensorless field-oriented control

Configuration 410 contains functions for sensorless, field-oriented control of a 3-phase machine. The current motor speed is determined from the present currents and voltages in combination with the machine parameters. In this configuration, parallel connection of several 3-phase motors is possible to a limited extent only.

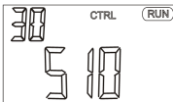


Configuration 411, DMR w. Technology Controller

Configuration 411 extends the functionality of Configuration 410 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.

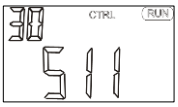
Configuration 430, DMR N or M Controlled

Configuration 430 extends the functionality of Configuration 410 by functions for torque-dependent, field-oriented control. The reference torque is represented as a percentage and it is transmitted into the corresponding operational performance of the application. Change-over between variable-speed control and torque-dependent control is done jerk-free during operation.



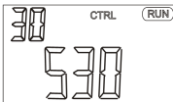
Configuration 510, FOC Syn. Speed Controlled

Configuration 510 contains the functions for speed-controlled, field-oriented control of a synchronous machine with speed sensor feedback. The separate control of torque and flux-forming current enables high drive dynamism with a high load moment. The necessary speed sensor feedback results in a precise speed and torque performance.



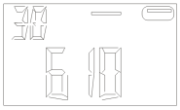
Configuration 511, FOC Syn. Speed Controlled w. Technology Controller

Configuration 511 extends the functionality of Configuration 510 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.



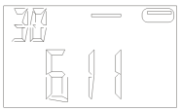
Configuration 530, FOC Syn. N or M Controlled

Configuration 530 extends the functionality of Configuration 510 by functions for torque-dependent, field-oriented control. The reference torque is represented as a percentage and it is transmitted into the corresponding operational performance of the application. Change-over between variable-speed control and torque-dependent control is done jerk-free during operation.



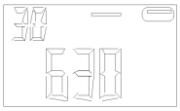
Configuration 610, DMR for PMSM

Configuration 610 contains the functions for sensorless field-oriented control of a synchronous machine without resolver feedback. The separate control of torque and flux-forming current enables high drive dynamism with a high load moment. The missing resolver feedback results in slightly lower dynamism and speed quality compared to Configuration 510.



Configuration 611, DMR PMSM w. Technology Controller

Configuration 611 extends the functionality of Configuration 610 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.



Configuration 630 – DMR PMSM N or M Controlled

Configuration 630 extends the functionality of the sensorless field-oriented control of Configuration 610 by a Torque Controller. The reference torque is represented as a percentage and it is transmitted into the corresponding operational performance of the application. Change-over between variable-speed control and torque-dependent control is done jerk-free during operation.

In the table, you will find a list of functions which are available in the different configurations.

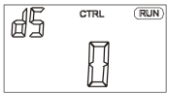
Function	Chapter	Configuration						
		V/f		Field-oriented control				
		Sensorless 1xx		SynRM 3xx		Sensor 2xx		
		110	111	310	330	210	211	230
Speed control	18.5.5			x	x	x	x	x
Torque control	18.5.2				x			x
Switch-over speed/torque control	16.4.6				x			x
Dynamic voltage pre-control	17.1	x	x					
Intelligent current limits	18.1	x	x	x	x	x	x	x
Voltage controller	18.2	x	x	x	x	x	x	x
Technology controller:	18.3		x				x	
- Pressure control	18.3		x				x	
- Flow rate control	18.3		x				x	
- Contents level control	18.3		x				x	
- Speed control	18.3		x				x	
Slip compensation	18.4.1	x						
Current limit value controller	18.4.2	x	x					
Current controller	18.5.1			x	x	x	x	x
Limit value sources	18.5.2			x	x	x	x	x
Acceleration pre-control	18.5.6			x	x	x	x	x
Field controller	18.5.7			x	x	x	x	x
Modulation controller	18.5.8			x	x	x	x	x
Starting behavior:	13.1	x	x	x	x	x	x	x
- Starting current injection	13.1.1.1	x	x	x	x			
- Flux formation	13.1.2			x	x	x	x	x
Stopping behavior:	13.2	x	x	x	x	x	x	x
- Direct current brake	13.2.3	x	x					
Auto start	13.4	x	x	x	x	x	x	x
Search run	13.5	x	x	x	x	x	x	x
Reference point positioning	13.6.1	x		x		x		
Axle positioning	13.6.2					x		
Frequency reference channel	15.4	x		x	x	x		x

Function	Chapter	Configuration						
		V/f		Field-oriented control				
		Sensorless 1xx		SynRM 3xx		Sensor 2xx		
		110	111	310	330	210	211	230
Reference percentage channel	15.5		x		x		x	x
Fixed frequencies	15.6.1	x	x	x	x	x		x
Fixed percentages	15.6.3		x		x		x	x
Block frequencies	15.9	x	x	x	x	x		x
PWM-/repetition frequency input	15.11	x	x	x	x	x	x	x
Brake chopper	19.4	x	x	x	x	x	x	x
Motor circuit breaker	19.5	x	x	x	x	x	x	x
V-belt monitoring	19.5.2	x	x	x	x	x	x	x
Motor chopper	19.7.1			x	x	x	x	x
Temperature Adjustment	19.7.2			x	x	x	x	x
Speed sensor monitoring	19.7.3					x	x	x

Function	Chapter	Configuration								
		Field-oriented control								
		Sensorless 4xx			Servo 5xx			Servo sensorless 6xx		
		410	411	430	510	511	530	610	611	630
Speed control	18.5.5	x		x	x	x	x	x	x	x
Torque control	18.5.2			x			x			x
Switch-over speed /torque control	16.4.6			x			x			x
Dynamic voltage pre-control	17.1									
Intelligent current limits	18.1	x	x	x	x	x	x	x	x	x
Voltage controller	18.2	x	x	x	x	x	x	x	x	x
Technology controller:	18.3		x			x			x	
Pressure control	18.3		x			x			x	
Flow rate control	18.3		x			x			x	
Contents level control	18.3		x			x			x	
Speed control	18.3		x			x			x	
Slip compensation	18.4.1									
Current limit value controller	18.4.2									
Current controller	18.5.1	x	x	x	x	x	x	x	x	x
Limit value sources	18.5.2	x	x	x	x	x	x	x	x	x
Acceleration pre-control	18.5.6	x	x	x	x	x	x	x	x	x
Field controller	18.5.7	x	x	x						
Modulation controller	18.5.8	x	x	x						
Starting behavior:	13.1	x	x	x	x		x	x	x	x
Starting current injection	13.1.1.1	x	x	x		x		x	x	x
Flux formation	13.1.2	x	x	x						
Stopping behavior:	13.2	x	x	x	x	x	x	x	x	x
Direct current brake	13.2.3									
Auto start	13.4	x	x	x	x	x	x	x	x	x
Search run	13.5	x	x	x	x	x	x	x	x	x
Reference point positioning	13.6.1	x			x			x		
Axis positioning	13.6.2				x					
Frequency reference channel	15.4	x		x	x		x	x		x

Function	Chapter	Configuration								
		Field-oriented control								
		Sensorless 4xx			Servo 5xx			Servo sensorless 6xx		
		410	411	430	510	511	530	610	611	630
Reference percentage channel	15.5		x	x		x	x		x	x
Fixed frequencies	15.6.1	x	x	x	x	x	x	x	x	x
Fixed percentages	15.6.3		x	x		x	x		x	x
Block frequencies	15.9	x	x	x	x	x	x	x	x	x
PWM-/repetition frequency input	15.11	x	x	x	x	x	x	x	x	x
Brake chopper	19.4	x	x	x	x	x	x	x	x	x
Motor circuit breaker	19.5	x	x	x	x	x	x	x	x	x
V-belt monitoring	19.5.2	x	x	x	x	x	x	x	x	x
Motor chopper	19.7.1	x	x	x						
Temperature Adjustment	19.7.2	x	x	x						
Speed sensor monitoring	19.7.3									

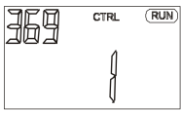
9.2.2 Data Set



The data set change-over function enables the selection of one of four data sets for storing parameter settings.
If data set 0 is selected (factory setting), the parameter values saved in data set 0 are copied to data sets 1 through 4. In this way, all values determined during the guided commissioning procedure are saved in all data sets. In the factory settings, the frequency inverter uses data set 1 as the active data set. (For information on data set change-over via logic signals, refer to the chapter 16.4.7 "Switch data set")
For example, if data set 2 is selected for guided commissioning ("SETUP"), all values which were determined or entered are saved in this data set. The other data sets will still contain the default values. For the operation of the frequency inverter, data set 2 must be selected as the active data set in this case.

Data Set Setup	
dS	**Function**
0	All data sets (DS0)
1	Data set 1 (DS1)
2	Data set 2 (DS2)
3	Data set 3 (DS3)
4	Data set 4 (DS4)

9.2.3 Motor Type



The properties of the control functions and methods to be set vary depending on the motor which is connected. Parameter *Motor Type* **369** offers a range of motor variants with the corresponding values. The verification of the entered rated values and the guided commissioning are carried out on the basis of the parameterized motor type. The selection of motor types varies according to the applications of the different control methods. In operating instructions the functionality and operating performance are described for 3-phase motors.

Motor Type 369		Function
0 -	Unknown	The motor is not a standard type.
1 -	Asynchronous	Three-phase asynchronous motor, squirrel cage
2 -	Synchronous	Three-phase synchronous motor
3 -	Reluctance	Three-phase reluctance motor
10 -	Transformer [1)]	Transformer with three primary windings.

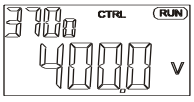
[1] For setting of parameter *Motor type* **369** to operation mode "10 – Transformer", no parameter identification is performed.

NOTICE

Polling and setting of parameter values depends on the operation mode selected for parameter *Motor type* **369**.
If the motor type is not entered correctly, the drive may be damaged.

When the motor type is specified, the machine data must be entered. This is described in the following chapter. The data is queried in accordance with the table in this chapter.

9.2.4 Machine data



The machine data to be entered during the guided commissioning procedure are indicated on the rating plate or the data sheet of the motor. The factory settings of the machine parameters are based on the nominal data of the frequency inverter and the corresponding four-pole three-phase motor. The entered and calculated machine data are checked for plausibility during the guided commissioning procedure. The user should verify the factory-set rated data of the three-phase motor.
U_{FIN}, I_{FIN}, P_{FIN} are rated values of the frequency inverter.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
370	Rated Voltage	$0.17 \cdot U_{FIN}$	$2 \cdot U_{FIN}$	U_{FIN}
371	Rated Current	$0.01 \cdot I_{FIN}$	$10 \cdot o \cdot I_{FIN}$	I_{FIN}
372	Rated Speed	96 min^{-1}	60 000 min^{-1}	n_N
374	Rated Cosinus Phi	0.01	1.00	$cos(\varphi)_N$
375	Rated Frequency	10.00 Hz	599.00 Hz	50.00
376	Rated Mech. Power	$0.01 \cdot P_{FIN}$	$10 \cdot P_{FIN}$	P_{FIN}

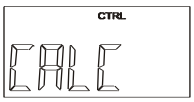
- Use the arrow keys to select the required parameter and edit the parameter value.
- Use the ENT key to confirm the selected parameter and the parameter values entered.

The rated data of the motor are to be entered according to the specifications on the rating plate for the motor connection type used (star or delta connection).
If the data entered deviate from the rating plate, the parameters will not be identified correctly. Parameterize the rated data according to the rating plate of the motor for the wiring of the motor winding. Consider the increased rated current of the connected three-phase motor.

Example: BONFIGLIOLI BN 90LA Motor

Parameter		Star	Delta
370	Rated Voltage	400 V	230 V
371	Rated Current	3.7 A	6.4 A
372	Rated Speed	1410 min^{-1}	1410 min^{-1}
374	Rated Cosine Phi	0.77	0.77
375	Rated Frequency	50 Hz	50 Hz
376	Rated Mech. Power	1.5 kW	1.5 kW

9.2.5 Plausibility check



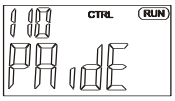
After the machine data (and the speed sensor data, if applicable) have been entered, the calculation or examination of the parameters is started automatically. The display changes over to "CALC" for a short time. If the verification of the machine data is successful, the guided commissioning procedure continues with the identification of the parameters.
Verification of the machine data should only be skipped by experienced users. The configurations contain complex control processes which depend to a large degree on the correctness of the machine parameters entered.

The warning and error messages displayed during the verification process have to be observed. If a critical condition is detected during the guided commissioning, it is displayed by the control unit. Depending on the deviation from the expected parameter value, either a warning or an error message is displayed.

- To ignore the warning or error messages, press the ENT key. The guided commissioning is continued. However, it is recommended that the data be checked and corrected if necessary.
- To correct the entered parameter values after the warning or error message, press the ESC key. Use the arrow keys to switch to the parameter value which is to be corrected.

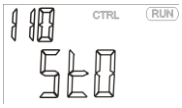
If an error message is displayed, the rated values must be checked and corrected. The guided commissioning procedure is the rated values have been entered correctly. Aborting the guided commissioning procedure by pressing ESC key should only be done be expert users because it may be possible that rated values have not been entered or determined correctly.

9.2.6 Parameter identification



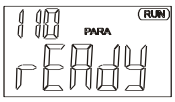
In addition to the parameterized rated data, the selected configuration demands knowledge of further machine data not stated on the rating plate of the three-phase machine. In addition to entering the rated motor parameters or as an alternative, the required machine data can also be measured during the guided commissioning process. The machine data are measured while the drive is at a standstill. The measured values are entered in the parameter automatically either directly or after the calculation. The procedure and the duration of the parameter identification depend on the type of machine connected and the device.
After checking the machine data entered, the guided commissioning switches to the parameter identification.
Confirm the display "PAidE" by pressing the ENT key.
During the parameter identification, the connected load is measured.

No parameter identification is performed for setting Parameter *Motor Type* **369** of Operation Mode "10 - Transformer".



The safety functions of the frequency inverter avoid enabling of the power unit if no signal is present at digital input S1IND/STOA (terminal X210A.3) and S7IND/STOB (terminal X210B.2). If signals were already applied at the beginning of the guided commissioning, the "StO" message is not displayed.

In order to be able to control the drive via the control unit, the digital inputs S1IND/STOA (terminal X210A.3) and S7IND/STOB (terminal X210B.2) must be connected for enabling the output.



Confirm the final "rEAdY" message by pressing the ENT key.
Cancelling the operation with the ESC key or withdrawing the enable signal S1IND/STOA or S7IND/STOP results in an incomplete take-over of the values.

Guided commissioning must be carried out when the machine is cold, since a part of the machine data depends on the operating temperature.

After completion of the parameter identification, warning messages may be displayed. Depending on the warning message code, the following instructions should be followed and the measures indicated should be taken.

9.2.7 Status messages during commissioning (SS...)

The following status messages are possible during commissioning (setup):

Status message		Meaning
SS000	OK	Auto set-up routine has been carried out.
SS001	PC Phase 1	The plausibility check (PC) of the motor data is active.
SS002	PC Phase 2	The calculation of dependent parameters is active.
SS003	STO	The parameter identification requires release on digital input STOA and STOB.
SS004	Parameter Identification	The rated motor values are checked by the parameter identification feature.
SS010	Setup already active	The setup routine via the control panel is being carried out.
SS030	No Release	The parameter identification demands the controller release on digital input STOA and STOB.
SS031	Error – check P.259	Error during the auto set-up routine. Check value of *Current Error* **259.**
SS032	Warning Phase Asymmetry	The parameter identification feature diagnosed an unbalance during the measurements in the three motor phases.
SS099	Setup not carried out yet.	Self-setup has not yet been carried out.

9.2.8 Warnings during commissioning (SA...)

Code	Measures / Remedy
	Warning messages
SA000	No warning message present. This message can be read out via an optional communication board.
SA001	The value of the parameter *Rated Voltage* **370** is out of the rated voltage range of the frequency inverter. The maximum reference voltage is indicated on the nameplate of the frequency inverter.
SA002	For a three-phase motor, the calculated efficiency is in the limit range. Check the values entered for parameters *Rated Voltage* **370**, *Rated Current* **371** and *Rated Mech. Power* **376**.
SA003	The value entered for parameter *Rated Cosinus Phi* **374** is outside of normal range (0.6 to 0.95). Check the value.
SA004	For three-phase motor, the calculated slip is in the limit range. Check the values for parameters *Rated Speed* **372** and *Rated Frequency* **375** .
SA011	Current Controller non typical value; also see Chapter 18.5.1.
SA012	Current Controller non typical value with 2kHz; also see Chapter 18.5.1.
SA014	Current Controller non typical value with 4 kHz; also see Chapter 18.5.1.
SA018	Current Controller non typical value with 8 kHz; also see Chapter 18.5.1.
SA021	Stator Resistance very high. The following causes are possible: – The motor cable cross-section is not sufficient. – The motor cable is too long. – The motor cable is not connected correctly. – The contacts are not in a proper condition (corrosion).
SA022	Rotor Resistance very high. The following causes are possible: – The motor cable cross-section is not sufficient. – The motor cable is too long. – The motor cable is not connected correctly. – The contacts are not in a proper condition (corrosion).
SA031	Shorten Motor Line for Switching frequency 16 kHz.
SA032	Shorten Motor Line for Switching frequency 12 kHz and higher.
SA033	Shorten Motor Line for Switching frequency 8 kHz and higher.

Code	Measures / Remedy
	Warning messages
SA041	The slip speed was not determined correctly. Check the values for parameters *Rated Speed* **372** and *Rated Frequency* **375** .
SA042	The slip speed was not determined correctly. Check the values for parameters *Rated Speed* **372** and *Rated Frequency* **375** .
SA051	The machine data for star connection were entered, the motor, however, is connected in delta. For star operation, change the motor cable connection. For delta operation, check the entered rated motor values. Repeat the parameter identification
SA052	The machine data for delta connection were entered, the motor, however, is connected in star. For delta operation, change the motor cable connection. For star operation, check the entered rated motor values. Repeat the parameter identification
SA053	A phase asymmetry was measured. Check the cables at the terminals of the motor and the frequency inverter for proper connection and check the contacts for corrosion.
SA054	Resolver offset not adjusted.

9.2.9 Error messages during commissioning (SF...)

After completion or during the parameter identification, error messages may be displayed. Depending on the error code, the following instructions should be followed and the measures indicated should be taken.

Code	Measures / Remedy
	Error messages
SF000	No Error
SF001	The value entered for parameter *Rated Current* **371** is too low. Correct the value.
SF002	The value for parameter *Rated Current* **371** is too high, referred to parameters *Rated Mech. Power* **376** and *Rated Voltage* **370**. Correct the values.
SF003	The value entered for parameter
SF004	The calculated slip frequency is negative. Check and, if necessary, correct the values for parameters *Rated Speed* **372** and *Rated Frequency* **375**.
SF005	The calculated slip frequency is too high. Check and, if necessary, correct the values for parameters *Rated Speed* **372** and *Rated Frequency* **375**.
SF006	The calculated total output of the drive is lower than the rated power. Check and, if necessary, correct the value entered for parameter *Rated Mech. Power* **376**.
SF007	The set configuration is not supported by the auto set-up routine.
SF011	The main inductance measurement has failed because the motor has a high sliP.Correct the rated motor values in parameters **370**, **371**, **372**, **374**, **375** and **376** . Carry out the guided commissioning once again. In case an error message is displayed again, enter value 110 for *parameter Configuration* **30** (sensor-less control (SLC) according to V/f characteristic) if value 410 was set so far. Carry out the guided commissioning once again.
SF012	The leakage inductance measurement has failed because the motor has a high sliP.Correct the rated motor values in parameters **370**, **371**, **372**, **374**, **375** and **376** . Carry out the guided commissioning once again. In case an error message is displayed again, enter value 110 for *parameter Configuration* **30** (sensor-less control (SLC) according to V/f characteristic) if value 410 was set so far. Carry out the guided commissioning once again.
SF021	The measurement of the stator resistance did not deliver a plausible value. Check the cables at the terminals of the motor and the frequency inverter for proper connection and check the contacts for corrosion and safe contact. Repeat the parameter identification
SF022	The measurement of the rotor resistance did not deliver a plausible value. Check the cables at the terminals of the motor and the frequency inverter for proper connection and check the contacts for corrosion and safe contact. Repeat the parameter identification
SF026	Setup aborted

9.2.10 Application data

Other parameters must be checked due to the great variety of drive applications and the resulting parameter settings. The parameters queried during the guided commissioning procedure were selected from standard applications. After completion of commissioning, further parameters can be set in the PARA menu branch.

In the KP500 control unit, parameter numbers > 999 are shown in hexadecimal form (999, A00 … B5 … C66).

9.2.10.1 Acceleration and deceleration

The settings define how fast the output frequency changes after a reference value change or a start, stop or brake command.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
420	Acceleration (Clockwise)	0.00 Hz/s	9999.99 Hz/s	5.00 Hz/s
421	Deceleration (Clockwise)	0.00 Hz/s	9999.99 Hz/s	5.00 Hz/s

NOTICE

The deceleration of the drive is monitored in the default parameter *Operation Mode Voltage Controller* **670**. The deceleration ramp can be extended in the case of an increase in the DC link voltage during regenerative operation and/or during the braking process.

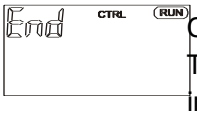
9.2.10.2 Set points at multifunction input

Multifunction input MFI1 can be parameterized for a reference value signal in *Operation Mode* **452**. Operation Mode 3 should only be selected by expert users for drive control via *Fixed Frequency 1* **480** and *Fixed Frequency 2* **481**.

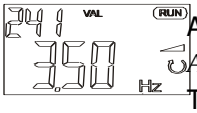
Operation Mode 452		Function
1 -	Voltage Input	voltage signal (MFI1A), 0 V ... 10 V
2 -	Current Input	current signal (MFI1A), 0 ...20 mA.
3 -	Digital input	digital signal (MFI1D), 0 V ... 24 V

Use multifunction input MFI1 as digital input for slow signals. For rapidly and regularly changing signals, use a digital input S2IND…S6IND or a digital input of an extension module EM.

9.2.11 Quitting commissioning



Confirm the "End" display by pressing the ENT key.
The guided commissioning of the frequency inverter is terminated via a reset and the initialization of the frequency inverter. Relay output X10 reports a fault due to default setting *OP.Mode Digital Output 3* **532** = „103 - Inv. Error Signal" (Inv: inverted).



After successful initialization of the frequency inverter, the factory-set parameter *Actual Frequency* **241** is displayed.
The drive is accelerated to the set *Min. Frequency* **418** (default: 3.50 Hz in Configurations 110, 111, 330, 410, 411, 430 or 0.00 Hz in Configurations 210, 211, 230, 510) by:

- signals at digital inputs S1IND/STOA (STOA) and S7IND/STOB (STOB) and
- Start clockwise by rising signal edge at S2IND or Start anticlockwise by rising signal edge at S3IND

Status signals

160 -	Standby Message	1)	Signals that frequency inverter has been initialized and is ready for operation.
1 -	Ready or Standby Signal	2)	
161 -	Run Message	1)	Signals that start command has been released and is present (output frequency present).
2 -		2)	Signals that start command has been released and is present (output frequency present). Factory setting: Message via digital output S1OUT.

162 -	Error Signal	1)	Monitoring function signals operating error with display in Parameter *Current Error* **259**.
3 -		2)	

1) For linking to frequency inverter functions
2) For output via a digital output.

9.2.12 Selection of an actual value for display

After commissioning, the value of parameter *Actual Frequency* **241** is displayed at the control unit KP500.
If another actual value is to be displayed after a restart, make the following settings:

- Use the arrow keys to select the actual value to be displayed as from now.
- Use the ENT key to display the value of the parameter.
- Press the ENT key again. "SEt" is displayed for confirmation.

As from now, the selected actual value is displayed after each restart.
If the parameter settings were made via the optional control software or in the PARA menu branch of the operating unit, the display of the selected actual value must be activated manually. Use the ESC key to switch to the selection of the actual value for display again.

9.3 Setup via the Communication Interface

Parameter-setting and commissioning of the frequency inverter via one of the optional communication interfaces include the plausibility check and the parameter identification functions. The parameters can be adjusted by qualified users. The parameter selection during the guided commissioning procedure includes the basic parameters. These are based on standard applications of the corresponding configuration and are therefore useful for commissioning.

WARNING

Faulty parametrization

Faulty or incorrect parametrization may lead to unwanted device behavior. This may lead to device damage or to personal injuries.

- Parameter settings may only be changed by skilled personnel. Before starting the commissioning process, read the documentation carefully and comply with the safety instructions.

Parameter *SETUP Select* **796** defines the function which is carried out directly after the selection (if controller enabling signal is present at digital inputs S1IND and S7IND). The operation modes include functions which are also carried out automatically one after the other during the guided commissioning procedure.

SETUP Select 796		Function
0 -	Clear status	The auto set-up routine does not perform a function.
1 -	Continue	The warning message is acknowledged and the auto set-up routine is continued.
2 -	Abort	The auto set-up routine is stopped and a RESET of the frequency inverter is performed.
10 -	Complete Setup, DS0	The auto set-up routine is performed in data set 0 and the parameter values are stored in all of the four data sets identically.
11 -	Complete Setup, DS1	The parameter values of the auto set-up are stored in data set 1.
12 -	Complete Setup, DS2	The parameter values of the auto set-up are stored in data set 2.
13 -	Complete Setup, DS3	The parameter values of the auto set-up are stored in data set 3.
14 -	Complete Setup, DS4	The parameter values of the auto set-up are stored in data set 4.
20 -	Plaus.-Check Machine Data, DS0	The auto set-up routine checks the rated motor parameters in the four data sets.
21 -	Plaus.-Check Machine Data, DS1	The rated motor parameters in data set 1 are checked for plausibility.
22 -	Plaus.-Check Machine Data, DS2	The rated motor parameters in data set 2 are checked for plausibility.
23 -	Plaus.-Check Machine Data, DS3	The rated motor parameters in data set 3 are checked for plausibility.
24 -	Plaus.-Check Machine Data, DS4	The rated motor parameters in data set 4 are checked for plausibility.

SETUP Select 796		Function
30 -	Calculation and Para-Ident., DS0	The auto set-up routine determines extended motor data via the parameter identification feature, calculates dependent parameters and stores the parameter values in all of the four data sets identically.
31 -	Calc. and Para-Ident., DS1	Further motor data are measured, dependent parameters are calculated and the parameter values are saved in data set 1
32 -	Calc. and Para-Ident., DS2	Further motor data are measured, dependent parameters are calculated and the parameter values are saved in data set 2
33 -	Calc. and Para-Ident., DS3	Further motor data are measured, dependent parameters are calculated and the parameter values are saved in data set 3
34 -	Calc. and Para-Ident., DS4	Further motor data are measured, dependent parameters are calculated and the parameter values are saved in data set 4
40 -	Para-Ident., Machine Data only, DS0	Extended motor data are measured and saved identically in all data sets.
41 -	Para-Ident., Machine Data only, DS1	Extended motor data are measured and saved data set 1.
42 -	Para-Ident., Machine Data only, DS2	Extended motor data are measured and saved data set 2.
43 -	Para-Ident., Machine Data only, DS3	Extended motor data are measured and saved data set 3.
44 -	Para-Ident., Machine Data only, DS4	Extended motor data are measured and saved data set 4.
110 -	Complete Setup w/o Para-Ident., DS0	The auto set-up routine is performed in data set 0 and the parameter values are stored in all of the four data sets identically. Extended motor data are not measured.
111 -	Complete Setup w/o Para-Ident., DS1	The parameter values of the auto set-up are stored in data set 1. Extended motor data are not measured.
112 -	Complete Setup w/o Para-Ident., DS2	The parameter values of the auto set-up are stored in data set 2. Extended motor data are not measured.
113 -	Complete Setup w/o Para-Ident., DS3	The parameter values of the auto set-up are stored in data set 3. Extended motor data are not measured.
114 -	Complete Setup w/o Para-Ident., DS4	The parameter values of the auto set-up are stored in data set 4. Extended motor data are not measured.

In the "Extended motor data" settings, the current controller settings are changed, too.

The individual steps of the auto set-up routine can be monitored and checked via parameter *SETUP Status* **797**. The setup routine via the communication interface continuously updates the status parameter which can be read out via the interface.

For auto-setup status messages, refer to

- Chapter 9.2.7 "Status messages during commissioning (SS…)"
- Chapter 9.2.8 "Warnings during commissioning (SA…)"
- Chapter 9.2.9 "Error messages during commissioning (SF…)"

9.4 Check direction of rotation

To check if the reference value and the actual direction of rotation of the drive correspond to one another, proceed as follows:

- Operate the drive at low speed, i. e. specify a reference value of approx. 10%.
- Switch on release of frequency inverter briefly:
  Connect digital inputs S1IND/STOA and S7IND/STOB as well as S2IND (Start Clockwise) or digital inputs S1IND/STOA and S7IND/STOB as well as S3IND (Start Anticlockwise) .
- Check if the motor shaft turns in the required direction.
  In case the sense of rotation is wrong, exchange two motor phases, e.g. U and V at the terminals of the frequency inverter. The mains-side connection of the frequency inverter does not affect the sense of rotation of the drive. In addition to checking the drive, the corresponding actual values and operating messages can be read out by means of the operating unit.

The commissioning of the frequency inverter is complete and can be complemented by further settings in the PARA menu. The set parameters have been selected in such a way that they are sufficient for commissioning in most applications. The other settings which are relevant to the application can be checked according to the operating instructions.

If the controller release of the frequency inverter at MF4ID/STOA and S7IND/STOB is switched off the power output stage will be disabled. The motor will coast down or, if installed, a break will be activated.

9.5 Speed sensor

In some configurations, an incremental speed sensor must be connected. Depending in the type of speed sensor , it is connected to the basic device or an extension module. In some cases, speed sensors are connected to both the basic device and the extension module.

The source of the actual speed value is selected via parameter *Actual Speed Source* **766**. By default, speed sensor 1 is used as the actual speed source. If speed sensor 2 or 3 of an expansion module delivers the actual value signal for the speed controller, speed sensor 2 must be selected as the source.

Actual Speed Source 766	Function
1 - Speed Sensor 1	The actual speed source is speed sensor 1 of the basic device (factory setting).
2 - Speed Sensor 2	The actual speed source is speed sensor 2 of an extension module.[1)]

[1)] Only available if extension module is installed

Depending on the application and speed sensors used, the parameter settings must be adjusted according to the following table:

Parameter		Only Speed Sensor 1	Only Speed Sensor 2	Both Speed sensor
490	Operation Mode Speed Sensor 1	> 0	0 - off	> 0
491	Division Marks, Speed Sensor 1	1...8192	X	1...8192
493	Operation Mode Speed Sensor 2	0 - off	> 0	> 0
494	Division Marks, Speed Sensor 2	X	1...8192	1...8192
495	Level	X	Selection	Selection
766	Act. Speed Source	1	2	1 or 2

X: can be set to any value, it is not evaluated

The parameters listed above can be selected depending on the configuration selected and/or if an extension module is available.

Some applications require two speed sensors. Parameter *Actual Speed Source* **766** must be set to the motor speed sensor for motor control. The other speed sensor is used externally. Comply with the application manuals "Electronic gear" and "Positioning".

9.5.1 Speed Sensor 1

- Connect the speed sensor tracks to the digital inputs S5IND (track A), S4IND (track B) and S6IND (track Z).

  The speed sensor type and the evaluation required are adjusted via the *Operation Mode* **490** of speed sensor 1.

For a detailed description of possible settings refer to Chapter 11.4.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
490	Operation Mode Speed Sensor 1	Selection		
491	Division Marks	1	8192	1024

Depending on the *Operation Mode* **490** of speed sensor 1 the digital inputs S4IND, S5IND and S6IND are disabled for other functions. The functions will not be evaluated. The actual speed and frequency of speed sensor 1 is displayed in Parameters **217** and **218**.

9.5.2 Speed Sensor 2

WARNING

Digital inputs disabled

Depending on *Operation Mode* **493** of Speed Sensor 2, certain digital inputs are disabled for other functions. The functions will not be evaluated.

- Check the functions connected with / depending on the digital inputs.
- Exercise caution when having safety functions controlled by digital signals.

Speed sensor 2 must be connected to an extension module.

With extension modules EM and sensor input modules, it is also possible to connect and evaluate sensors as speed sensor 2. Refer to the relevant extension module operating instructions for information on connection, functions and detailed parameter descriptions. Speed sensor 1 and speed sensor 2 are configured independently from one another.

Depending on the actual product configuration, not all of the parameters described below are available for setting.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
493	Operation Mode	Selection		
494	EC2 Division Marks	1	8192	1024
495	EC2 Level	Selection		

Parameters **493**, **494** and **495** can be selected depending on the extension module used.

The actual speed and frequency of speed sensor 1 is displayed in Parameters **219** and **220**.

10 Inverter data

10.1 Serial Number

Serial Number **0**:	603409000 ; 06053980 (part no.; serial no.)
Rating plate:	Type: ACU 410 – 09 ; Serial No.: 06053980

10.2 Optional Modules

Modular extension of the hardware is possible via the plug-in slots. The *Optional Modules* **1** detected by the frequency inverter and the corresponding designations are displayed on the control unit and in the optional control software VPlus after initialization. For the parameters required for the extension module, refer to the corresponding operating instructions.

CM-232 ; EM-IO-01

10.3 Inverter Software Version

The firmware stored in the frequency inverter defines the available parameters and functions of the software. The software version is indicated in parameter *Inverter Software Version* **12**. In addition to the version, the software key is printed on the rating plate of the frequency inverter.

Inverter Software Version **12** :	7.0.4.0
Rating plate :	Version: 7.0.4.0; Software: 15 000 190

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10.4 Set Password

As a protection against unauthorized access, parameter *Set Password* **27** can be set such that anyone who wants to change parameters must enter this password this password before. A change of parameter is only possible if the password in entered correctly. If parameter *Set Password* **27** is set to zero, no password is required for access to the parameters. The previous password is deleted.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
27	Set Password	0	999	0

10.5 Control Level

The *Control Level* **28** defines the scope of the functions to be parameterized. The operating instructions describe the parameters on the third control level. These parameters should only be set by qualified users.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
28	Control Level	1	3	1

10.6 User Name

The *User Name* **29** can be entered via the optional control software VPlus.

32 alphanumeric characters

10.7 Configuration

Configuration **30** determines the assignment and basic function of the control inputs and outputs as well as the software functions. The software of the frequency inverters offers various configuration options. These differ with respect to the way in which the drive is controlled. Analog and digital inputs can be combined and complemented by optional communication protocols.

10.8 Language

The parameters are stored in the frequency inverter in various languages. The parameter description is displayed by the PC control software (e.g. VPlus) in the selected *Language* **33**.

Language 33	Function
0 - Deutsch	Parameter description in German
1 - English	Parameter description in English
2 - Italiano	Parameter description in Italian
100 -	The Language is set via VPlus (ACU Firmware as from 5.2.0)

Up to ACU Firmware 5.1.11, the language is set via *Language* **33** = `0,1,2` as from ACU Firmware Version 5.2.0, the parameter texts are managed by the VPlus PC software. If *Language* **33** is set to `100`, settings `0`, `1` and `2` are disabled.
As from Firmware Version 5.2.0, you will need a suitable VPlus Version (VPlus 7.38 or higher).

10.9 Programming

Parameter *Program* **34** enables acknowledgment of an error signal and resetting to the factory settings. The display of the control unit reads "dEFLt" or "rESEt" and the LEDs indicate the status of the frequency inverter.

Program 34	Function
111 - Parameter transfer	Control unit P 500 is prepared for parameter transmission. A connected frequency inverter can receive data from the control unit.
110 - Standard operation	Resetting of control unit KP 500 to standard operation mode.
123 - Reset	The current error message can be acknowledged via digital input S1IND/STOA or the software parameter. The display of the control unit reads "`rESEt`".
4444 - Default	The parameters of the selected configuration, except for a few exceptions, are reset to the default settings. The display of the control unit reads "`dEFLt`".

Parameters *Control Level* **28** and *Configuration* **30** are not changed when reset to default setting *(Program* **34** = `4444`).

11 Machine data

The input of the machine data is the foundation for the functionality of the control functions and methods. In the course of the guided commissioning, the necessary parameters are queried according to the selected *Configuration* **30**.

11.1 Rated motor parameters

Configure the rated motor parameters according to the rating plate of the motor or the motor data sheet. The default settings of the machine parameters are based on the nominal data of the frequency inverter and a four-pole asynchronous motor. The machine data required for the control functions and methods are checked for plausibility and calculated in the course of the commissioning.

- Check the default ratings.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
370	Rated Voltage	$0.17 \cdot U_{FIN}$	$2 \cdot U_{FIN}$	U_{FIN}
371	Rated Current	$0.01 \cdot I_{FIN}$	$10 \cdot o \cdot I_{FIN}$	I_{FIN}
372	Rated Speed	96 min^{-1}	60000 min^{-1}	n_N
373	No. of pole pairs	1	50	2
374	Rated Cosinus (φ)	0.01	1.00	$\cos(\varphi)_N$
375	Rated Frequency	10.00 Hz	599.00 Hz	50.00 Hz
376	Rated Mech. Power	$0.01 \cdot P_{FIN}$	$10 \cdot P_{FIN}$	P_{FIN}

U_{FIN} = Rated frequency inverter voltage, typically 400 V or 230 V
I_{FIN} = Rated frequency inverter output current
P_{FIN} = Rated frequency inverter power
o: Overload capacity of frequency inverter.

Parameter *Rated Cosinus (φ)* **374** is not available in Configurations `5xx` and `6xx` (synchronous motor).

In the case of asynchronous machines, the speed can be increased at a constant torque if the motor winding can be switched over from star to delta connection. The change-over leads to a modification of the dependent rated figures by a square root of three.

NOTICE

Wrong parametrization

The rated data of the motor must be entered according to the specifications on the rating plate for the motor connection type used (star or delta connection).
If the data entered deviate from the rating plate, the parameters will not be identified correctly.

- Parameterize the rated data according to the rating plate of the motor for the wiring of the motor winding. Consider the increased rated current of the connected three-phase motor.

11.2 Further motor parameters

In particular the field-oriented control requires the determination of further data which cannot be read off the rating plate of the 3-phase machine for the precise calculation of the machine model. In the course of the guided commissioning, the parameter identification was carried out to measure the further motor parameters.

11.2.1 Stator resistance

The resistance of the stator winding is measured during the guided commissioning. The measured value is saved as a phase value in parameter *Stator Resistance* **377** and is 3 times smaller than the winding resistance in delta connection.

By default, the equivalent stator resistance of a standard motor was entered to match the reference output of the frequency inverter.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
377	Stator Resistance [1)]	0 mΩ	65535 mΩ	R_{sN}
1190	Stator Resistance [2)]	0.001 Ω	100.000 Ω	10.000 Ω

[1)] In settings 1xx, 2xx, 4xx of Parameter *Configuration* **30**.
[2)] In settings 5xx and 6xx of Parameter *Configuration* **30**.

Stator resistance asynchronous motor:

The stator resistance of an asynchronous motor can be optimized while the machine is in no-load operation. At the stationary operating point, the torque-forming current *Isq* **216** and/or the estimated *Active Current* **214** should be zero. Due to the temperature-dependent of the stator resistance, the adjustment should be done at a winding temperature which is also reached during normal operation.
A correct measurement will optimize the control functions.

Stator resistance synchronous motor:

The stator resistance value of a synchronous machine is entered during commissioning. The stator resistance is needed for the current controller settings and should be available and entered as exactly as possible for this reason. The *Stator Resistance* **1190** is referred to the value between two motor phases and can typically be applied directly from the motor data sheet.

11.2.2 Leakage coefficient

The leakage coefficient of the machine defines the ratio of the leakage inductance to the main inductance. The torque and flux-forming current components are thus coupled via the leakage coefficient. Optimization of the leakage coefficient within the field-oriented control systems demands an acceleration to various operating points of the drive. The flux-forming current *Isd* **215** should be largely independent of the load torque (unlike the torque-forming current *Isq* **216**). The flux-forming current component is inversely proportional to the leakage coefficient. If the leakage coefficient is increased, the torque-forming current increases and the flux-forming component drops. The adjustment should result in a relatively constant actual current *Isd* **215** matching the set *Rated Magnetising Current* **716**, regardless of the load on the drive.
The sensorless control system uses the parameter *Leakage Coeff.* **378** in order to optimize the synchronization to one drive.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
378	Leakage coefficient	1.0 %	20.0 %	7.0 %

11.2.3 Magnetizing Current

The *Rated Magnetising Current* **716** is a measure of the flux in the motor and thus of the voltage which is present at the machine in no-load condition depending on the speed. The guided commissioning determines this value at approx. 30 % of the *Rated Current* **371**. This current can be compared to the field current of an externally excited direct current machine.
In order to optimize the sensorless field-oriented control system, the machine must be operated without load at a rotational frequency which is below the *Rated Frequency* **375**. The accuracy of the optimization increases with the adjusted *Switching Frequency* **400** and when the drive is in no-load operation. The flux-forming actual current value *Isd* **215** to be read out should roughly match the set *Rated Magnetising Current* **716**.
The field-oriented control with speed sensor feedback uses the parameterized *Rated Magnetising Current* **716** for the flux in the motor.

The dependence of the magnetizing on the frequency and voltage at the corresponding operating point in question is taken into account by a magnetizing characteristic. The characteristic is calculated via three points, in particular in the field weakening area above the rated frequency. The parameter identification has determined the magnetizing characteristic and set the parameters *Magnetising Current 50% Flux* **713**, *Magnetising Current 80% Flux* **714** *and Magnetising Current 110% Flux* **715** .

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
713	Magnetizing current 50%	1.00 %	50.00 %	31.00 %
714	Magnetizing current 80%	1.00 %	80.00 %	65.00 %
715	Magnetizing current 110%	110.00 %	197.00 %	145.00 %
716	Rated magnetizing current	$0.01 \cdot I_{FIN}$	$o \cdot I_{FIN}$	$0.3 \cdot I_{FIN}$

11.2.4 Rated slip correction factor

The rotor time constant results from the inductance of the rotor circuit and the rotor resistance. Due to the temperature-dependence of the rotor resistance and the saturation effects of the iron, the rotor time constant is also dependent on temperature and current. The load behavior and thus the rated slip depend on the rotor time constant. The guided commissioning determines the machine data during the parameter identification and sets the parameter *Rated Slip Correction Factor* **718** accordingly. For the fine adjustment or a check of the rotor time constant, proceed as follows: Load the machine at fifty percent of the *Rated Frequency* **375**. As a result, the voltage must be approximately fifty percent of the *Rated Voltage* **370** with a max. deviation of 5%. If this is not the case, the correction factor must be changed accordingly. The larger the correction factor is set, the stronger the voltage drop when the machine is loaded. The software-calculated rotor time constant value can be read via actual value *Act. Rotor Time Constant* **227**. The adjustment should be done at a winding temperature which is also reached during normal operation of the motor.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
718	Rated slip correction factor	0.01 %	300.00 %	100.00 %

11.2.5 Voltage Constant

In Configuration 5xx and 6xx for control of synchronous machines, the control behavior can be improved for highly dynamic requirements by setting parameter *Voltage Constant* **383**.
For the voltage constant, refer to the motor data sheet. In the motor data sheet, the value may be indicated in

$$\frac{V}{1000 \frac{U}{min}}.$$

This value can be applied to parameter *Voltage Constant* **383**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
383	Voltage Constant	0.0 mVmin	850.0 mVmin	0.0 mVmin

If guided commissioning (Setup) is not used, the self-setup should be performed to improve the drive behavior, especially for small speeds, via parameter *SETUP Select* **796**. Select one of the settings `10 … 14` for *SETUP Select* **796**.
During guided commissioning (via control panel and VPlus) of Bonfiglioli motors, the Voltage Constant is preset.
In the case of non-Bonfiglioli motors, the voltage constant should be entered if known. If you don't know the voltage constant, set *Voltage Constant* **383** to `0 mV` before commissioning, to enable automatic calculation and measurement.
The voltage constant should be optimized after the guided commissioning procedure: In no-load operation, set 50 % of the rated speed. Change the voltage constant in small steps until parameter *Rotor Flux* **225** reads `101% (±0.5%)`.

In the case of motors with a very high number of pole pairs (e.g. higher than 20), it is possible that the maximum setting range of the parameter is not sufficient. In this case, divide the voltage constant by `10` and enter the value. The division by `10` is considered internally.

11.2.6 Stator inductance

In Configuration 5xx for control of synchronous machines, the control behavior can be improved for highly dynamic requirements by setting parameter *Stator Inductance* **384**.
The *Stator Inductance* **384** is referred to the value between two motor phases and can typically be applied directly from the motor data sheet.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
384	Stator inductance	0.1 mH	500.0 mH	1.0 mH

11.2.7 Peak current

Parameter *Peak Current* **1192** is used during motor commissioning in order to set the Isq setpoint limit in the frequency inverter. This is to protect the connected synchronous motor. The value can be taken from the motor rating plate or the motor data sheet. Exceeding the value specified by the manufacturer may result in motor damage.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1192	Peak current	0.01 % $I_{FU,N}$	100 000 % o·$I_{FU,N}$	100 % $I_{FU,N}$

$I_{FU,N}$: Nominal value of frequency inverter
o: Overload capacity of frequency inverter.

11.2.8 Reverse sense of rotation

Parameter *Change Sense of Rotation* **1199** reverses the sense of motor rotation.

Change Sense of Rotation 1199	Positive setpoint	Negative setpoint
0 - off	Motor turning right (clockwise)	Motor turning left (anti-clockwise)
1 - On	Motor turning left (anti-clockwise)	Motor turning right (clockwise)

Bonfiglioli Vectron GmbH definition: clockwise sense of rotation with positive setpoint, looking to the A-side of motor, provided that motor phases are connected correctly. Upon reversal of the sense of rotation, the direction of rotation is reversed while the setpoint remains the same. Any gears which might be installed must be taken into consideration.

The sense of rotation can only be changed while the output stage is disabled.

Via *Change Sense of Rotation* **1199,** the sense of rotation of the whole system (motor control and sensor evaluation) is reversed.
If the senses of rotation of the motor and the sensor are different, this can be changed in two ways:

1) By exchanging Track A and Track B the sensor inputs at ACU.
2) Change sense of rotation of connected sensor via parameters **490** or **493**.

11.2.9 Iron Axis Impedance Ld for SynRM

The parameter *Iron Axis Impedance* **1051** determines the inductivity value for the stator of the motor. The value for the inductivity should be entered, if known. If the value is not known before commissioning, the default value may be left as is. Otherwise an estimated value can be entered. The correct values can be measured by the parameter identification procedure. See chapter 9.2.6 Parameter identification for further details.

For the correct operational behavior it is necessary that the SETUP parameter identification is carried out.

11.2.10 Air Axis Impedance Lq for SynRM

The parameter *Air Axis Impedance* **1052** determines the inductivity value for the air gap axis of the motor. The value for the inductivity should be entered, if known. If the value is not known before commissioning, the default value may be left as is. Otherwise an estimated value can be entered. The correct values can be measured by the parameter identification procedure. See chapter 9.2.6 Parameter identification for further details.

11.3 Internal values

The following parameters are used for internal calculation of motor data and do not require any set-up.

Parameter	
No.	**Description**
399	Internal value 01
402	Internal value 02
508	Internal value 03
702	Internal value 04
703	Internal value 05
704	Internal value 06
705	Internal value 07

Parameter	
No.	**Description**
706	Internal value 08
707	Internal value 09
708	Internal value 10
709	Internal value 11
745	Internal value 12
798	Internal value 13

11.4 Speed Sensor 1

The frequency inverters are to be adapted to the application depending on the requirements. Some of the available *Configurations* **30** require continuous measurement of the actual speed for the control functions and methods. The necessary connection of an incremental speed sensor is done on the digital control terminals S5IND (track A) and S4IND (track B) of the frequency inverter.

With extension modules EM and sensor input modules, it is also possible to connect and evaluate sensors as speed sensor 2. Please refer to the corresponding operating instructions. Speed sensor 1 and speed sensor 2 are configured independently from one another.

11.4.1 Operation Mode Speed Sensor 1

Operation Mode **490** for speed sensor 1 can be selected according to the connected incremental speed sensor. A unipolar speed sensor is to be connected to the standard control terminals.

Operation Mode **490**		Function
0 -	off	Speed measurement is not active; the digital inputs are available for other functions.
1 –	Single Evaluation	Two-channel speed sensor with recognition of direction of rotation via track signals A and B; one signal edge is evaluated per division mark.
4 –	Quadruple Evaluation	Two-channel speed sensor with recognition of direction of rotation via track signals A and B; four signal edges are evaluated per division mark.

Operation Mode 490		Function
11 –	Single Evaluationun-signed	One-channel speed sensor via track signal A; the actual speed value is positive. One signal edge is evaluated per division mark. The digital input S4IND is available for further functions.
12 –	Double Evaluation unsigned	One-channel speed sensor via track signal A; the actual speed value is positive. Two signal edges are evaluated per division mark. The digital input S4IND is available for further functions.
31 –	Single evaluation, sense of rot. via contact	Single-channel speed sensor via track signal A. The actual speed value is positive for signal "Low" and negative for signal "High" at digital input S4IND. One signal edge is evaluated per division mark.
32 –	Double Evaluation, Dir. via contact	Single-channel speed sensor via track signal A. The actual speed value is positive for signal "Low" and negative for signal "High" at digital input S4IND. Two signal edges are evaluated per division mark.
101 –	Single evaluation inverted	Like Operation Mode 1. The actual speed value is inverted. (Alternative to exchanging the track signals)
104 –	Quadruple evaluation inverted	Like Operation Mode 4. The actual speed value is inverted. (Alternative to exchanging the track signals)
111 –	Single Evaluation negative	Like Operation Mode 11. Actual speed is negative.
112 –	Double Evaluation negative	Like Operation Mode 12. Actual speed is negative.
131 –	Single evaluation, sense of rot. Cont. inverted	Single-channel speed sensor via track signal A. The actual speed value is negative for signal "Low" and positive for signal "High" at digital input S4IND. One signal edge is evaluated per division mark.
132 –	Double Evaluation, Dir. Cont. inverted	Single-channel speed sensor via track signal A. The actual speed value is negative for signal "Low" and positive for signal "High" at digital input S4IND. Two signal edges are evaluated per division mark.
1001 –	Single Evaluation w. Ref.-Pulse	Two-channel speed sensor with recognition of direction of rotation via track signals A and B, reference track via digital input S6IND. One signal edge is evaluated per division mark.
1002 –	Double Evaluation w. Ref.-Pulse	Two-channel speed sensor with recognition of direction of rotation via track signals A and B, reference track via digital input S6IND. Two signal edges are evaluated per division mark.
1004 –	Quadruple Evaluation w. Ref.-Pulse	Two-channel speed sensor with recognition of direction of rotation via track signals A and B, reference track via digital input S6IND. Four signal edges are evaluated per division mark.
1011 –	Single Evaluation unsigned w. Ref.-Pulse	One-channel speed sensor via track signal A; the actual speed value is positive. The reference track is connected to digital input S6IND. One signal edge is evaluated per division mark. The digital input S4IND is available for further functions.
1012 –	Double Evaluation unsigned w. Ref.-Pulse	One-channel speed sensor via track signal A; the actual speed value is positive. The reference track is connected to digital input S6IND. Two signal edges are evaluated per division mark. The digital input S4IND is available for further functions.
1031 –	Single Evaluation, Dir. Cont. w. Ref.-Pulse	Single-channel speed sensor via track signal A. The actual speed value is positive for signal "Low" and negative for signal "High" at digital input S4IND. One signal edge is evaluated per division mark. The reference track is connected to digital input S6IND.
1032 –	Double Evaluation, Dir. Cont. w. Ref.-Pulse	Single-channel speed sensor via track signal A. The actual speed value is positive for signal "Low" and negative for signal "High" at digital input S4IND. Two signal edges are evaluated per division mark. The reference track is connected to digital input S6IND.
1101 –	Single Evaluation inverted w. Ref.-Pulse	Like Operation Mode 1001. Actual speed is negative.
1102 –	Double Evaluation inverted w. Ref.-Pulse	Like Operation Mode 1002. Actual speed is negative.

Operation Mode **490**		**Function**
1104 –	Quadruple Evaluation inverted w. Ref.-Pulse	Like Operation Mode 1004. Actual speed is negative.
1111 –	Single Evaluation inverted unsigned w. Ref.-Pulse	Like Operation Mode 1011. Actual speed is negative.
1112 –	Double Evaluation inverted unsigned w. Ref.-Pulse	Like Operation Mode 1012. Actual speed is negative.
1131 –	Single Evaluation, Dir. Cont. inverted w. Ref.-Pulse	Single-channel speed sensor via track signal A. The actual speed value is negative for signal "Low" and positive for signal "High" at digital input S4IND. One signal edge is evaluated per division mark. The reference track is connected to digital input S6IND.
1132 –	Double Evaluation, Dir. Cont. inverted w. Ref.-Pulse	Single-channel speed sensor via track signal A. The actual speed value is negative for signal "Low" and positive for signal "High" at digital input S4IND. Two signal edges are evaluated per division mark. The reference track is connected to digital input S6IND.

In configurations 210, 211 and 230, digital input S4IND is by default set for the evaluation of a speed sensor signal (track B).
If an operation mode without sign is selected (Operation Mode `11` or Operation Mode `12`), this input is not set for the evaluation of a speed sensor signal and can be used for other functions.

11.4.2 Division Marks, Speed Sensor 1

The number of increments of the connected speed sensor can be adjusted via parameter *Division Marks Speed Sensor 1* **491**. Select the division marks of the speed sensor according to the speed range of the application.
The maximum number of division marks S_{max} is defined by the frequency limit of f_{max}=150 kHz of the digital inputs S5IND (track A) and S4IND (track B).

$$S_{max} = f_{max} \cdot \frac{60}{n_{max}}$$

f_{max} = 150000 Hz
n_{max} = max. speed of the motor in RPM

for example:

$$S_{max} = 150000\ Hz \cdot \frac{60s}{1500} = 6000$$

To guarantee true running of the drive, an encoder signal must be evaluated at least every 2 ms (signal frequency f = 500 Hz). The minimum number of division marks S_{min} of the incremental encoder for a required minimum speed n_{min} can be calculated from this requirement.

$$S_{min} = f_{min} \frac{60}{A \cdot n_{min}}$$

n_{min} = min. speed of the motor in RPM= evaluation (1, 2, 4)
A

for example:

$$S_{min} = 500\ Hz \cdot \frac{60\ s}{2 \cdot 10} = 1500$$

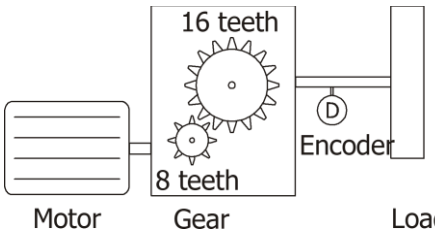
Parameter		**Setting**		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
491	Division Marks, Speed Sensor 1	1	8192	1024

11.4.3 Gear factor speed sensor 1

Setting of parameters *EC1 Gear Factor Numerator* **511** and *EC1 Gear Factor Denominator* **512** is required if a gear is installed between the speed sensor and the motor shaft. The parameters define the mechanical transmission ratio between the speed sensor and the motor side. The parameters must be set such that the gear factor numerator corresponds to the motor rotations and the gear factor denominator corresponds to the sensor rotations.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
511	EC1 Gear Factor Numerator	-300.00	300.00	1.00
512	EC1 Gear Factor Denominator	0.01	300.00	1.00

Example: The motor shaft turns twice while the load shaft rotates once (16/8).



$$\frac{\text{Revolutions of motor axis}}{\text{Revolutions of load axis}} = \frac{EC\,1\,Gear\,Factor\,Numerator\,\mathbf{511}}{EC\,1\,Gear\,Factor\,Denominator\,\mathbf{512}}$$

In this example, parameter *EC1 Gear Factor Numerator* **511** must be set to 2 and parameter *EC1 Gear Factor Denominator* **512** must be set to 1.

For optimum motor control, Bonfiglioli Vectron GmbH recommends installing a speed sensor directly at the motor.

11.4.4 Filter time constant, Speed Sensor 1

EC1 Filter time constant **1193** can be used in order to filter the speed of speed sensor 1. This filter can be used in situations where the speed sensor fluctuates (e.g. for mechanical reasons).
Bonfiglioli Vectron GmbH recommends changing the value in small steps and checking the individual results. Do not change the value in great steps.

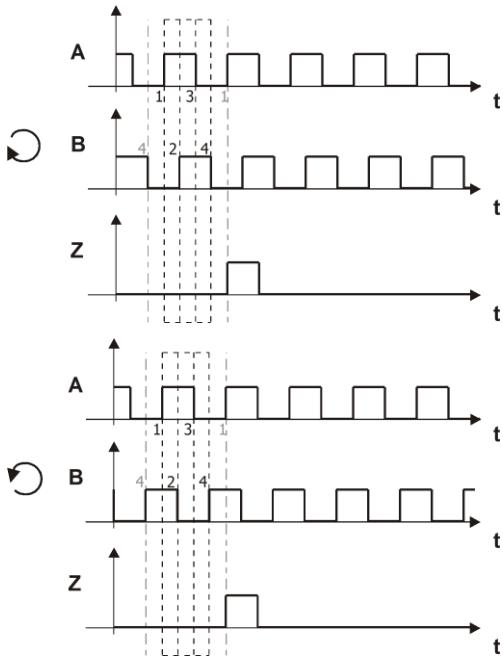
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1193	EC1 Filter time constant	0 us	32000 us	0 us

11.5 Sensor evaluation

In the field of drive engineering, TTL and HTL sensors with 512, 1024 or 2048 division marks are widely used. However, other division mark values are used, too. These division marks (often also referred to as „increments") determine the resolution (accuracy) at which a plant can be operated. A "division mark" is defined as a pulse including the pause following the pulse – the pulse-duty factor is typically 1:1, i.e. with each revolution, a track delivers the number of increments for evaluation. Depending on the characteristics of the sensor and the requirements in the plant, different degrees of sensor evaluation are possible. Typical evaluation accuracy levels include:
Single evaluation: One edge of a pulse of a track is counted and evaluated.
Double evaluation: Two edges (the positive and the negative edge) of a pulse of a track are counted and evaluated.
Quadruple evaluation: A second (offset) track delivers additional edges which can be evaluated. Any status change of the two tracks is registered and evaluated. Thanks to the offset arrangement of the tracks, the direction of rotation can be detected additionally. The two tracks are commonly referred to as A and B. Depending on when the edges occur, it can be determined if the motor rotates in clockwise or in anticlockwise direction.

With double or quadruple evaluation, internal calculation for motor control is improved. The number of division marks does not change.
In addition to tracks A and B, sensors often feature a reference track (also referred to as Z track, zero track, C track). The reference track delivers one pulse per revolution. This track is used for plausibility checking or for additional functions.

If an operation mode with reference track is selected for the speed sensor, the frequency inverter will make sure that the Z track occurs according to the parameterized *Division Marks Speed Sensor 1* **491**. If the evaluation is not consistent, a reaction as per parameter *Operation Mode* **760** is triggered.



Example (quadruple evaluation):
Each edge 1, 2, 3 and 4 is an evaluated signal within the pulse-pause cycle of Track A. After that, the cycle is restarted. The type of edges indicates the direction of rotation:
Clockwise direction of rotation: A rising edge of A (1) is followed by a rising edge of B (2).

Anticlockwise direction of rotation A rising edge of A (1) is followed by a falling edge of B (2).

Track Z: One pulse per revolution

HTL encoders can be connected to the basic device. For connection of TTL encoders, you will need a type EM-ENC encoder module. For connection of SinCos encoders or absolute encoders, you will need a type EM-ABS encoder module.

12 System data

The various control functions and methods according to the selected *Configuration* **30 are** supplemented by control and special functions. For monitoring the application, process parameters are calculated from electrical control parameters.

12.1 Actual value system

Parameter *Factor Actual Value System* **389** can be used if the drive is monitored via actual value *Actual Value System* **242**.
The *Actual Frequency* **241** to be monitored is multiplied by the *Factor Actual Value System* **389** and can be read out via Parameter *Actual Value System* **242** , i. e. *Actual Frequency* **241** x *Factor Actual Value System* **389** = *Actual Value System* **242**.

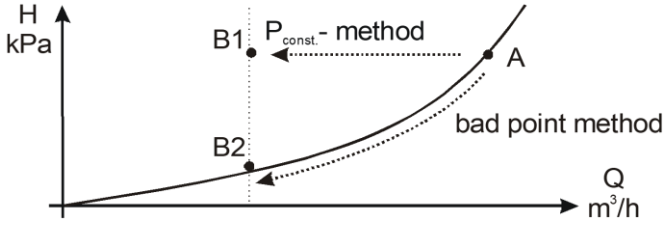
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
389	Factor Actual Value System	-100.000	100.000	1.000

12.2 Volume Flow and Pressure

Parameterization of factors *Nominal Volumetric Flow* **397** and *Nominal Pressure* **398** is necessary if the matching actual values *Volumetric Flow* **285** and *Pressure* **286** are used for drive monitoring. The conversion is done using the electrical control parameters.
Volumetric Flow **285** and *Pressure* **286** are referred to *Active Current* **214** in the case of sensor-less control methods. In the case of the field-oriented control methods, they are referred to the torque-forming current component *Isq* **216**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
397	Nominal Volumetric Flow	1 m^3/h	99999 m^3/h	10 m^3/h
398	Nominal pressure	0.1 kPa	999.9 kPa	100.0 kPa

Line mains or channel characteristic:



Point A in the figure describes the rating point of a pump. The transition to partial load operation mode `B1` can be effected at a constant pressure H (change of conveying flow Q, pressure H remains constant). The transition to partial load operation mode `B2` can be effected according to the bad point method (change of pressure H and conveying flow Q). Both methods can be realized with the integrated technology controller in configurations `111`, `211`, `411` and `611`. The actual values displayed are calculated according to the bad point method independently of the selected *Operation Mode* **440** of the technology controller.

13 Operating behavior

The operational behavior of the frequency inverter can be adjusted to the application by setting the parameters appropriately. In particular the acceleration and deceleration behavior can be selected according to the selected *Configuration* **30**. Additionally, features such as Auto Start, and the synchronization and positioning functions facilitate the integration in the application.

13.1 Starting behavior

The start of the 3-phase machine can be parameterized in accordance with the control functions and methods. In contrast to the sensorless control method, the field-oriented control methods only require the definition of the limit values *Max. Flux-Formation Time* **780** and *Current during Flux-Formation* **781** for the adjustment of the acceleration behavior. The acceleration behavior of the sensorless control method in configurations `110` and `111` can be selected as described in the following chapter.

13.1.1 Starting Behavior of Sensorless Control System

Parameter *Operation Mode* **620** for the starting behavior is available in Configurations `110` and `111`. Depending on the operation mode selected, the machine is magnetized first or a starting current is impressed. The voltage drop across the stator resistance which reduces the torque in the lower frequency range can be compensated by the IxR compensation.
To ensure the correct function of the IxR compensation, the stator resistance is determined during the guided commissioning. The IxR compensation is only activated when the stator resistance was determined correctly.

Operation Mode 620	Starting behavior
0 - off	During startup, at an output frequency of 0 Hz, the voltage is set via parameter *Starting Voltage* **600**. After this, the output voltage and the output frequency are changed according to the control method. The break-away torque and the current at the start is determined by the adjusted starting voltage. It may be necessary to optimize the starting behavior via the parameter *Starting Voltage* **600**.
1 - Magnetization	In this operation mode, the *Current during Flux-Formation* **781** for magnetization is impressed into the motor after release. The output frequency is kept at 0 Hz for the *Max. Flux-Formation Time* **780**. After this time has expired, the output frequency follows the adjusted V/f characteristic. (see operation mode 0- Off)
2 - Magnetisation+Current Impr.	Operation mode `2` includes operation mode `1`. Once the *Max. Flux-Formation Time780* **has** elapsed, the output frequency is increased according to the set acceleration. If the output frequency reaches the value set with the parameter *Frequency Limit* **624** the *Starting Current* **623** is withdrawn. There is a smooth transition to 1.4 times the frequency limit to the set V/f characteristic. As from this operating point, the output current depends on the load.
3 - Magnetization +IxR compensation	Operation mode `3` includes operation mode `1` of the start function. When the output frequency reaches the value set with parameter *Frequency Limit* **624**, the increase of the output voltage by the IxR compensation becomes effective. The V/f characteristic is displaced by the portion of voltage which depends on the stator resistance.
4 - Magnetization +current impr.+I*R-Comp.	In this operation mode, the current set with the parameter *Current during Flux-Formation* **781** is impressed into the motor for magnetization after release. The output frequency is kept at `0` Hz for the *Max. Flux-Formation Time* **780**. Once this time has elapsed, the output frequency is increased according to the set acceleration. Once the output frequency reaches the value set with parameter *Frequency Limit* **624**, the *Starting Current* **623** is withdrawn. There is a smooth transition to the V/f characteristic, and a load-dependent output current is obtained. At the same time, the increase of the output voltage by the IxR compensation becomes effective as from this output frequency. The V/f characteristic is displaced by the portion of voltage which depends on the stator resistance.

Operation Mode 620	Starting behavior
12 - Magn.+ Curr.ImP. w. Ramp Stop	Operation mode 12 contains an additional function to guarantee a starting behavior under difficult conditions. The magnetization and starting current impression are done according to operation mode 2. The ramp stop takes the current consumption of the motor at the corresponding operating point into account and controls the frequency and voltage change by stopping the ramp. The *Controller Status* **275** signals intervention of the controller by displaying message "RSTP".
14 - Magn.+ Curr.ImP. w. RS.+ I*R-Comp.	In this operation mode, the functions of operation mode 12 are extended by the compensation of the voltage drop across the stator resistance. When the output frequency reaches the value set with parameter *Frequency Limit* **624**, the increase of the output voltage by the IxR compensation becomes effective. The V/f characteristic is displaced by the portion of voltage which depends on the stator resistance.

In contrast to field-oriented control systems, sensorless control systems feature a current controller which controls the starting behavior. The PI controller controls the current impress of parameter *Starting Current* **623**. The proportional and integrating part of the current controller can be set via parameters *Amplification* **621** and *Integral Time* **622**. The control functions can be deactivated by setting the parameters to 0.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
621	Amplification	0.01	10.00	1.00
622	Integral Time	1 ms	30 000 ms	50 ms

13.1.1.1 Starting current

The *Starting Current* **623** ensures, particularly for high-torque start, a sufficient torque until the *Frequency Limit* **624** is reached.

Applications in which high current is permanently needed at a low speed are to be realized using forced-ventilated motors to prevent thermal overload.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
623	Starting current	0.0 A	$o \cdot I_{FIN}$	I_{FIN}

I_{FIN} = Rated frequency inverter output current
o: Overload capacity of frequency inverter.

In the following settings, the starting current injection is used for the starting behavior:

- *Configuration* **30** = 1xx (V/f control of asynchronous motor),
  Operation mode **620** =2, 4, 12 or 14
- *Configuration* **30**= 4xx (FOC of an asynchronous motor)
- *Configuration* **30**= 610 (PMSM: sensor-less field-oriented control -DMC), synchronous motor
- *Configuration* **30**= 310 Speed Control (sensorless), Synchronous reluctance machine (SRM)
- *Configuration* **30**= 330 Switchable Speed and torque control (sensorless), Synchronous reluctance machine (SRM)

13.1.1.2 Frequency Limit

The *Starting Current* **623** is impressed in configurations 1xx, 3xx, 4xx and 6xx for control of the relevant configuration until the *Frequency Limit* **624** is reached. Permanent operating points below the frequency limit are only permissible if forced-ventilated motors are used.

The transition to the control method of the selected *Configuration* **30** takes place above the frequency limit.

The *Frequency Limit* **624** is set automatically during guided motor commissioning in the field-oriented configurations 3xx, 4xx and 6xx. In V/f control configuration 1xx, parameter *Frequency Limit* **624** is not changed during guided motor commissioning.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
624	Frequency Limit	0.00 Hz	100.00 Hz	2.60 Hz

13.1.1.3 Brake release time

In order to protect the motor holding brake against damage, the motor may only start after the brake has been released. Startup to reference speed is effected only after the *Brake Release Time* **625** has elapsed. The time should be set such that it is at least as long as the time required for releasing the holding brake. By using negative values for the parameter, release of the brake is delayed. This can be done in order to prevent loads from falling down, for example.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
625	Brake Release Time	-5000 ms	5000 ms	0 ms

13.1.2 Flux formation

Field-oriented control in the configurations `2xx` and `4xx` are based on separate regulation of the flux-forming and torque-forming current components. Upon startup, the machine is magnetized and a current is impressed first. With parameter *Current during Flux-Formation* **781**, the magnetization current I_{sd} is set. With parameter *Max. Flux-Formation Time* **780** the maximum current impression time is set. The current impression is done until the reference value of the rated magnetizing current is reached or the *Max. Flux-Formation Time* **780** is exceeded.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
780	Max. Flux-Formation Time	1 ms	10000 ms	300 ms **1)** 1000 ms **2)** 50 ms **3)**
781	Current during flux formation	$0.1 \cdot I_{FIN}$	$o \cdot I_{FIN}$	I_{FIN}

The factory setting of parameter *Max. Flux-Formation Time* **780** depends on parameter *Configuration* **30**:
1) Configurations 1xx
2) Configurations 2xx/4xx
3) Configurations 6xx

The magnetizing current changes according to the rotor time constant of the motor. By setting the parameters *Max. Flux-Formation Time* **780** and *Min. Flux-Formation Time* **779** a constant flux formation time can be achieved. With parameter *Min. Flux-Formation Time* **779** the minimum time for flux-forming current can be set. This enables a defined time between start signal and run-up of the drive. For an optimum setting of the parameters the rotor time constant, the required starting torque and *Current during Flux-Formation* **781** have to be considered.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
779	Minimum flux formation time	1 ms	10000 ms	10 ms 1) 50 ms 2)

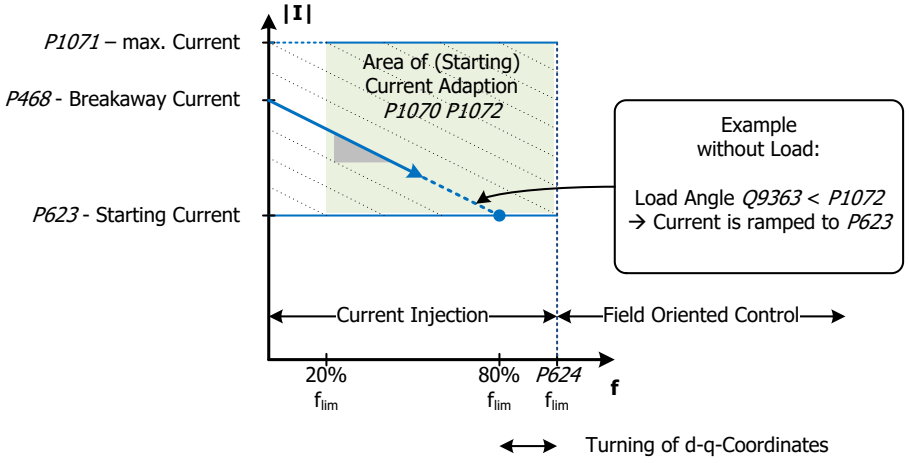
The factory setting of parameter *Min. Flux-Formation Time* **779** depends on parameter *Configuration* **30**:
1) Configurations 2xx/4xx
2) Configurations 6xx

Min. Flux-Formation Time **779** = 0	Flux formation is stopped as soon – as the reference flux value or the – maximum flux formation time were reached
Min. Flux-Formation Time **779** > 0	Current is impressed for flux formation at least for this time even if the reference flux value was reached.
Min. Flux-Formation Time **779** = *Max. Flux-Formation Time* **780**	Flux formation is stopped after the set flux formation time, regardless of whether the reference flux value was reached or not.
Min. Flux-Formation Time **779** > *Max. Flux-Formation Time* **780**	Flux formation is stopped after the maximum flux formation time.

13.1.3 Starting behavior for the SynRM

The following parameters are relevant for the starting behavior of the synchronous reluctance machine:

Parameter	
No.	**Description**
1029	Operation mode starting behavior
468	Breakaway current
1050	Maximum time at f < f_{limit}
1071	Maximum current of current injection



Operation mode starting behaviour **1029**
1 - Current injection

The parameter identification sets the values for each

- *Starting current* **623**,
- *Breakaway current* **468**,
- *Current during flux-formation* **781**,
- *Maximum current of current injection* **1071** = 1.2 * **P.371** and
- *Holding Current* **1008**

to the value of the *Rated magnetizing current* **716**. Depending on the application (required torque at low frequency) these values must be increased.

For startup in sensorless control mode three options are possible:

1 Start with current injection (standard)
2 Start with field oriented control
Only possible at fast ramps

***Starting current* 623**

See chapter 13.1.1.1 Starting current. The starting current value should be within the range of the *Rated magnetizing current* **716** and *Rated current* **371**.

***Breakaway current* 468**

To provide extra torque at zero speed the amplitude of the injected current vector can be increased by setting a current value in **P.468**.

The amplitude of the current vector is reduced to the value set in *Starting Current* **623** when the *Frequency Limit* **624** is reached and if no load is detected.

High values (> I_N) set in **P.468** will lead to poor starting performance at no load.

- Set **P.468** not higher than needed if the start at no load is required.

If higher starting torque is required, set the **P.468** to higher current values (e. g. 150% of I_N) and also adapt **P.1071** (**P.468** is limited by **P.1071**, *Maximum Current of Current Injection*) after parameter identification process during setup.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
468	Breakaway current	xx A	I_{FUmax}	P.716

***maximum time at f < flimit* 1050**

The parameter **P.1050** is relevant if transition between current injection (or any other starting method) and field oriented control is critical, i.e. at fast stop ramps.

P.1050 defines the time, during which the drive can be operated in the sensorless FOC mode below the *Frequency limit* **624**. If the ramp is steep enough to cause the rated frequency to reach the frequency limit during this time, the drive shifts to FOC immediately without current injection.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
1050	maximum time at f < flimit	0.000 s	4.000 s	0.300 s

***Maximum Current of Current Injection* 1071**

(= 120 % * **P.371**)

The parameter **1071** defines the upper limit of current adaption for the case where a load-dependent starting current increase is made.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
1071	Maximum Current of Current Injection	0.00 A	I_{max}	1.2 * I_n

The parameter **1035** defines the upper limit for the hf-current as related to the rated current of the machine. The default value 8 % produces a good enough ratio of performance and acoustic noise in the most cases. The value can be reduced to reduce the acoustic noise level.

13.2 Stopping behavior

The stopping behavior of the three-phase machine can be defined via parameter *Operation Mode* **630**. The signal states of the digital inputs or logic signals for parameters *Start Clockwise* **68** and *Start Anticlockwise* **69** will activate stopping procedure. Depending on the setting for *Configuration* **30**, digital inputs or logic signals must be assigned to these parameters or were already set in the factory. By combining the digital input states or logic signals, the stopping behaviors can be selected from the following table.

Stopping behavior									
Operation Mode **630**		**Start clockwise = 0 and Start anticlockwise = 0**							
		Stopping behavior 0	Stopping behavior 1	Stopping behavior 2	Stopping behavior 3	Stopping behavior 4	Stopping behavior 5	Stopping behavior 6	Stopping behavior 7
Start clockwise = 1 and Start anticlockwise = 1	Stopping behavior 0 (Coasting)	0	1	2	3	4	5	6	7
	Stopping behavior 1 (Shutdown and switch off)	10	11	12	13	14	15	16	17
	Stopping behavior 2 (Shut-down and hold)	20	21	22	23	24	25	26	27
	Stopping behavior 3 (Shut-down and DC brakes	30	31	32	33	34	35	36	37
	Stopping behavior 4 (Emergency stop and switch off)	40	41	42	43	44	45	46	47
	Stopping behavior 5 (Emergency stop and hold)	50	51	52	53	54	55	56	57

Stopping behavior									
	Stopping behavior 6 (Emergency stop and DC brakes)	60	61	62	63	64	65	66	67
	Stopping behavior 7 (DC brakes)	70	71	72	73	74	75	76	77

Operation Mode **630** of the stopping behavior is to be parameterized according to the matrix. The selection of the operation modes can vary according to the control method and the available control inputs.

Example: The machine is to stop according to stopping behavior 2 if the digital logic signals *Start Clockwise* **68** = 0 and *Start Anticlockwise* **69** = 0.

Additionally, the machine is to stop according to stopping behavior 1 if the digital logic signals *Start Clockwise* **68** = 1 and *Start Anticlockwise* **69** = 1.

To achieve this, parameter *Operation Mode* **630** must be set to 12.

By selecting the stopping behavior you also select the control of a mechanical brake if operation mode „41 - Brake release" is used for one digital output for controlling the brake.

Stopping behavior	
Stopping behavior Coast to stop	The inverter is disabled immediately. The drive deenergized immediately and coasts freely.
Stopping behavior 1 **Stop + off**	The drive is brought to a standstill at the set deceleration. As soon as the drive is at a standstill, the inverter is disabled after a after a holding time. The holding time can be set via parameter *Holding Time* **638**. Depending on the setting of parameter *Starting Function* **620**, the *Starting Current* **623** will be impressed or the *Starting Voltage* **600** will be applied.
Stopping behavior 2 **Stop + Hold**	The drive is brought to a standstill at the set deceleration and remains permanently supplied with current. Depending on the setting of parameter *Starting Function* **620**, the *Starting Current* **623** will be impressed as from standstill, or the *Starting Voltage* **600** will be applied. In Configurations 2xx, the magnetizing current is used instead of the *Starting Current* **623**. The magnetizing current results from *the Rated Magnetising Current* **716** and *Reduction Factor Flux* **778**.
Stopping behavior 3 **Stop + DC brakes**	The drive is brought to a standstill at the set deceleration. As from standstill, the DC set via parameter *Braking Current* **631** is impressed for the *Braking Time* **632**. Comply with the notes in chapter "Direct current brake". Stopping behaviors 3, 6 and 7 are only available in the configurations of sensor-less V/f control (1xx).
Stopping behavior 4 **emergency stop + off**	The drive is brought to a standstill at the emergency stop deceleration. As soon as the drive is at a standstill, the inverter is disabled after a after a holding time. The holding time can be set via parameter *Holding Time* **638**. Depending on the setting of parameter *Starting Function* **620**, the *Starting Current* **623** will be impressed or the *Starting Voltage* **600** will be applied as from standstill.
Stopping behavior 5 **Emergency stop + hold**	The drive is brought to a standstill at the emergency stop deceleration and remains permanently supplied with current. Depending on the setting of parameter *Starting Function* **620**, the *Starting Current* **623** will be impressed or the *Starting Voltage* **600** will be applied as from standstill.
Stopping behavior 6 **Emergency stop + DC brakes**	The drive is brought to a standstill at the set emergency stop deceleration. As from standstill, the DC set via parameter *Braking Current* **631** is impressed for the *Braking Time* **632**. Comply with the notes in chapter "Direct current brake". Stopping behaviors 3, 6 and 7 are only available in the configurations of sensor-less V/f control (1xx).
Stopping behavior 7 **DC brake**	DC braking is activated immediately. The direct current set with the parameter *Braking Current* **631** is impressed for the *Braking Time* **632**. Comply with the notes in chapter "Direct current brake". Stopping behaviors 3, 6 and 7 are only available in the configurations of sensor-less V/f control (1xx).

Please refer to Chapter 16.3.5 "Brake release" for information on mechanical brake control.

If a synchronous motor is connected, Bonfiglioli Vectron GmbH recommends setting *Operation Mode* **630** = 22.

13.2.1 Switch-Off Threshold

NOTICE

Switch-off threshold too low

If the motor builds up a stopping torque, the switch-off threshold stop function may not be reached due to the slip frequency and the standstill of the drive is not recognized.

- In this case, increase the value of the *Switch-off threshold stop function* **637**.

The *Switch-Off Threshold.* **637** defines the frequency as from which a standstill of the drive is recognized. This percentage parameter value is relative to the set *Maximum Frequency* **419**.
The switch-off threshold is to be adjusted according to the load behavior of the drive and the device output, as the drive must be controlled to a speed below the switch-off threshold.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
637	Switch-Off Threshold	0.0 %	100.0 %	1.0 %

13.2.2 Holding Time

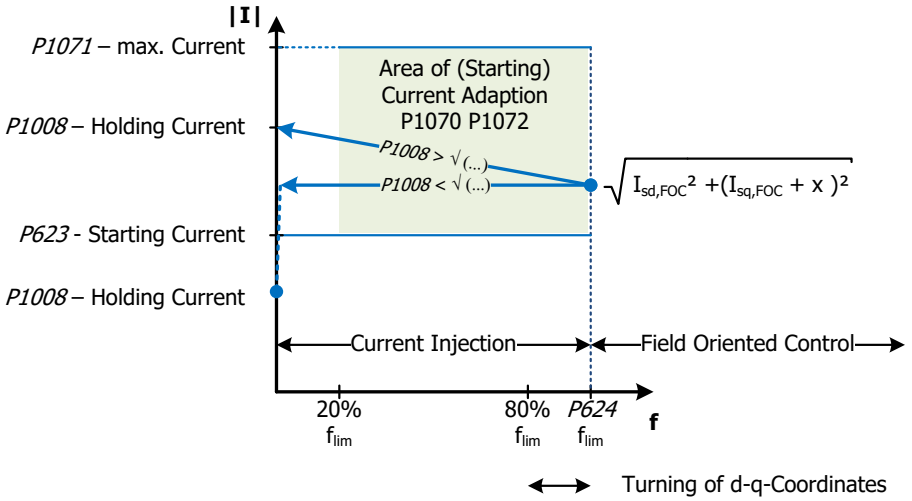
The *Holding Time* **638** is considered in stopping behavior 1, 3, 4 and 6. Control to Zero speed results in the motor heating up and should only be done for a shor t period in the case of internally ventilated motors.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
638	Holding time stop function	0.0 s	200.0 s	1.0 s

13.2.3 Stopping behavior for the SynRM

The following parameters are relevant for the stopping behavior of the synchronous reluctance machine:

Parameter	
No.	**Description**
1008	Holding current



In the ramp down phase the value for the current injection is adjusted to the value set in the parameter *Holding current* **1008**. This current value is held constant until the output stages are switched off.

13.2.4 Direct current brake

Stopping behaviors 3, 6, 7 and the search run function include the direct current brake. Depending on the setting of the stop function, a direct current is impressed into the motor either directly or, when it is at a standstill, after the demagnetization time. The impression of the *Braking Current* **631** results in the motor heating up and should only be done for a short period in the case of internally ventilated motors.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
631	Braking current	0.00 A	$\sqrt{2}\cdot I_{FIN}$	$\sqrt{2}\cdot I_{FIN}$

I_{FIN}: Rated value of frequency inverter

The setting of the parameter *Braking Time* **632** defines the time-controlled stopping behavior. Contact-controlled operation of the direct current brake is activated by entering the value zero for the *Braking Time* **632.**

Time controlled:

The direct current is controlled by the status of the signals Start clockwise and Start anticlockwise. The current set by the parameter *Braking Current* **631** flows until the time set by the parameter *Braking Time* **632** has elapsed.

For the duration of the braking time, the control signals Start clockwise and Start anticlockwise are logical 0 (Low) or 1 (High).

Contact-controlled:

If parameter *Braking Time* **632** is set to the value 0.0 s, the direct current brake is controlled by the Start clockwise and Start anticlockwise signals. The time monitoring and limitation by *Braking Time* **632** are deactivated. The braking current will be impressed until the controller enable control signal (S1IND/STOA and S7IND/STOB) becomes logical 0 (low).

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
632	Braking time	0.0 s	200.0 s	10.0 s

To avoid current surges, which can possibly lead to an error switch-off of the frequency inverter, a direct current may only be impressed into the motor after the motor has been demagnetized. As the demagnetization time depends on the motor used, it can be set with the parameter *Demagnetizing Time* **633**.

The selected demagnetizing time should be approximately three times the *Act. Rotor Time Constant* **227.**

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
633	Demagnetizing time	0.1 s	30.0 s	5.0 s

The selected stopping behavior is supplemented by a current controller to control the direct current brake. The compensated proportional regulator controls the current impression of the parameterized *Braking Current* **631**. The proportional and integrating part of the current controller can be set via parameters *Amplification* **634** and *Integral Time* **635**. The control functions can be deactivated by setting the parameters to 0.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
634	Amplification	0.00	10.00	1.00
635	Integral Time	0 ms	1000 ms	50 ms

13.3 Auto start

WARNING

Risk due to moving parts

Due to an active autostart function portions of the system can start moving unexpectedly. This may lead to injuries or to system damage.

- Comply with VDE provision 0100 part 227 and provision 0113, in particular Sections 5.4, protection against automatic after main line voltage failure and voltage recovery, and Section 5.5 "Undervoltage protection".

  Appropriate measures must be taken to exclude any risk for staff, machines and production goods.
- In addition to that, all specific regulations relevant to the application as well all national directives are to be complied with.
- When the Autostart function is activated, the operator, in accordance with DIN EN 61800-5-1, shall provide a clear warning/sign in the plant, indicating automatic restart.

The auto start function is suitable for applications which permit a start at mains voltage by their function. By activation of the auto-start function via parameter *Operation Mode* **651,** the frequency inverter accelerates the drive after application of the mains voltage. Control signals STOA and STOB for release and the start command are required as per the regulations. When the motor is switched on, it is accelerated according to the parameterization and the reference value signal.

Operation Mode 651	Function
0 - off	No auto start. The drive is accelerated, after application of the mains voltage, as soon as the release and the start command are present (edge based).
1 - On	The drive is accelerated by the frequency inverter as soon as the mains voltage is applied (level based).

13.4 Search run

The synchronization to a rotating drive is necessary in applications which drive the motor by their behavior or in which the drive is still rotating after an error switch-off. Via *Operation Mode Search Run* **645**, the motor speed is synchronized to the current motor speed without an "Overcurrent" error signal. After this, the motor is accelerated to the reference speed at the set acceleration. This synchronization function determines the current rotary frequency of the drive via a search run in operation modes `1` to `5`.

The synchronization in operation modes `10` to `15` is accelerated by short test impulses. Torsional frequencies up to 175 Hz are determined within 100 ms to 300 ms. For higher frequencies, a wrong frequency is determined and the synchronization fails. In the "`Quick synchronization`" operation modes, the search run cannot determine whether an synchronization attempt has failed.

For operation of a synchronous motor, the flux direction can be determined in order to prevent alignment of the motor shaft (jerking) during start-uP. Determining the flux direction takes approx. 20 ms. In this process, there are short torque pulses. This method is not suitable for very dynamic drives since the torque pulses result in a rotation of the drive and consequently in wrong measurements. Once the flux direction has been determines, the flux is built up (parameters *Min. Flux-Formation Time* **779**, *Max. Flux-Formation Time* **780**, *Current during Flux-Formation* **781**) in order to improve the starting behavior.

Operation Mode 645	Function
0 - off	The synchronization to a rotating drive is deactivated.
1 - Search Dir. acc. to Preset Val., DCB	The search direction is defined by the sign of the setpoint. If a positive setpoint (clockwise field of rotation) is entered, the search is in a positive direction (clockwise field of rotation), with a negative setpoint, the search is in a negative direction (anticlockwise field of rotation).
2 - First clockw.then anticlockw.,DCB	The first attempt is to synchronize to the drive in positive direction (clockwise field of rotation). If this attempt fails, it is tried to synchronize to the drive in negative direction (anticlockwise field of rotation).

3 - First anticlockw.then clockw.,DCB	The first attempt is to synchronize to the drive in negative direction (anticlockwise field of rotation). If this attempt fails, it is tried to synchronize to the drive in positive direction (clockwise field of rotation).
4 - Clockw. only,DCB	Synchronization to the drive is only done in positive direction (clockwise field of rotation).
5 - Anticlockw. only,DCB	Synchronization to the drive is only done in negative direction (anticlockwise field of rotation).
10 - Quick Synchronisation	An attempt is made to synchronize to the drive in positive direction (clockwise field of rotation) and in negative direction (anticlockwise field of rotation).
11 - Quick Synch. acc. to Preset Value	The search direction is defined by the sign of the setpoint. If a positive setpoint (clockwise field of rotation) is entered, the search is in a positive direction (clockwise field of rotation), with a negative setpoint, the search is in a negative direction (anticlockwise field of rotation).
14 - Quick Sync., Clockwise Only	Synchronization to the drive is only done in positive direction (clockwise field of rotation).
15 - Quick Sync., Anti-clockwise Only	Synchronization to the drive is only done in negative direction (anticlockwise field of rotation).

Operation modes 1, 4 and 5 define a direction of rotation for the search run and avoid a deviating direction. The search run can accelerate drives by checking the rotary frequency if the drives have a low moment of inertia and/or a small load moment.

In operation modes 10 to 15, it cannot be ruled out that a wrong direction of rotation is determined in quick synchronization. For example, a frequency not equal to zero may be determined although the drive is at a standstill. If there is no overcurrent, the drive is accelerated accordingly. The direction of rotation is defined in operation modes 11, 14 and 15.

The synchronization changes the parameterized starting behavior of the selected configuration. First, the start command activates the search run in order to determine the rotary frequency of the drive. In operation modes 1 to 5, the *Current / Rated Motor Current* **647** is used for synchronization as a percentage of *Rated Current* **371**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
647	Current / Rated Motor Current	1.00 %	100.00 %	70.00 %

The sensorless control is extended for the search run by a compensated proportional regulator, which regulates the parameterized *Current / Rated Motor Current* **647**. The proportional and integrating part of the current controller can be set via parameters *Amplification* **648** and *Integral Time* **649**. The control functions can be deactivated by setting the parameters to 0.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
648	Amplification	0.00	10.00	1.00
649	Integral Time	0 ms	1000 ms	20 ms

If the *Operation Mode Synchronisation* **645** parameter was set to operation mode 1 to 5 (search run), the search run is not started before the *Demagnetizing Time* **633** has elapsed.

If synchronization to the drive mechanism is not possible, the *Braking Current* **631** is impressed into the motor in operation modes 1 to 5 for the duration of the *Brak. Time after Search Run* **646**. The impression of the direct current set in the parameters of the direct current brake leads to a heating of the motor and should only be done for a short period in internally ventilated motors

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
646	Brak. time after search run	0.0 s	200.0 s	10.0 s

The search run function is designed for operation with motors without brake. Brake motors my not be operated perfectly with the search run function (depending on parameterization and brake control.

13.5 Positioning

Positioning is done in operation mode "Reference positioning" via the definition of the positioning distance or in operation mode "Axis positioning" via the definition of the position angle.
Reference positioning uses a digital reference signal from a selectable signal source for positioning the drive independent of the speed.
Axis positioning uses a digital reference signal from a speed sensor.
The function "Reference positioning" is available in configurations 110, 210, 410, 510 and 610 and is activated by selecting operation mode 1 for parameter *Operation Mode* **458** .
The function "Axis positioning" is available in configurations 210 and 510 (Parameter *Configuration* **30**) and is activated by selecting operation mode 2 for parameter *Operation Mode* **458**.

Operation Mode 458	Function
0 - off	Positioning switched off.
1 - Reference positioning	Positioning from reference point via definition of positioning distance (rotations). The reference point is acquired via a *Signal source* **459** Available in configurations 110, 210, 410, 510, 610.
2 - Axle Positioning	Reference positioning via definition of the positioning angle, reference signal from speed sensor Available in configurations 210, 510.

13.5.1 Reference Positioning

The feedback of the current position is referred to the revolutions of the motors relative to the time of the reference signal. The accuracy of the positioning for the application to be realized is dependent on the current *Actual Frequency* **241**, *Deceleration (Clockwise)* **421**, the *No. of Pole Pairs* **373**, the selected *Positioning distance* **460** and the parameterized control behavior.
The distance between the reference point and the required position is to be defined in motor revolutions. The calculation of the distance covered is done with the selected *Positioning distance* **460** according to the application.
The setting 0.000 U for *Positioning distance* **460** causes an immediate stop of the drive according to the selected stopping behavior for *Operation Mode* **630**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
460	Positioning distance	0.000 U	1000000.000 U	0.000 U

The actual value parameter *Rotations* **470**facilitates the setting and optimization of the function. The revolutions of the motor displayed should correspond to the *Positioning distance* **460** at the required position.
The minimum number of revolutions needed until the required position is reached depends on the *Actual Frequency* **241** and *Deceleration (Clockwise)* **421** (or *Deceleration Anticlockwise* **423**) as well as the *No. of Pole Pairs* **373** of the motor.

$$U_{min} = \frac{f^2}{2 \cdot a \cdot p}$$

U_{min} = min. number of rotations
f = *Actual Frequency* **241**
a = *Deceleration* **421 (423)**
p = *No. of Pole Pairs* **373** of motor

Example:
f = 20 Hz, a = 5 Hz/s, p = 2 $\Rightarrow U_{min} = 20$
With an actual frequency of 20 Hz and a delay of 5 Hz/s, at least 20 rotations are needed until standstill at the required position. This is the minimum value for the *Positioning distance* **460**, a shorter positioning distance is not possible. If the number of rotations until the required position is reached is to be lower, the frequency must be reduced, the deceleration increased, or the reference point must be shifted.
The digital signal for registration of the reference point and the logical assignment are to be chosen from a selection of *Signal source* **459**. The link of the digital inputs S2IND, S3IND and S6IND to further functions is to be checked according to selected *Configuration* **30** (e. g. in configurations 110 and 210, digital input S2IND is linked to the function "Start of clockwise operation").
The signals for positioning and a stopping behavior should not be assigned to the same digital input.

Signal source 459	Function
2 - S2IND, neg. edge	The positioning starts with the change of the logic signal from 1 (HIGH) to 0 (LOW) at the reference point.
3 - S3IND, neg. edge	
6 - S6IND, neg. edge	
1x - SxIND, pos. edge	The positioning starts with the change of the logic signal from 0 (LOW) to 1 (HIGH)
2x - SxIND, pos./neg. edge	The positioning begins with the change of the logic signal

The registration of the reference position via a digital signal can be influenced by a variable dead time while the control command is read and processed. The signal running time is compensated by a positive figure for the *Signal correction* **461**. The setting of a negative signal correction decelerates the processing of the digital signal.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
461	Signal correction	-327.68 ms	+327.67 ms	0.00 ms

The influences on the positioning which depend on the operating point can be corrected empirically via *the Load correction* **462** parameter. If the required position is not reached, the deceleration duration is increased by a positive load correction value. The distance between the reference point and the required position is extended. Negative values accelerate the braking process and reduce the positioning distance. The limit of the negative signal correction results from the application and the *Positioning distance* **460**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
462	Load correction	-32768	+32767	0

The behavior of the positioning after the required position of the drive is reached can be defined via the *Activity after positioning* **463** parameter.

Activity after positioning 463	Function
0 - End of positioning	The drive is stopped with the stopping behavior of *Operation Mode* **630**.
1 - Wait for positioning signal	The drive is stopped until the next signal edge; with a new edge of the position signal, it is accelerated in the previous direction of rotation.
2 - Reversal by new edge	The drive is held until the next signal edge; with a new edge of the position signal, it is accelerated in the opposite direction of rotation.
3 - Positioning; off	The drive is stopped and the power output stage of the inverter is switched off.
4 - Start by time control	The drive is stopped for the *Time to wait* **464**; after the waiting time, it is accelerated in the previous direction of rotation.
5 - Reversal by time control	The drive is held for the *Time to wait* **464**; after the waiting time, it is accelerated in the opposite direction of rotation.

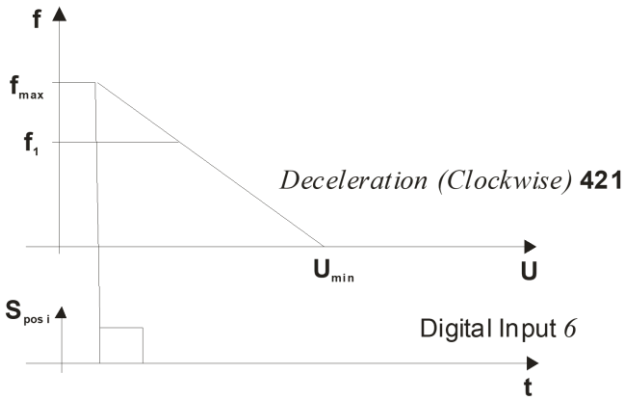
The position reached can be maintained for the *Time to wait* **464**, then the drive is accelerated according to operation mode `4` or `5`.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
464	Delay	0 ms	3600000 ms	0 ms

Positioning, Operation Mode 458 = 1

The diagram shows how the positioning to the set positioning distance is carried out. The positioning distance remains constant at different frequency values. At the reference point, the position signal S_{Posi} is generated. Starting from frequency f_{max} the positioning is effected at the set *Deceleration (Clockwise)* **421** . At a lower frequency value f_1, the frequency remains constant for some time before the drive is stopped at the set deceleration.

If, during acceleration or deceleration of the machine, positioning is started by the signal S_{Posi}, the frequency at the time of the positioning signal is maintained.



Examples of reference positioning as a function of the parameter settings selected.
The reference point is registered according to parameter *Signal source* **459** in operation mode `16-S6IND`, pos. edge by a signal on digital input 6.
The *Positioning distance* **460** with parameter value `0.000 U` (default) defines a direct stop of the drive with the deceleration behavior selected in parameter *Operation Mode* **630**, and the set *Deceleration (Clockwise)* **421.** If a *Positioning distance* **460** is set, positioning is done at the set deceleration.
The *Signal correction* **461 of** the signal run time from the measurement point to the frequency inverter is not used if it is set to `0 ms`.
The *Load correction* **462** can compensate a faulty positioning by the load behavior. By default, this function is deactivated, i.e. set to `0`.
The *Activity after positioning* **463 is** defined by operation mode `0-End positioning`.
The *Time to wait* **464** is not considered because operation mode `0` is selected for parameter *Activity after positioning* **463.**
The actual value *Rotations* **470** enables a direct comparison with the required *Positioning distance* **460.** In the case of deviations, a *Signal correction* **461** or *Load correction* **462** can be performed.

13.5.2 Axle Positioning

For axle positioning, a speed feedback system is required. In most cases, an additional extension module is required for evaluation. The operation mode for parameter *Operation Mode Speed Sensor 2* **493** is to be set to `1004` or `1104`. For information on how to set the parameter, refer to the instructions on the optional extension module. The positioning is started if a start signal is received and the frequency drops below an adjustable frequency limit. The machine stops with the selected stopping behavior at the entered position angle.
To ensure the correct function of the axis positioning, the speed controller should be optimized after the guided commissioning. This is described in chapter "Speed controller".
Via parameter *Reference orientation* **469**, the angle between the reference point and the required position is entered.
If this value is changed while the machine is at a standstill, the positioning operation is carried out again at a frequency of 0.5 Hz. For this, a stopping behavior must be selected for the parameter *Operation Mode* **630** which impresses a starting current either permanently when the drive is at a standstill or for the stopping time (refer to chapter 13.1.3).

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
469	Reference orientation	0.0°	359.9°	0.0°

WARNING

Personal injury or material damage possible

During the positioning operation, the direction of rotation of the drive may change, regardless of whether the command `Start clockwise` or `Start anticlockwise` was activated.

- Make sure that the change of the direction of rotation cannot result in any personal or material damage.

The positioning is started by a start command from a signal source (e. g. digital input), which must be assigned to parameter *Start Positioning of Axle* **37**. The signal source can be selected from the operation modes for digital inputs described in chapter "16.4".
The positioning starts on condition that the *Actual Frequency* **241** of the output signal is smaller than the value entered in parameter *Positioning Frequency* **471**. Due to a stopping behavior, the actual frequency drops below the positioning frequency.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
471	Positioning Frequency	1.00 Hz	50.00 Hz	50.00 Hz

Via parameter *Max. positional error* **472**, the permissible max. deviation from the *Reference orientation* **469** can be set.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
472	Max positional error	0.1°	90.0°	3.0°

Via parameter *time constant positioning contr.* **479**, the time constant for controlling the positional error can be set. The value of the time constant should be increased if oscillations of the drive around the reference orientation occur during the positioning.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
479	time constant positioning contr.	1.00 ms	9999.99 ms	20.00 ms

To make sure that the set position is maintained if a load torque is applied, a stopping behavior should be selected for parameter *Operation Mode* **630** which impresses a starting current either permanently when the drive is at a standstill or for the stopping time.
The status message "60-Target Position Reached" which is displayed when the reference orientation is reached can be assigned to a digital output. The message is output on the following conditions:

- Operation Mode 2 (axle positioning) for parameter *Operation Mode* **458 is** selected.
- The controller enable signal at digital inputs S1IND/STOA and S7IND/STOB is switched on.
- *Enable axis positioning* **37** is activated.
- The speed sensor monitoring is activated, i. e. operation mode 2 (error message) is selected for parameter *Operation Mode* **760 .**
- Operation mode 1004 or 1104 (quadruple evaluation with reference impulse) is selected for the speed sensor input.
- The *Actual Frequency* **241** is smaller than Hz.
- The deviation of the current position from the reference orientation is smaller than the *Max. positional error* **472**.

The current position after *Start Positioning of Axle* **37** is recognized by the frequency inverter as follows:
During commissioning, after switching on the frequency inverter, a search mode is performed for 3 rotations at a rotational frequency of 1 Hz in order to detect the reference signal. As soon as the reference signal was recognized twice, the drive is positioned to the *Reference orientation* **469**.
When a resolver is used, search mode will not be used during commissioning.
If the motor was already rotating before axis positioning was enabled, the positioning to the *Reference orientation* **469** is performed without search mode because the position of the reference point was already detected by the frequency inverter.
If the positioning is carried out, after controller enabling and start command, when the motor is at a standstill:

The motor is positioned clockwise to the reference orientation if the value for the reference orientation is higher than the value adjusted before.
The motor is positioned anticlockwise to the reference orientation if the value for the reference orientation is smaller than the value adjusted before.
The sense of rotation during the positioning is independent of whether `Start Clockwise` or `Start Anticlockwise` was activated.
The time required until the reference orientation is reached depends on:

- Actual Frequency
- Frequency ramp for deceleration
- Rotational angle to reference orientation
- Max positional error
- time constant positioning contr.

14 Error behavior and warning behavior

Operation of the frequency inverter and the connected load are monitored continuously. The monitoring functions are to be parameterized with the corresponding limit values specific to the application. If the limits were set below the switch-off limit of the frequency inverter, an error switch-off can be prevented by suitable measures if a warning message is issued.
The warning message is displayed by the LED's and can be read out on the operating unit via parameter *Warnings* **269 or** output via one of the digital control outputs.

14.1 Overload Ixt

The admissible load behavior depends on various technical data of the frequency inverters and the ambient conditions.
The selected *Switching Frequency* **400** defines the rated current and the available overload for one second and sixty seconds, respectively. The *Warning Limit Short Term Ixt* **405** and *Warning Limit Long Term Ixt* **406** are to be parameterized accordingly.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
405	Warning Limit Short Term Ixt	6%	100%	80%
406	Warning Limit Long Term Ixt	6%	100%	80%

Output signals

Reaching of warning limits is reported via digital signals.

165 -	Warning Ixt	1)	*Warning Limit Short Term Ixt* **405** or
7 -	Ixt warning	2)	*Warning Limit Long Term Ixt* **406** was reached.

1) For linking to frequency inverter functions
2) For output via a digital output.

14.2 Temperature

The ambient conditions and the energy dissipation at the current operating point result in the frequency inverter heating up. In order to avoid a fault switch-off of the frequency inverter, the *Warning Limit Inside Temp.* **407** for the heat sink temperature and the *Warning Limit Heat Sink Temp.* **408** as an internal temperature limit are to be parameterized. The temperature value at which a warning message is output is calculated from the type-dependent temperature limit minus the adjusted warning limit.
The switch-off limit of the frequency inverter for the maximum temperature is an internal temperature of 65 °C and a heat sink temperature of 80°C – 90°C.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
407	Warning Limit Heat Sink Temp.	-25 °C	0 °C	-5 °C
408	Warning Limit Inside Temp.	-25 °C	0 °C	-5 °C

Minimum temperatures are defined as -10 °C (interior) and 30 °C for the heat sink temperature.

Output signals

Reaching of warning limits is reported via digital signals.

166 -	Heat sink temperature warning	1)	The value "80 °C minus *Warning Limit Heat Sink Temp.* **407**" was reached.
8 -		2)	
167 -	Inside temperature warning	1)	The value "65 °C minus *Warning Limit Inside Temp.* **408**" was reached.
9 -		2)	
170 -	Warning overtemperature	1)	The value – "80 °C minus *Warning Limit Heat Sink Temp. Tk* **407"** or – "65 °C minus *Warning Limit Inside Temp. Ti* **408**" was reached.
12 -		2)	

1) For linking to frequency inverter functions
2) For output via a digital output.

14.3 Controller Status

The intervention of a controller can be indicated via the control unit or LED's. The selected control methods and the matching monitoring functions prevent a switch-off of the frequency inverter. The intervention of the function changes the operating behavior of the application and can be displayed by the status messages with parameter *Controller Status* **275**. The limit values and events which result in the intervention by the corresponding controller are described in the corresponding chapters. The behavior during the intervention of a controller is configured with parameter *Controller-Status Message* **409**.

Controller-Status Message 409	Function
0 - No message	The intervention of a controller is not reported. The controllers influencing the operating behavior are displayed in the *Controller status* **275** parameter.
1 – Warning Status	The limitation by a controller is displayed as a warning by the control unit.
11 – Warning status and LED	The limitation by a controller is displayed as a warning by the control unit and the LED's.

Refer to Chapter 16.3.8 and Chapter 22.3 for a list of controllers and additional controller status evaluation options.

14.4 IDC Compensation Limit

At the output of the frequency inverter a DC component can occur in the output current due to unbalances. This DC voltage component can be compensated by the frequency inverter. The maximum output voltage of the compensation is set with parameter *IDC Compensation Limit* **415**. If a higher voltage than the set limit is needed for the compensation of a DC voltage component, error "F1301 IDC COMPENSATION" is triggered.

If this fault occurs, it should be checked whether the load is defective. The voltage limit may have to be increased.

If the parameter *IDC Compensation Limit* **415** is reduced to zero, the DC compensation is deactivated.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
415	IDC Compensation Limit	0.0 V	1.5 V	1.5 **1)**
				0.0 **2)**

The factory setting of parameter *IDC Compensation Limit* **415** depends on the setting of parameter *Configuration* **30** :

1) Configurations 1xx
2) Configurations 2xx / 4xx / 5xx / 6xx

14.5 Frequency Switch-off Limit

The max. permissible output frequency of the frequency inverter can be set to a low frequency value via parameter *Frequency Switch-off Limit* **417**. If this frequency limit is exceeded by the *Stator Frequency* **210** or the *Actual Frequency* **241**, the frequency inverter is switched off and error signal "F1100" is displayed.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
417	Frequency Switch-off Limit	0.00 Hz	599.00 Hz	599.00 Hz

14.6 Motor temperature

The configuration of the control terminals includes the monitoring of the motor temperature. The monitoring function can be selected via parameter *Motor Temp. Operation Mode* **570**. Integration in the application is improved by an operation mode with delayed shutdown.

Motor Temp. Operation Mode 570	Function
0 - off	Motor temperature monitoring switched off.
1 - Warning only	The critical point of operation is displayed by the control unit and parameter Warnings **269**.
2 - Error switch-off	The fault switch-off is displayed by message F0400. The fault switch-off can be acknowledged via the control unit or the digital input.
3 - Error switch-off 1 min del.	The fault switch-off according to operation mode 2 is delayed by one minute.
4 - Error switch-off 5 min del.	The fault switch-off according to operation mode 2 is delayed by five minutes.
5 - Error switch-off 10 min del.	The fault switch-off according to operation mode 2 is delayed by ten minutes.

Output signals

Warnings are displayed in parameter *Warnings* **269** and output via digital signals.

168 - 10 -	Motor temperature warning	1) 2)	Monitor – selected via *Motor Temp. Operation Mode* **570** – reports critical operating point.

1) For linking to frequency inverter functions
2) For output via a digital output.

Via parameter *max. Temp. Windings* **617*** you can set the temperature value above which a warning message is displayed or the frequency inverter is switched off. The operating behavior of the frequency inverter when the value set for *max. Temp. Windings* **617** is exceeded, can be selected via parameter *Motor Temp. Operation Mode* **570**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
617	max. Temp. Windings*	50 °C	200 °C	150 °C

* The parameter is only available if an extension module featuring an input for KTY measuring resistance evaluation, e.g. EM-IO-04, is installed.

Via parameter *Therm. Contact* **204**, a digital input signal can be linked to the *Motor Temp. Operation Mode* **570**.

14.7 Earth fault identifier

The limit of the resultant current can be set with the parameter *Earth Fault Switch-Off Limit* **416** (IEOFF). If there is an unbalance between the three motor phases, for example due to an earth fault, after a triple check the inverter will be switched off with the error message **"F0505 Earth fault overload"**.

Frequency inverters of size 1 – 3 do not use this parameter.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
416	Earth fault switch-off limit	0.0 A	0 * IFIN	0.25 * IFIN

NOTICE

Fault monitoring switched off

If **P.416** is set to the value `0 A`, the monitoring of the phase currents for unbalance is switched off.

- Check the parameter for correct settings.

14.8 Phase failure

If a failure of one of the three motor or mains phases is not noticed, the frequency inverter, the motor and the mechanical drive components may be damaged. In order to prevent these components from being damaged, the phases are monitored for failure. Via parameter *Phase Supervision* **576** the behavior in case of a phase failure can be set.

14.8.1 Settings for sizes 1 to 7

Phase Supervision 576		Function
10 -	Mains: Error switch-off	In the case of a phase failure, the error switch-off takes place after 5 minutes, fault F0703 is displayed. During this time, the warning message A0100 is displayed.
11 -	Mains & Motor: Error switch-off	The phase monitor switches the frequency inverter off: immediately with error message F0403 in the case of a motor phase failure, after 5 minutes with error message F0703 in the case of a mains phase failure.
20 -	Mains: Shutdown	In the case of a mains phase failure, the drive is stopped after five minutes, fault F0703 is displayed.
21 -	Mains & Motor: Shutdown	The drive is stopped: immediately, in the case of a motor phase failure, after 5 minutes in the case of a mains phase failure.

14.8.2 Settings for size 8

Phase Supervision 576		Function
10 -	Mains: Error switch-off	In the case of a phase failure, the error switch-off takes place immediately, fault F0703 is displayed.
11 -	Mains & Motor: Error switch-off	The phase monitor switches the frequency inverter off: immediately with error message F0403 in the case of a motor phase failure, immediately with error message F0703 in the case of a mains phase failure

14.9 Automatic acknowledgment of errors/faults

The automatic error acknowledgment enables acknowledgment of the faults Overcurrent F0500, Overcurrent F0507 and Overvoltage F0700 without intervention by an overriding control system or the user. If one of the aforementioned errors occurs, the frequency inverter switches the power semi-conductors off and waits for the time stated with parameter *Restart Delay* **579**. If the error must be acknowledged, the speed of the machine is determined with the quick catching function and synchronized to the rotating machine. The automatic error acknowledgment makes use of "Quick Synchronization" operation mode, regardless of the search run *Operation Mode* **645**. The information given on this function in chapter 13.4 must be observed.

If an additional error occurs during the search run, leading to a subsequent deactivation of the inverter, this recent error will be displayed in **P.259**. In the error protocol (refer to Chapter 21 – **P.310**; **P.311**), the initial error that led to the search run in the first place will be registered. This behavior allows to register the second error as a consequence of the first error and facilitates the investigation of the root cause.

Errors occurring after the completion of the search run will be registered as individual new errors.

With parameter *Allowed No. of Auto-Acknowl.* **578**, you can define the number of automatic error acknowledgments which are permitted within 10 minutes.

An acknowledgment repeated above the permissible number within 10 minutes will result in the frequency inverter being switched off.

The errors Overcurrent F0500, Overcurrent F0507 and Overvoltage F0700 have separate error acknowledgment counters.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
578	Allowed no. of AutoAck.	0	20	5
579	Restart delay	0 ms	1000 ms	20 ms

15 Reference Values

The ACU series frequency inverters can be configured specific to the application and enable customer-specific adaptation of the module hardware and software structure.

15.1 Frequency Limits

The output frequency of the frequency inverter and thus the speed setting range are defined by the parameters *Minimum Frequency* **418** and *Maximum Frequency* **419**. The relevant control methods use the two limit values for scaling and limiting the frequency.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
418	Minimum frequency	0.00 Hz	599.00 Hz	3.50 Hz [1)]
				0.00 Hz [2)]
419	Maximum frequency	0.00 Hz	599.00 Hz	50.00 Hz

The factory settings depend on the setup of parameter *Configuration* **30**:
[1)] 3.50 Hz in Configurations 1xx, 3xx, 4xx; 6xx
[2)] 0.00 Hz in Configurations 2xx, 5xx

15.2 Slip Frequency

The torque-forming current component and thus the slip frequency of the 3-phase machine depend on the required torque in the case of the field-oriented control methods. The field-oriented control method also includes the parameter *Slip Frequency* **719** to limit the torque in the calculation of the machine model. The rated slip calculated from the rated motor parameters is limited in accordance with the *Slip Frequency* **719** which is parameterized as a percentage.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
719	Slip Frequency	0 %	10000 %	330 %

15.3 Percentage Value Limits

The percentage adjusting range is defined by parameters *Minimum Reference Percentage* **518** and *Maximum Reference Percentage* **519**. The relevant control methods use the two limit values for scaling and limiting of percentages.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
518	Minimum Reference Percentage	0.00 %	300.00 %	0.00 %
519	Maximum Reference Percentage	0.00 %	300.00 %	100.00 %

15.4 Frequency reference channel

The different functions for the defining the reference frequency are connected via the frequency reference value channel. The *Reference Frequency Source* **475** determines the additive assignment of the available reference value sources depending on the hardware installed.

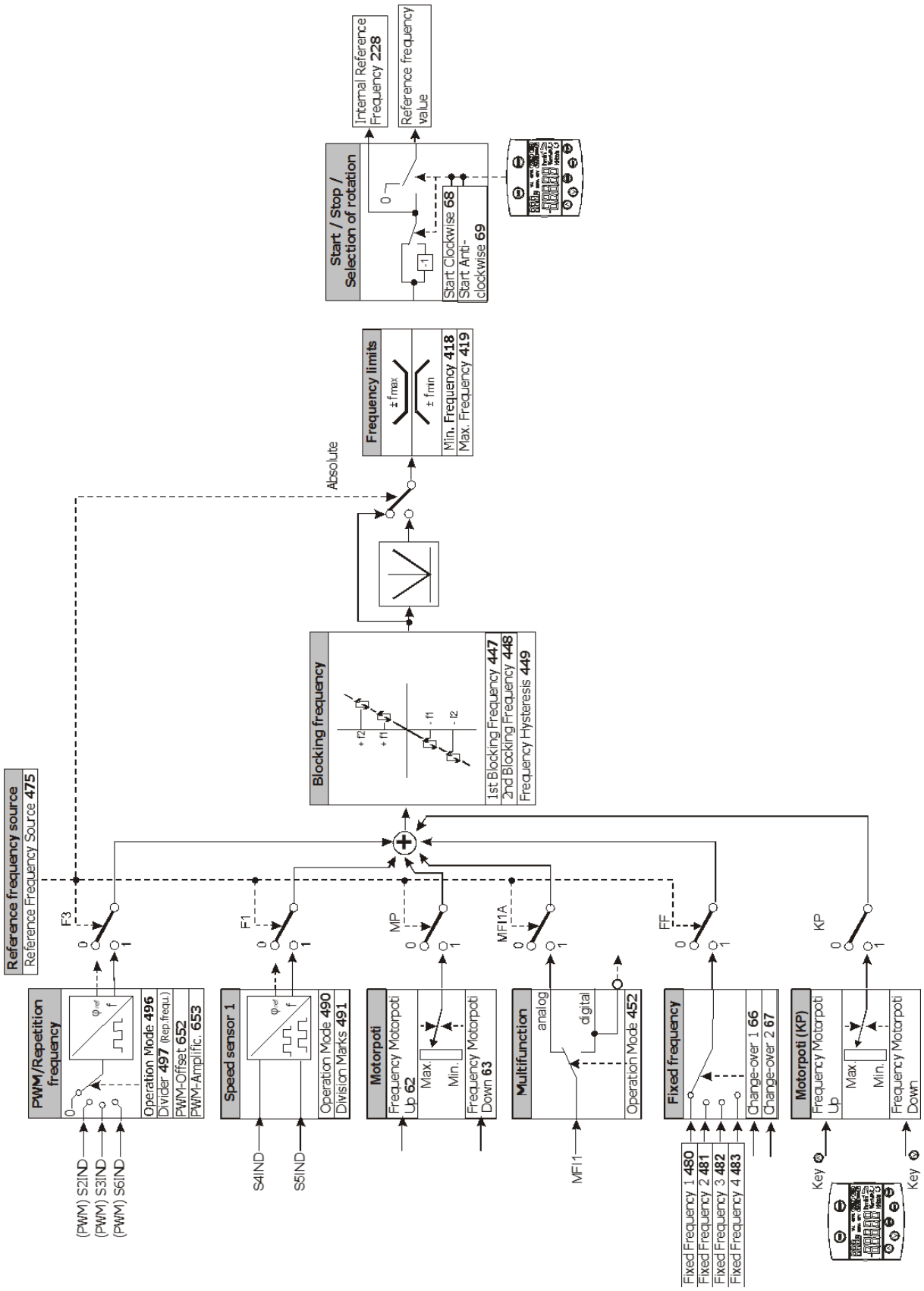
Reference Frequency Source 475	Function
1 - Abs. value analog value MFI1A	Multifunction input 1 in analog *Operation Mode* **452** is the reference value source.
2 - Abs. Analog Input EM-S1INA **1)**	The analog input of the extension module is the reference value source.
4 - Abs. Value MFI1A + EM-S1INA **1)**	Combination of operation modes 1 and 2.
10 - Abs. value fixed frequency (FF)	Fixed frequency according to *Fixed Frequency Change-Over 1* **66** and *Fixed Frequency Change-Over 2* **67** as well as the current data set.
11 - Abs. value MFI1A + FF	Combination of operation modes 10 and 1.
12 - Abs. Value EM-S1INA + FF**1)**	Combination of operation modes 10 and 2.
14 - Abs. Value MFI1A + EM-S1INA+FF**1)**	Combination of operation modes 10, 1 and 2.
20 - Abs. value Motorpoti (MP)	Reference value source: Function *Frequency Motorpoti Up* **62** and *Frequency Motorpot. Down* **63**
21 - Abs. value MFI1A + MP	Combination of operation modes 20 and 1.
22 - Abs. Value EM-S1INA + MP **1)**	Combination of operation modes 20 and 2.
24 - Abs. Value MFI1A + EM-S1INA + MP **1)**	Combination of operation modes 20, 1 and 2.
30 - Abs.Val. Speed Sensor 1 (F1)	The frequency signals in *Operation Mode* **490** are evaluated as a reference value.
31 - Abs. value MFI1A + F1	Combination of operation modes 30 and 1.
32 - Abs. Val. Rep.Freq./PWM Inp.(F3)	The frequency signal on the digital input according to *Operation Mode* **496** for the PWM/repetition frequency input.
33 - Abs. value MFI1A + F3	Combination of operation modes 1 and 32.
34 - Abs.Val. Speed Sensor 2 (F2) **2)**	The frequency signals of speed sensor 2 are evaluated as a reference value.
35 - Abs. value MFI1A + F2	Combination of operation modes 1 and 35.
40 - Abs. value Motorpoti (KP)	KP 500 is the reference value source, with keys ▲ for increasing the frequency and ▼ for reducing the frequency.
41 - Abs. value MFI1A + KP	Combination of operation modes 40 and 1.
42 - Abs. Value EM-S1INA + KP **1)**	Combination of operation modes 40 and 2.
44 - Abs. Value MFI1A + EM-S1INA + KP **1)**	Combination of operation modes 40, 1 and 2.
80 - Abs. value MFI1A + FF + KP + F3 + (EM-S1INA)**1)**	Combination of operation modes 1, 10, 40, 32 and 2.**1)**
81 - Abs. value MFI1A + FF + KP + F1 + F3 + (EM-S1INA)**1)**	Combination of operation modes 1, 10, 40, 30, 32 and 2.**1)**
82 - Abs. value MFI1A + FF + KP + F3 + (F2)**2)** + (EM-S1INA)**1)**	Combination of op.modes 1, 10, 40, 32, 34 **2)** and 21**)**
89 - Abs. value MFI1A + FF + KP + F1 + F3 + (F2)**2)** + (EM-S1INA)**1)**	Combination of op.modes 1, 10, 40, 30, 32, 34 **2)** and 2.**1)**
90 - Abs. value MFI1A + FF + MP + F3 + (EM-S1INA)**1)**	Combination of operation modes 1, 10, 20, 32 and 2.**1)**
91 - Abs. value MFI1A + FF + MP + F1 + F3 + (EM-S1INA)**1)**	Combination of operation modes 1, 10, 20, 30, 32 and 2.**1)**
92 - Abs. value MFI1A + FF + MP + F3 + (F2)**2)** + (EM-S1INA)**1)**	Combination of the operation modes 1, 10, 20, 32 (+ absolute amount speed sensor 2 (F2))**2)** (+ analog input extension module).**1)**
99 - Abs. value MFI1A + FF + MP + F1 + F3 + (F2)**2)** + (EM-S1INA)**1)**	Combination of operation modes 1, 10, 20, 30, 33, 32 **2)** and 2.**1)**
101 to 199	Operation modes with signs (+/-).

1) The reference value source is only available if an extension module with analog input is connected. For information, refer to the extension module operating instructions.
2) The reference value source is only available if an extension module with speed sensor input is connected. For information, refer to the extension module operating instructions.

Block diagram

The following table describes the software switches shown in the circuit diagram as a function of the selected *Reference Frequency Source* **475**.

Switch position on circuit diagram									
Operation Mode	**MFI1A**	**FF**	**MP**	**F1**	**F3**	**KP**	**EM-S1INA**	**F2**	**Sign**
1	1								Abs. value
10		1							Abs. value
11	1	1							Abs. value
12		1					1		Abs. value
14	1	1					1		Abs. value
20			1						Abs. value
21	1		1						Abs. value
22			1				1		Abs. value
24	1		1				1		Abs. value
30				1					Abs. value
31	1			1					Abs. value
32					1				Abs. value
33	1				1				Abs. value
34								1	Abs. value
35	1							1	Abs. value
40						1			Abs. value
41	1					1			Abs. value
42						1	1		Abs. value
44	1					1	1		Abs. value
80	1	1			1	1	1		Abs. value
81	1	1		1	1	1	1		Abs. value
82	1	1			1	1	1	1	Abs. value
89	1	1		1	1	1	1	1	Abs. value
90	1	1	1		1		1		Abs. value
91	1	1	1	1	1		1		Abs. value
92	1	1	1		1		1	1	Abs. value
99	1	1	1	1	1		1	1	Abs. value
101...199	Operation modes 1...99 with sign (+/-).								+/-



15.5 Reference percentage channel

The reference percentage channel combines various signal sources for definition of the reference figures. The percentage scaling facilitates integration into the application, taking various process parameters into account.

The *Reference Percentage Source* **476** determines the additive assignment of the available reference value sources depending on the hardware installed.

Reference Percentage Source **476**		Function
1 -	Abs. value analog value MFI1A	Multifunction input 1 in analog Operation Mode **452** is the reference value source.
2 -	Abs. value EM-S1INA[1)]	Analog input of EM-S1INA is the reference value source.
4 -	Abs. value MFI1 + EM-S1INA[1)]	Combination of operation modes 1 and 2.
10 -	Abs. value fixed percentage value (FP)	The percentage according to *Fixed Percent Change-Over 1* **75**, Fixed *Percent Change-Over 2* **76** and the current data set
11 -	Abs. value MFI1A + FP	Combination of operation modes 1 and 10.
12 -	Abs. value EM-S1INA + FP[1)]	Combination of operation modes 2 and 10.
14 -	Abs. value MFI1 + EM-S1INA + FP[1)]	Combination of operation modes 1, 2 and 10.
20 -	Abs. value Motorpoti (MP)	Reference value source: Function *Percent Motorpoti Up* **72** and *Percent Motorpoti Down* **73**
21 -	Abs. value MFI1A + MP	Combination of operation modes 1 and 20.
22 -	Abs. value EM-S1INA + MP[1)]	Combination of operation modes 2 and 20.
24 -	Abs. value MFI1 + EM-S1INA + FP	Combination of operation modes 1, 2 and 20.
32 -	Abs. value Rep.Freq./PWM Inp.(F3)	The frequency signal on the digital input according to *Operation Mode* **496** for the PWM/repetition frequency input.
33 -	Abs. value MFI1A + F3	Combination of operation modes 1 and 32.
90 -	Abs. value MFI1A + FP + MP + F3 (+ EM-S1INA) [1)]	Combination of the operation modes 1, 10, 20, 32 (+ analog input of an extension module) [1)]
95 -	Abs. value Obj. 0x6071 Target Torque	Reference value source: CANopen Object 0x6071.
96 -	Abs. value Profibus OUT-PZD3	Reference value source: Profibus OUT-PZD3.
99 -	Abs. value FT outp.percentage 1	Reference value source: Output of function table FT-Output Percentage 1.
101 to 199		Operation modes with signs (+/-).

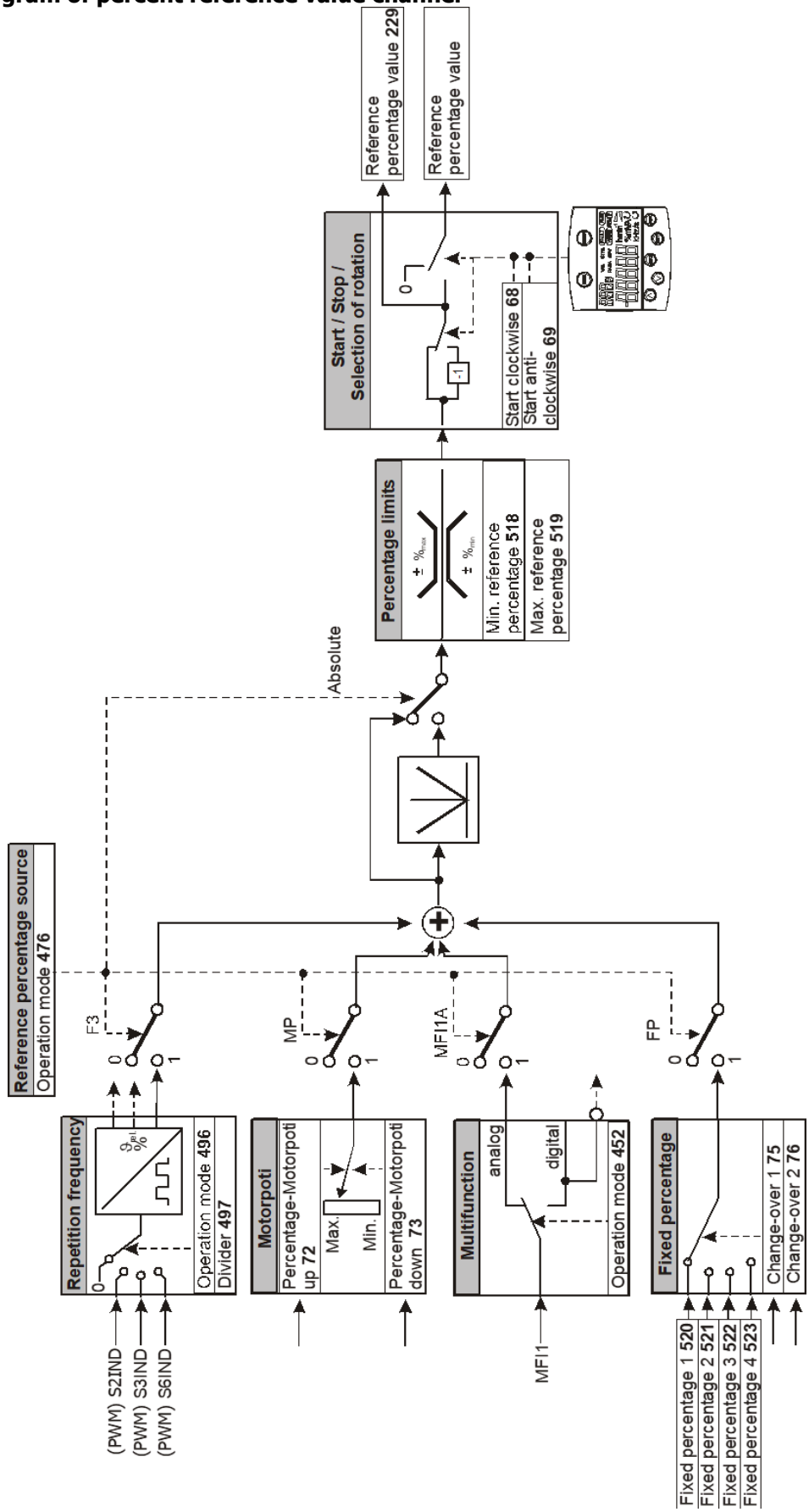
[1)] The reference value source is only available if an optional extension module with analog input is connected. For information, refer to the extension module operating instructions.

Block diagram

The following table describes the software switches shown in the circuit diagram as a function of the selected *Reference Percentage Source* **476.**

Switch position on circuit diagram						
Operation Mode	**MFI1A**	**FP**	**MP**	**F3**	**EM-S1INA**	**Sign**
1	1					Abs. value
2					1	Abs. value
4	1				1	Abs. value
10		1				Abs. value
11	1	1				Abs. value
12		1			1	Abs. value
14	1	1			1	Abs. value
20			1			Abs. value
21	1		1			Abs. value
22			1		1	Abs. value
24	1		1		1	Abs. value
32				1		Abs. value
33	1			1		Abs. value
90	1	1	1	1		Abs. value
95	CANopen Object 0x6071					Abs. value
96	Profibus OUT-PZD3					Abs. value
99	Output FT output percentage 1					Abs. value
101...199	Operation modes 1...99 with sign (+/-)					+/-

Circuit diagram of percent reference value channel



15.6 Fixed reference values

The fixed reference values are to be parameterized as fixed frequencies or fixed percentages according to the configuration and function.
The signs of the fixed reference values determine the direction of rotation. A positive sign means a clockwise rotation, a negative sign means an anticlockwise rotation. The direction can only be changed via the sign if the *Reference Frequency Source* **475** or *Reference Percentage Source* **476** is parameterized to an operation mode with sign (+/-). The direction of rotation can also be stated with the digital signal sources assigned to the parameters *Start Clockwise* **68** and *Start Anticlockwise* **69**.
The fixed reference values are to be parameterized in four data sets and are assigned to further sources via the reference value channel. The use of the functions *Data Set Change-Over 1* **70** and *Data Set Change-Over 2* **71** thus enables the setting of 16 fixed reference values.

15.6.1 Fixed frequencies

The four fixed frequencies define reference values which are selected via the *Fixed Frequency Change-Over 1* **66** and *Fixed Frequency Change-Over 2* **67**. The *Reference Frequency Source* **475** defines the addition of the various sources in the reference frequency channel.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
480	Fixed Frequency 1	-599.00 Hz	599.00 Hz	0.00 Hz
481	Fixed Frequency 2	-599.00 Hz	599.00 Hz	10.00 Hz
482	Fixed Frequency 3	-599.00 Hz	599.00 Hz	25.00 Hz
483	Fixed Frequency 4	-599.00 Hz	599.00 Hz	50.00 Hz

By combining the logic states of the fixed frequency change-over modes 1 and 2, fixed frequencies 1 through 4 can be selected:

Selection of fixed frequencies		
Fixed Frequency Change-Over 1 **66**	*Fixed Frequency Change-Over 2* **67**	Function/active fixed value
0	0	*Fixed Frequency 1* **480**
1	0	*Fixed Frequency 2* **481**
1	1	*Fixed Frequency 3* **482**
0	1	*Fixed Frequency 4* **483**

0 = Contact open 1 = Contact closed

Additional fixed frequencies can be selected if an optional extension module featuring digital inputs is installed. In this case, follow the instructions on the optional extension module.

15.6.2 JOG frequency

The JOG function forms part of the functions for controlling the drive mechanism via the control unit. Use the arrow keys to change the JOG frequency within the function. The frequency of the output signal is set to the entered value if the FUN key is pressed. The drive starts and the machine turns at the set *JOG-Frequency* **489**. If the JOG frequency has been changed using the arrow keys, this value is stored.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
489	JOG frequency	-599.00 Hz	599.00 Hz	5.00 Hz

15.6.3 Fixed percentages

The four fixed percentages define reference values which are selected via the *Fixed Percent Change-Over 1* **75** and *Fixed Percent Change-Over 2* **76**. The *Reference Percentage Source* **476** defines the addition of the various sources in the reference frequency channel.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
520	Fixed Percentage 1	-300.00 %	300.00 %	0.00 %
521	Fixed Percentage 2	-300.00 %	300.00 %	20.00 %
522	Fixed Percentage 3	-300.00 %	300.00 %	50.00 %
523	Fixed Percentage 4	-300.00 %	300.00 %	100.00 %

By combining the logic states of the fixed percentage change-over modes 1 and 2, fixed percentages 1 through 4 can be selected:

Fixed percentage control		
Fixed Percent Change-Over 1 **75**	*Fixed Percent Change-Over 2* **76**	Function / active fixed value
0	0	*Fixed Percentage 1* **520**
1	0	*Fixed Percentage 2* **521**
1	1	*Fixed Percentage 3* **522**
0	1	*Fixed Percentage 4* **523**

0 = Contact open 1 = Contact closed

15.7 Frequency ramps

The ramps determine how quickly the frequency value is changed if the reference value changes or after a start, stop or brake command. The maximum admissible ramp gradient can be selected according to the application and the current consumption of the motor.
If the settings of the frequency ramps are identical for both directions of rotation, the parameterization via the parameters *Acceleration (Clockwise)* **420** and *Deceleration (Clockwise)* **421** is sufficient. The values of the frequency ramps are applied to *Acceleration Anticlockwise* **422** and *Deceleration Anticlockwise* **423** if these have been parameterized to the factory setting of -0.01 Hz/s.
The parameter value of 0.00 Hz/s for the acceleration blocks the corresponding direction of rotation.

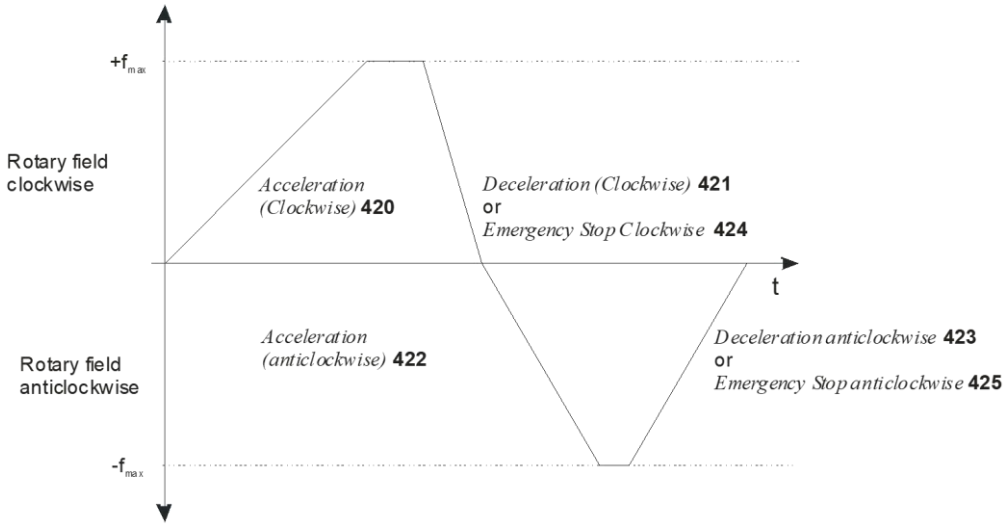
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
420	Acceleration (Clockwise)	0.00 Hz/s	9999.99 Hz/s	5.00 Hz/s
421	Deceleration (Clockwise)	0.01 Hz/s	9999.99 Hz/s	5.00 Hz/s
422	Acceleration Anticlockwise	- 0.01 Hz/s [1)]	9999.99 Hz/s	- 0.01 Hz/s
423	Deceleration Anticlockwise	- 0.01 Hz/s [2)]	9999.99 Hz/s	- 0.01 Hz/s

[1)] Value -0.01 Hz/s means that the value of *Acceleration (Clockwise)* **420** is used.
[2)] Value -0.01 Hz/s means that the value of *Deceleration (Clockwise)* **421** is used.

Setting 0.00 Hz/s will not accelerate nor decelerate the drive due to the limitation of the ramp.

The ramps for *Emergency Stop Clockwise* **424** and *Emergency Stop Anticlockwise* **425** of the drive to be activated via *Operation Mode* **630** for the stopping behavior must be selected according to the application. The non-linear (S-shaped) course of the ramps is not active in the case of an emergency stop of the drive.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
424	Emergency stop clockwise	0.01 Hz/s	9999.99 Hz/s	5.00 Hz/s
425	Emergency stop anti-clockwise	0.01 Hz/s	9999.99 Hz/s	5.00 Hz/s



The parameter *Maximum Leading* **426** limits the difference between the output of the ramp and the current actual value of the drive. The set maximum deviation is a dead time for the control system which should be kept as low as possible.

In case the drive is loaded heavily and high acceleration and deceleration values are selected it is possible, that a set controller limit is reached while the drive is accelerated or decelerated. In this case, the drive cannot follow the defined acceleration or deceleration ramps. With *Maximum Leading* **426** , you can limit the max. leading of the ramp.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
426	Maximum leading	0.01 Hz	599.00 Hz	5.00 Hz

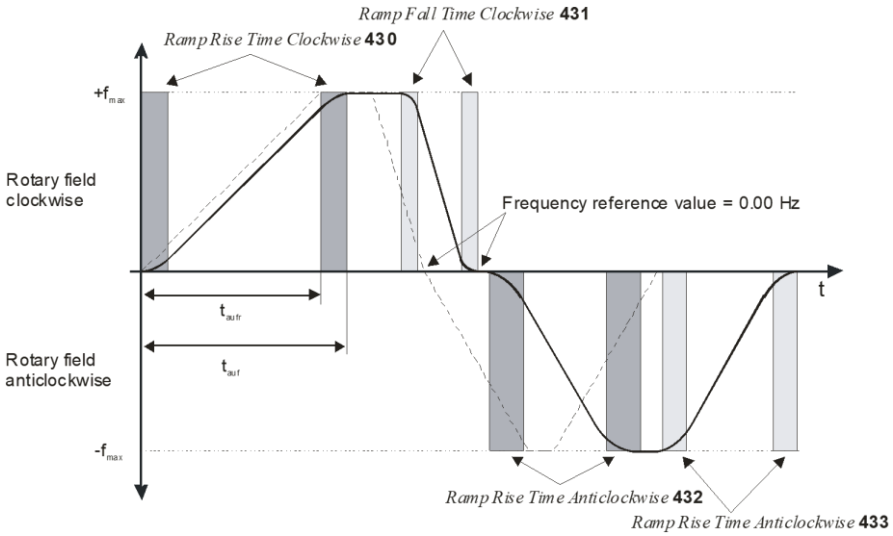
Example: Fixed value at ramp output = 20 Hz, current actual value of drive = 15 Hz, selected *Maximum Leading* **426** = 5 Hz

The frequency at the ramp output is increased to 15 Hz only, it is not increased further. The difference (leading) between the frequency value at the ramp output and the current actual frequency of the drive is limited to 5 Hz in this way.

The load occurring in a linear acceleration of the drive is reduced by the adjustable modification speeds (S curve). The non-linear course of the frequency is defined as a ramp and states the time range in which the frequency is to be guided to the set ramp. The values set with parameters 420 to 423 are maintained regardless of the selected ramp times.

Setting the ramp rise time to 0 ms deactivates the function S curve and enables the use of the linear ramps. The data set change-over of the parameters within an acceleration phase of the drive mechanism demands the defined take-over of the values. The controller calculates the values required in order to reach the reference value from the ratio of the acceleration to the ramp time and uses it until the acceleration phase is complete. With this method, exceeding the reference values is avoided and a data set change-over between extremely deviating values becomes possible.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
430	Ramp rise time clockwise	0 ms	65000 ms	0 ms
431	Ramp fall time clockwise	0 ms	65000 ms	0 ms
432	Ramp rise time anticlockwise	0 ms	65000 ms	0 ms
433	Ramp rise time anticlockwise	0 ms	65000 ms	0 ms



Example:

Calculation of the acceleration time in clockwise rotation with an acceleration from 20 Hz to 50 Hz (fmax) and an acceleration ramp of 2 Hz/s for parameter *Acceleration (Clockwise)* **420**. The *Ramp Rise Time Clockwise* **430** is set to 100 ms.

$$t_{aufr} = \frac{\Delta f}{a_r}$$

$$t_{aufr} = \frac{50\,Hz - 20\,Hz}{2\,Hz/s} = 15\,s$$

$$t_{auf} = t_{aufr} + t_{Vr}$$

$$t_{auf} = 15\,s + 100\,ms = 15{,}1\,s$$

t_{aufr} = acceleration time clockwise rotary field

Δf = change of frequency acceleration ramp

a_r = Acceleration Clockwise

t_{Vr} = Ramp Rise Time Clockwise

t_{auf} = Acceleration time + Ramp rise time

15.8 Percentage Value Ramps

The percentage value ramps scale the change of the reference value (in percent) for the corresponding input function. The acceleration and deceleration of the drive are parameterized via the frequency ramps.

The behavior *Gradient Percentage Ramp* **477** corresponds to a function which takes the time behavior of the drive system into account. If the parameter is set to 0 %/s, this function is deactivated and a direct reference value modification for the following function is obtained.

The default value depends on *Configuration* **30**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
477	Gradient Percentage Ramp	0 %/s	60000 %/s	x %/s

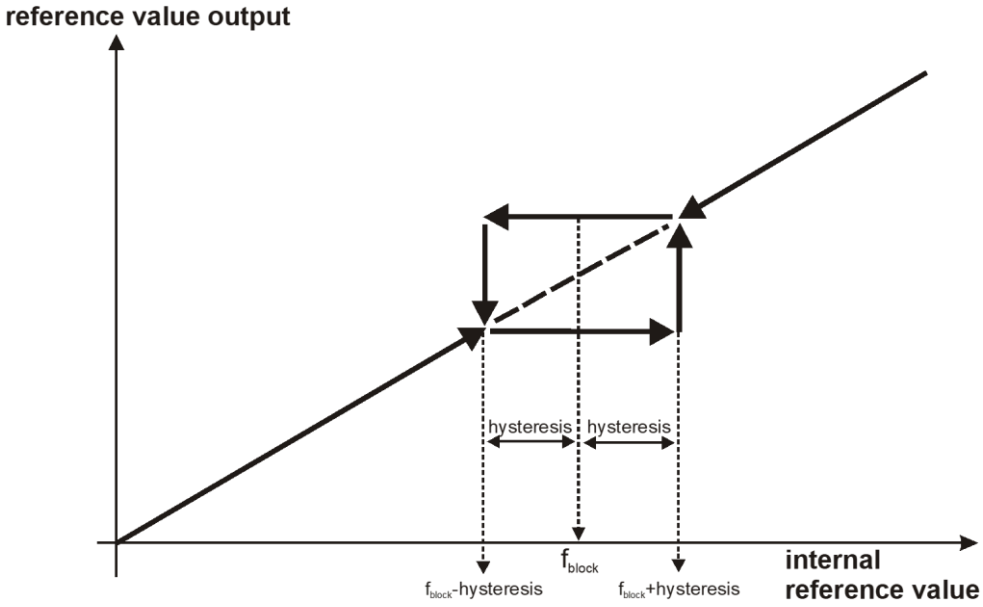
15.9 Blocking frequencies

In certain applications, it is necessary to fade out reference frequencies. In this way, resonance points of the system as stationary operating points are avoided. Parameters *1st Blocking Frequency* **447** and *2nd Blocking Frequency* **448** with parameter *Frequency Hysteresis* **449** define two resonance points.

A blocking frequency is active if the parameter values of the blocking frequency and the frequency hysteresis are not equal to 0.00 Hz.

The area faded out as a stationary working point by the hysteresis is passed through as quickly as possible according to the ramp set. If the output frequency is limited as a result of the selected control parameter settings, e.g. if the current limit is reached, the hysteresis is passed through with a delay. The behavior of the reference value can be determined from its direction of movement according to the following diagram.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
447	1. Block frequency	0.00 Hz	599.00 Hz	0.00 Hz
448	2. Block frequency	0.00 Hz	599.00 Hz	0.00 Hz
449	Frequency hysteresis	0.00 Hz	100.00 Hz	0.00 Hz



15.10 Motor potentiometer

Via the motor potentiometer function, the motor speed is controlled via

- digital control signals (function Motorpoti MP) or via
- the keys of the control unit KP°500 (Function Motorpoti KP).

The control up/down commands are assigned the following functions:

Control				
Motorpoti (MP)		**Motorpoti (KP)**		**Function**
Up	**Down**	**Up**	**Down**	
0	0	–	–	Output signal does not change
1	0	▲	–	Output value rises at set ramp
0	1	–	▼	Output value drops at set ramp
1	1	▲ + ▼		Output value is reset to initial value

0 = Contact open 1 = Contact closed
▲ ▼ = Arrow keys on control unit KP 500

The motor potentiometer function and its link to other reference value sources can be selected in the corresponding reference value channels with parameters *Reference Frequency Source* **475** or *Reference Percentage Source* **476**.

For a description of the possible links of the reference value sources, refer to chapters "Reference Values", "Reference Values" and "Reference Values".

Availability of functions "Motorpoti (MP)" and "Motorpoti (KP)" differs in the individual reference value channels:

Reference value channel		
	Reference Frequency Source **475**	*Reference Percentage Source* **476**
Motorpoti (MP)	X	X
Motorpoti (KP)	X	0

X = Function available 0 = Function not available

Depending on the active reference value channel, the function is assigned to a digital signal via parameters *Frequency Motorpoti Up* **62**, *Frequency Motorpot. Down* **63** or *Percent Motorpoti Up* **72**, *Percent Motorpoti Down* **73**.

For a summary of available digital signals, refer to chapter "Digital Inputs".

The *Operation Mode* **474** of the motor potentiometer function defines the behavior of the function at various operating points of the frequency inverter.

Operation Mode 474	Function
0 - Not Latching	In the operation mode motor potentiometer **Not Latching**, the drive goes to the set minimum reference value at each start.
1 - Latching	In the operation mode Latching the motor goes to the reference value selected before the switch-off at the start. The reference value is also stored when the device is switched off.
2 - Taking Over	The operation mode Motorpoti **Taking Over** is to be used for the data set change-over of the reference value channel. The current reference value is used when the motorpoti function is activated.
3 - Taking Over and Latching	This operation mode combines the behavior in operation mode 1 and 2.

15.10.1 Motorpoti (MP)

Function "Motorpoti (MP)" is to be parameterized via parameter *Reference Frequency Source* **475** or *Reference Percentage Source* **476**.

Reference Frequency Channel

Via the digital control inputs, the required functions *Frequency Motorpoti Up* **62** and *Frequency Motorpot. Down* **63** are triggered.

Limitation of the reference values is effected via parameters *Minimum Frequency* **418** and *Maximum Frequency* **419**.

Reference percentage channel

Via the digital control inputs, the required functions *Percent Motorpoti Up* **72** and *Percent Motorpoti Down* **73** are triggered. Limitation of the reference values is effected via parameters *Minimum Reference Percentage* **518** and *Maximum Reference Percentage* **519.**

15.10.2 Motorpoti (KP)

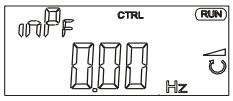
The function „Motorpoti (KP)" is only available in the reference frequency channel. The function and its link to other reference value sources can be selected via parameter *Reference Frequency Source* **475**.

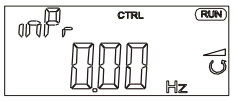
Via the keys of the control unit KP 500, the required functions *Frequency Motorpoti Up* **62** and *Frequency Motorpot. Down* **63** are triggered.

Limitation of the reference values is effected via parameters *Minimum Frequency* **418** and *Maximum Frequency* **419**.

Operation as described in Chapter 15.10.3.

If the function Motorpoti (KP) is activated "inPF" will be displayed for clockwise direction of rotation and "inPr" for anticlockwise direction of rotation.





The keys on the control unit have the following functions:

Key functions	
▲ / ▼	Increase / reduce frequency.
ENT	Reversal of the sense of rotation independent of the control signal on the terminals Clockwise S2IND or Anticlockwise S3IND.
ENT (1 sec)	Save the selected function as default value. The direction of rotation is not changed.
ESC	Cancel function and return to the menu structure.
FUN	Switch from internal reference value inP to JOG-Frequency; drive starts. Release the key to switch to the sub-function and stop the drive.
RUN	Start drive; alternative to control signal S2IND or S3IND.
STOP	Stop drive; alternative to control signal S2IND or S3IND.

15.10.3 Controlling the Motor via the Control Unit

Parameter *Reference Frequency Source* **475** enables linking of the reference sources in the reference frequency channel. The operation modes can be set without the function "Motorpoti (KP)".

If an operation mode without „Motorpoti (KP)" is selected, a connected motor can be controlled via the keys of the control unit KP 500.
The speed of the modification of the reference value is limited by parameter *Ramp Keypad-Motorpoti* **473**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
473	Ramp Keypad Motorpoti	0.00 Hz/s	999.99 Hz/s	2.00 Hz/s

PWM-/repetition frequency input
The use of a PWM (pulse-width modulated) frequency signal completes the various possibilities of the reference value specification. The signal at one of the available digital inputs is evaluated according to the selected *Operation Mode* **496**.
PWM frequencies ranging from 50 Hz to 150 kHz can be evaluated.

Operation Mode 496	Function
0 - off	The PWM signal or repetition frequency are zero.
2 - PWM S2IND, 0 - 100%	PWM signal capture on terminal X210A.4. 0 ... 100% of *Maximum Reference Percentage* **519** or 0 ... 100% of *Maximum Frequency* **419**.
3 - PWM S3IND, 0 - 100%	PWM signal capture on terminal X210A.5. 0 ... 100% of *Maximum Reference Percentage* **519** or 0 ... 100% of *Maximum Frequency* **419**.
6 - PWM S6IND, 0 - 100%	PWM signal capture on terminal X210B.1. 0 ... 100% of *Maximum Reference Percentage* **519** or 0 ... 100% of *Maximum Frequency* **419**.
12 - PWM S2IND, -100 - 100%	PWM signal capture on terminal X210A.4. -100 ... 100% of *Maximum Reference Percentage* **519** or -100 ... 100% of *Maximum Frequency* **419**.
13 - PWM S3IND, -100 - 100%	PWM signal capture on terminal X210A.5. -100 ... 100% of *Maximum Reference Percentage* **519** or -100 ... 100% of *Maximum Frequency* **419**.
16 - PWM S6IND, -100 - 100%	PWM signal capture on terminal X210B.1. -100 ... 100% of *Maximum Reference Percentage* **519** or -100 ... 100% of *Maximum Frequency* **419**.
21 - S2IND Single Evaluation Pos.	Repetition Frequency Input at terminal X210A.4. One edge of the frequency signal is evaluated with a positive sign.
22 - S2IND Double evaluation pos.	Repetition Frequency Input at terminal X210A.4. Both edges of the frequency signal are evaluated with a positive sign.
31 - S3IND Single Evaluation Pos.	Repetition Frequency Input at terminal X210A.5. One edge of the frequency signal is evaluated with a positive sign.
32 - S3IND Double evaluation pos.	Repetition Frequency Input at terminal X210A.5. Both edges of the frequency signal are evaluated with a positive sign.
61 - S6IND Single Evaluation Pos.	Repetition Frequency Input at terminal X210B.1. One edge of the frequency signal is evaluated with a positive sign.
62 - S6IND Double evaluation pos.	Repetition Frequency Input at terminal X210B.1. Both edges of the frequency signal are evaluated with a positive sign.
121 to 162	Repetition Frequency Input. Operation modes 21 to 62 with evaluation of the frequency signal, but with a negative sign.

If a digital input is configured as a PWM or repetition frequency input, this input cannot be used for other functions.
Check the link of the digital inputs to other functions.

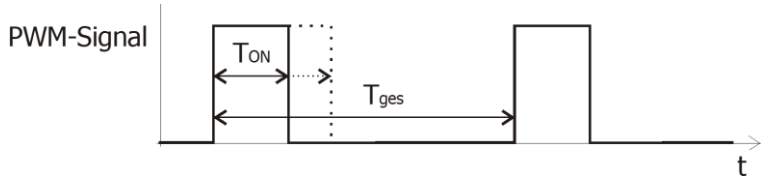
The signal frequency at the selected repetition frequency input can be scaled via the parameter *Divider* **497**. The parameter value can be compared to the number of division marks of an encoder per rotation of the drive. The frequency limit of the parameterized digital input is to be taken into account for the frequency of the input signal.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
497	Divider	1	8192	1024

The reference value specification within the different functions enables the use of the repetition frequency signal as a percentage figure. A signal frequency of 100 Hz at the repetition frequency input corresponds to 100%, 1 Hz corresponds to 1%. The parameter *Divider* **497** is to be used in a way comparable with the speed sensor simulation.

Via parameters *Offset* **652** and *Amplification* **653** the PWM input signal can be adjusted for the application.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
652	Offset	-100.00%	100.00%	0.00%
653	Amplification	5.0%	1000.0%	100.0%



$$\text{PWM} - \text{Value} = \textit{Offset}\,\mathbf{652} + \left(\frac{T_{on}}{T_{ges}}[\%] \times \textit{Amplification}\,\mathbf{653} \right)$$

For definition of reference values, the following settings are possible:

- For reference frequencies:
  Reference Frequency Source **475** = "32 - Abs. value/PWM Inp.(F3)". The PWM-value for the signal is referred to *Maximum Frequency* **419**.
- For reference percentages:
  Reference Percentage Source **476** = "32 - Abs. value/PWM Inp.(F3)". The PWM-value for the signal is referred to *Maximum Reference Percentage* **519**.

The actual value of the PWM input is shown in parameter *PWM-Input* **258**.

16 Control inputs and outputs

The modular structure of the frequency inverters enables a wide spectrum of applications on the basis of the available hardware and software functionality. The control inputs and outputs of terminals X210A and X210B described in the following can be linked to software modules freely via the described parameters.

16.1 Multifunction input MFI1

Multifunction input MFI1 can be configured as a voltage, current or a digital input. Depending on the selected *Operation Mode* **452** for the multifunction input, a link to various functions of the software is possible. The unused operation modes are assigned the signal value 0 (LOW).

Operation Mode 452	Function
1 - Voltage Input	voltage signal (MFI1A), 0 V ... 10 V
2 - Current Input	current signal (MFI1A), 0 mA ... 20 mA
3 - Digital input	digital signal (MFI1D), 0 V ... 24 V

The sampling rate of multi-function input MFI1D is slower than that of digital signals S1IND, S2IND, etc. For this reason, this input should only be used for signals which are **not time-critical**.

Analog Input MFI1A

Multifunction input MFI1 is configured by default for an analog reference value source with a voltage signal of 0V to 10V.

Alternatively, you can select the operation mode for an analog current signal of 0 mA to 20 mA. The current signal is continuously monitored and the error signal "F1407" displayed if the maximum figure is exceeded.

16.1.1 Characteristic

Mapping of the analog input signal onto a reference frequency value or a reference percentage value is possible for various requirements. Parameterization can be done via two points of the linear characteristic of the reference value channel.

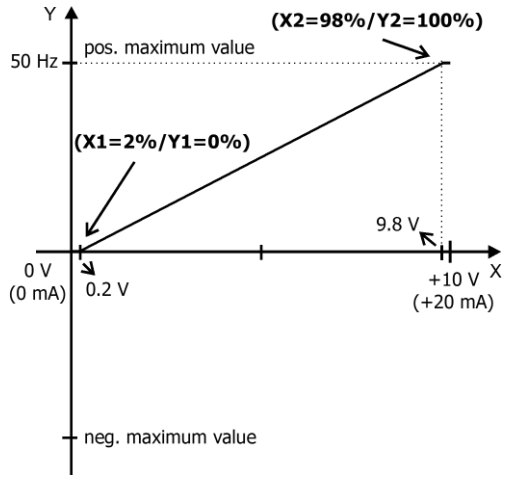
Point 1 with coordinates X1 and Y1 and point 2 with coordinates X2 and Y2 can be set in four data sets.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
454	Point X1	0.00 %	100.00 %	2.00 %
455	Point Y1	-100.00 %	100.00 %	0.00 %
456	Point X2	0.00 %	100.00 %	98.00 %
457	Point Y2	-100.00 %	100.00 %	100.00 %

The coordinates of the points relate, as a percentage, to the analog signal with 10 V or 20 mA and parameter *Maximum Frequency* **419** or parameter *Maximum Reference Percentage* **519**. The direction of rotation can be changed via the digital inputs and/or by selection of the points.

The monitoring of the analog input signal via the parameter *Error/Warning Behavior* **453** demands the examination of the parameter *Point X1* **454**

The following characteristic is set by default and can be adapted to the application via the parameters mentioned.



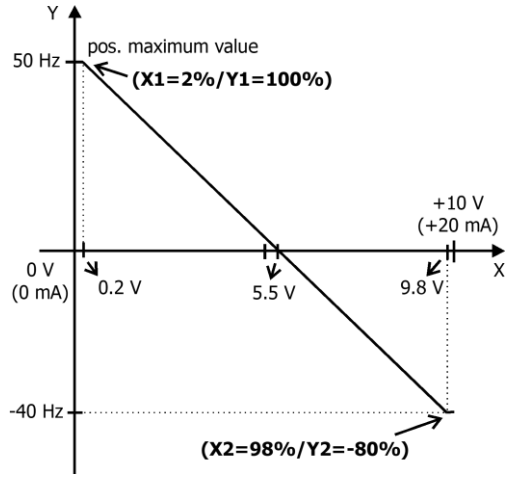
Point 1:

$$X1 = 2{,}00\% \cdot 10\ V = 0{,}20\ V$$
$$Y1 = 0{,}00\% \cdot 50{,}00\ Hz = 0{,}00\ Hz$$

Point 2:

$$X2 = 98{,}00\% \cdot 10\ V = 9{,}80\ V$$
$$Y2 = 100{,}00\% \cdot 50{,}00\ Hz = 50{,}00\ Hz$$

The freely configurable characteristic enables setting a tolerance at the ends as well as a reversal of the direction of rotation.
The following example shows the inverse reference value specification with additional reversal of the direction of rotation. This is often used in pressure control systems.



Point 1:

$$X1 = 2{,}00\% \cdot 10\ V = 0{,}20\ V$$
$$Y1 = 100{,}00\% \cdot 50{,}00\ Hz = 50{,}00\ Hz$$

Point 2:

$$X2 = 98{,}00\% \cdot 10\ V = 9{,}80\ V$$
$$Y2 = -80{,}00\% \cdot 50{,}00\ Hz = -40{,}00\ Hz$$

The change of direction of rotation is done in this example at an analog input signal of 5.5 V. pos./neg. maximum figure

The definition of the analog input characteristic can be calculated via the two-point form of the line equation. The speed Y of the drive is controlled according to the analog control signal X.

$$Y = \frac{Y2 - Y1}{X2 - X1} \cdot (X - X1) + Y1$$

16.1.2 Scaling

The analog input signal is mapped to the freely configurable characteristic. The maximum admissible setting range of the drive can be set via the frequency limits or percentage limits according to the configuration selected. In the case of the parameterization of a bipolar characteristic, the set minimum and maximum limits for both directions of rotation are effective. The percentage values of the characteristic points are relative to the limits selected.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
418	Minimum frequency	0.00 Hz	599.00 Hz	3.50 Hz [1)]
				0.00 Hz [2)]
419	Maximum frequency	0.00 Hz	599.00 Hz	50.00 Hz

The factory settings depend on the setup of parameter *Configuration* **30**:
[1)] 3.50 Hz in configurations 1xx, 4xx; [2)] 0.00 Hz in configurations 2xx, 5xx

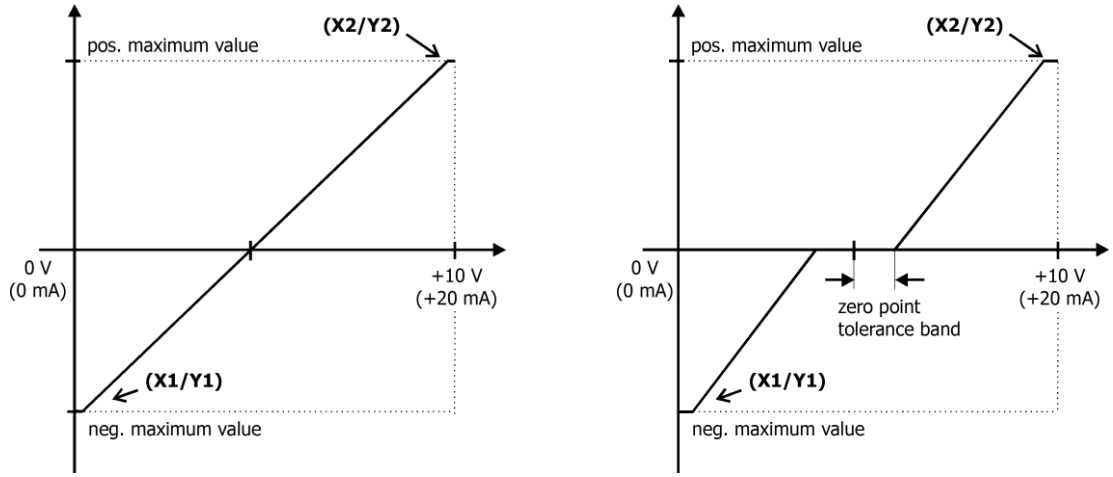
The control system uses the maximum value of the output frequency, which is calculated from the *Maximum Frequency* **419** and the compensated slip of the drive mechanism. The frequency limits define the speed range of the drive, and the percentage values supplement the scaling of the analog input characteristic in accordance with the functions configured.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
518	Minimum Reference Percentage	0.00%	300.00%	0.00%
519	Maximum Reference Percentage	0.00%	300.00%	100.00%

16.1.3 Tolerance Band and Hysteresis

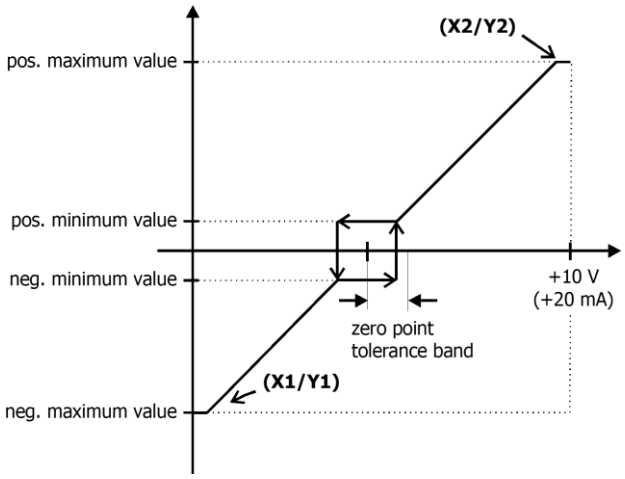
The analog input characteristic with change of sign of the reference value can be adapted by the parameter *Tolerance Band* **450** of the application. The adjustable tolerance band extends the zero passage of the speed relative to the analog control signal. The parameter value (percent) is relative to the maximum current or voltage signal.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
450	Tolerance Band	0.00%	25.00%	2.00%



Without tolerance band | With tolerance band

The default *Minimum Frequency* **418** or *Minimum Reference Percentage* **518** extends the parameterized tolerance band to the hysteresis.



Tolerance band with set maximum frequency

For example, the output variable coming from positive input signals is kept on the positive minimum value until the input signal becomes lower than the value for the tolerance band in the negative direction. Then, the output variable follows the set characteristic.

16.1.4 Filter time constant

The time constant of the filter for the analog reference value can be set via parameter *Filter time constant* **451** .

The time constant indicates the time during which the input signal is averaged by means of a low pass filter, e.g. in order to eliminate fault effects.

The setting range is between 0 ms and 5000 ms in 15 steps.

Filter time constant 451	Function
0 - Time constant 0 ms	Filter deactivated – analog reference value is forwarded unfiltered
2 - Time constant 2 ms	Filter activated – averaging of the input signal via the set value of the filter time constants.
4 - Time constant 4 ms	
8 - Time constant 8 ms	
16 - Time constant 16 ms	
32 - Time constant 32 ms	
64 - Time constant 64 ms	
128 - Time constant 128 ms	
256 - Time constant 256 ms	
512 - Time constant 512 ms	
1000 - Time constant 1000 ms	
2000 - Time constant 2000 ms	
3000 - Time constant 3000 ms	
4000 - Time constant 4000 ms	
5000 - Time constant 5000 ms	

16.1.5 Error and warning behavior

For monitoring the analog input signal, an operation mode can be selected via parameter *Error/Warning Behavior* **453** .

Error/Warning Behavior 453	Function
0 - off	The input signal is not monitored.
1 - Warning < 1V/2 mA	If the input signal is lower than 1 V or 2 mA, a warning message is issued.
2 - Shut Down < 1V/2 mA	If the input signal is lower than 1 V or 2 mA, a warning message is issued; the drive is decelerated according to stopping behavior 2.
3 - Error switch-off < 1V/2 mA	If the input signal is lower than 1 V or 2 mA, a warning and error signal is issued and the drive coasts to a standstill (stopping behavior 0).

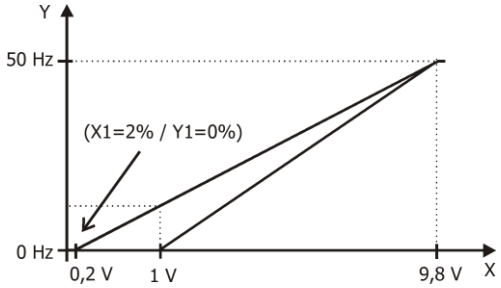
Monitoring of the analog input signal is active regardless of the release of the frequency inverter according to the operation mode selected.

Operation Mode 2 defines the shut-down and stopping of the drive, regardless of the setting of *parameter Operation Mode* **630** for the stopping behavior. The drive is stopped according to stopping behavior 2. If the set holding time has expired, an error message is issued. The drive can be started again by switching the start signal on and off.

Operation Mode 3 defines the free coasting of the drive, regardless of the setting of parameter *Operation Mode* **630** for the stopping behavior.

The monitoring of the analog input signal via the parameter *Error/Warning Behavior* **453** demands the examination of parameter *Point X1* **454**.

Example: *Error/Warning Behavior* **453 =** "2 - Shutdown < 1V/2mA" or "3 - Error-Switch-Off < 1V/2mA". In the default settings of parameter *Point X1* **454** shutting down or fault switch-off are effected at an output frequency ≠ 0Hz. If shutting down or fault switch-off are to be effected at an output frequency of 0 Hz, the Point X1 must be adjusted (e.g. X1=10% /1 V).



16.2 Multifunction Output MFO1

Multifunction output MFO1 can either be configured as a digital, analog or a repetition frequency output. Depending on the selected *Operation Mode* **550** for the multifunction output, a link to various functions of the software is possible. The operation modes not used are deactivated internally.

Operation Mode 550	Function
0 - off	Output has the logic signal LOW
1 - Digital	Digital output, 0 ... 24 V
2 - Analog	Analog output, 0 ... 24 V
3 - Repetition frequency	Repetition frequency output, 0 ... 24 V, f_{max} = 150 kHz

16.2.1 Analog Output MFO1A

By default, the multifunction output MFO1 is configured for the output of a pulse width modulated output signal with a maximum voltage of DC 24V.
The selected configuration determines which actual values can be selected for parameter *Analog Operation* **553** of Multifunction output 1.

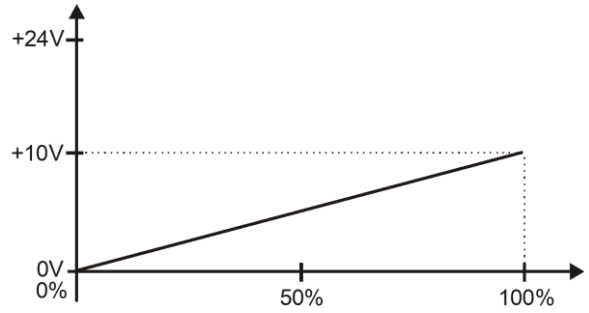
Analog Operation 553	Function
0 - off	Analog operation MFO1 is switched off.
1 - Abs. Fs	Abs. value of the Stator Frequency 0,00 Hz ... *Maximum Frequency* **419**.
2 - Abs. Fs betw. fmin/fmax	Abs. value of the Stator Frequency Minimum Frequency 418 ... *Maximum Frequency* 419.
3 - Abs. Speed Sensor 1	Abs. value of speed sensor signal 1, 0,00 Hz ... Maximum Frequency 419.
7 - Abs. actual frequency	Abs. value of act. frequency, 0,00 Hz ... Maximum Frequency 419.
20 - Abs. Iactive	Abs. value of current effective current I_{WIRK}, 0.0 A ... Inverter rated current.
21 - Abs. Isd	Abs. value of flux-forming current component, 0.0 A ... Inverter rated current.
22 - Abs. Isq	Abs. value of torque-forming current component, 0.0 A ... Inverter rated current.
30 - Abs. Pactive	Abs. value of current active power P_{WIRK}, 0.0 kW ... Rated Mech. Power 376.
31 - Abs. M	Abs. value of calculated torque M, 0.0 Nm ... rated torque.
32 - Abs. inside temperature	Abs. value of measured inside temperature, 0 °C ... 100 °C
33 - Abs. Heat Sink Temperature	Abs. value of measured heat sink temperature, 0 °C ... 100 °C
40 - Abs. value analog input MFI1A	Abs. signal value at analog input MFI1A, 0.0 V ... 10.0 V.
50 - Abs. I	Abs. current value of measured output currents, 0.0 A ... Inverter rated current.
51 - DC-Link Voltage	DC-Link Voltage U_d, 0.0 V ... 1000.0 V.
52 - U	Output voltage U, 0.0 V ... 1000.0 V.
53 - Volume Flow	Abs. value of calculated volume flow 0.0 m^3/h ... Nominal Volumetric Flow 397.
54 - Pressure	Abs. value of calculated pressure 0.0 kPa ... *Nominal Pressure* 398.
101 to 133	Operation modes in analog operation with signs.

16.2.1.1 Output Characteristic

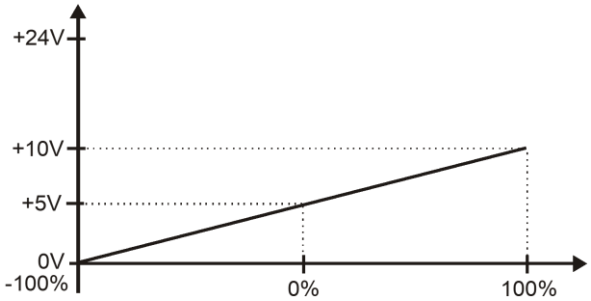
The voltage range of the output signal at multifunction output 1 can be adjusted. The value range of the actual value selected via *parameter Analog Operation* **553** is assigned to the value range of the output signal which is adjusted via the parameters *Voltage 100%* **551** and *Voltage 0%* **552**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
551	Voltage 100%	0.0 V	22.0 V	10.0 V
552	Voltage 0%	0.0 V	24.0 V	0.0 V

Analog Operation **553** with abs. actual value:



Analog Operation **553** with sign:



With parameters *Voltage 100%* **551** and *Voltage 0%* **552** the voltage range at 100% and 0% of the output parameter is set. If the output value exceeds the reference value, the output voltage also exceeds the value of the parameter *Voltage 100%* **551** up to the maximum value of 24 V.

16.2.2 Frequency Output MFO1F

Multifunction output MFO1 can be used as a frequency output by setting parameter *Operation Mode* **550** = "3 - Repetition Frequency". The DC 24 V output signal is assigned to the absolute speed/frequency value via parameter *Repetition Freq. Operation* **555**. The selection of the operation modes depends on the extension modules installed as an option.

Repetition Freq. Operation 555	Function
0 - off	Repetition frequency operation MFO1 switched off
1 - Actual frequency	Abs. value of *Actual Frequency* **241**.
2 - Stator Frequency	Abs. value of *Stator Frequency* **210**.
3 - Frequency Speed Sensor 1	Abs. value of *Encoder 1 Frequency* **217**.
5 - Repetition frequency input	Abs. value of *Repetition Frequency Input* **252**.

16.2.2.1 Scaling

The repetition frequency mode for the multifunction output corresponds to the emulation of an incremental sensor. Parameter *Division Marks* **556** must be set according to the frequency to be output. The minimum frequency of *Repetition Freq. Operation* is 30 Hz. Smaller values will be output as 0 Hz. The pulse-pause ratio is not 1:1. For this reason, *Repetition Freq. Operation* should only be evaluated with the rising or falling edge in the evaluation device.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
556	Division Marks	30	8192	1024

The frequency limit of f_{max}=150 kHz must not be exceeded in the calculation of parameter *Division Marks* **556**.

$$S_{max} = \frac{150000\ \text{Hz}}{\text{Frequency value}}$$

16.3 Digital Outputs

Op.Mode Digital Output 1 **530** and the relay output with parameter *Op.Mode Digital Output 3* **532** link the digital outputs to various functions. The selection of the functions depends on the parameterized configuration. When multifunction output MFO1 is to be used as a digital output, an *Operation Mode* **550** must be selected and linked via parameter *Digital Operation* **554**.

Operation mode 530, 532, 554		Function
0 -	off	Digital output is switched off
1 -	Ready or Standby Signal	Frequency inverter is initialized and on stand-by or in operation
2 -	Run Signal	Signal enable STO (S1IND/STOA and S7IND/STOB) and a start command are present, output frequency available.
3 -	Error Signal	Message is displayed via parameter *Current Error* **259** and *Warnings* **269.**
4 -	Setting Frequency	The *Stator Frequency* **210** is higher than the parameterized Setting Frequency 510.
5 -	Reference frequency reached	The *Actual Frequency* **241** of the drive has reached the *Internal Reference Frequency* **228.**
6 -	Reference percentage reached	The *Actual Percentage Value* **230** has reached the *Reference Percentage Value* **229.**
7 -	Ixt warning	The *Warning Limit Short Term Ixt* **405** or *Warning Limit Long Term Ixt* **406** were reached.
8 -	Warning Heat Sink Temperature	Max. heat sink temperature T_K of 80 °C minus Warning Limit *Heat Sink Temp.* **407** reached.
9 -	Inside temperature warning	Max. Inside Temperature T_i of 65 °C minus Warning Limit *Inside Temp.* **408** reached.
10 -	Motor temperature warning	Waring behavior as per configured Motor Temp. Operation Mode 570 at max. motor temperature T_{PTC}.
11 -	General warning	Message is displayed via parameter *Warnings* **269**.
12 -	Warning overtemperature	The selected *Warning Limit Heat Sink Temp.* **407,** *Warning Limit Inside Temp.* **408** or maximum motor temperature were exceeded.
13 -	Mains failure	Failure of the mains voltage and power regulation active according to *Operation Mode* **670 for** the voltage controller.
14 -	Warning motor circuit breaker	Parameterized *Operation Mode* **571** for motor circuit breaker was triggered.
15 -	Warning current limitation	A controller or *Operation Mode* **573** of the intelligent current limits limit the output current.
16 -	Controller current limit. long term Ixt	The overload reserve for 60 s has been used up and the output current is being limited.
17 -	Controller current limit. short term Ixt	The overload reserve for 1 s has been used up and the output current is being limited.
18 -	Controller current limit Tk	Max. heat sink temperature T_K reached, intelligent current limits of *Operation Mode* **573** active.
19 -	Controller current limit. motor temp.	Max. motor temperature reached, intelligent current limits of *Operation Mode* **573** active.
20 -	Comparator 1	The comparison according to the selected *Op.Mode Comparator 1* **540** is true.
21 -	Comparator 2	The comparison according to the selected *Op.Mode Comparator 2* **543** is true.
22 -	Warning V-belt	Warning of *Operation Mode* **581** of V-belt Montoring.
23 -	Timer 1	The selected *Operation Mode Timer 1* **790** generates an output signal of the function.
24 -	Timer 2	The selected *Operation Mode Timer 2* **793** generates an output signal of the function.
25 -	Warning mask	Message of the configurable parameter Create Warning Mask 536.
26 -	Warning, application	A warning application is signaled. Display of the actual value is effected via parameter *Application Warnings* **273**.
27 -	Warning mask, application	Message of the configurable parameter *Create Appl. Warning Mask* **626**.
28 -	Warning gen. + warning appl.	A warning or warning application is signaled.
29 -	Warning mask gen. + Warning mask appl.	Message of configurable parameters Create Warning Mask 536 and *Create Appl. Warning Mask* **626**.

Operation mode 530, 532, 554	Function
30 - Flux forming finished	Magnetic field has been impressed.
41 - Release brake	Activation of a brake unit depending on Operation Mode 620 for the staring behavior, *Operation Mode* **630** for the stopping behavior or the configured brake control system.
43 - External fan	The *Switch-On Temperature* **39** was reached.
50 - Synchronization Fault [1]	The phase error of the index control exceeded the *Warning Level* **597**.
51 - Signal Fault [1]	Index signal period too short during index control.
56 - Phasing Done [2]	Message of phasing function. For positioning in combination with the function of the electronic gear, the value *Phasing: Offset* **1125** was reached.
57 - In Gear [1] [2]	Synchronization of the electronic gear is reached. The slave drive is engaged and operates at a synchronous angle with the master.
58 - Position Comparator [2]	The current actual value is in the range between *On-Position* **1243** to *Off-Position* **1244** of the position comparator. The set value of parameter *Hysteresis* **1245** is considered.
59 - Homing DONE [2]	Homing was started and the reference position for a positioning operation was set.
60 - Target Position Reached	The *Reference orientation* **469** of axis positioning was reached or the *Target Position / Distance* **1202** of a positioning operation [2] was reached (current actual position is within the range set in parameter *Target Window* **1165** for a minimum time of *Target Window Time* **1166**).
61 - Warning Deviation of Position [2]	The contouring error monitoring *Warning Threshold* **1105** was exceeded.
62 - Motion-Block Digital Signal 1 [2]	Message on status of a travel order during a positioning operation. The requirements set for parameter Digital Signal 1 **1218** were met. "Start", "Reference value reached" and "End" of a motion block were evaluated.
63 - Motion-Block Digital Signal 2 [2]	Message on status of a travel order during a positioning operation. The requirements set for parameter Digital Signal 2 **1219** were met. "Start", "Reference value reached" and "End" of a motion block were evaluated.
64 - Motion-Block Digital Signal 3 [2]	Message on status of a travel order during a positioning operation. The requirements set for parameter Digital Signal 3 **1247** were met. "Start", "Reference value reached" and "End" of a motion block were evaluated.
65 - Motion-Block Digital Signal 4 [2]	Message on status of a travel order during a positioning operation. The requirements set for parameter Digital Signal 4 **1248** were met. "Start", "Reference value reached" and "End" of a motion block were evaluated.
80 - FT-Outp.Buffer 1 [3]	Output signal of a FT instruction. Signal source "2401 - FT output buffer 1" is the output signal. This signal source contains the output value of the FT-instruction assigned to signal source 2401. Assignment is done via parameter *FT-target output 1* **1350** or *FT-target output 2* **1351**.
81 - FT-Outp.Buffer 2 [3]	Output signal of a FT instruction. Signal source "2402 - FT output buffer 2" is the output signal. This signal source contains the output value of the FT-instruction assigned to signal source 2402. Assignment is done via parameter *FT-target output 1* **1350** or *FT-target output 2* **1351**.
82 - FT-Outp.Buffer 3 [3]	Output signal of a FT instruction. Signal source "2403 - FT output buffer 3" is the output signal. This signal source contains the output value of the FT-instruction assigned to signal source 2403. Assignment is done via parameter *FT-target output 1* **1350** or *FT-target output 2* **1351**.
83 - FT-Outp.Buffer 4 [3]	Output signal of a FT instruction. Signal source "2404 - FT output buffer 4" is the output signal. This signal source contains the output value of the FT-instruction assigned to signal source 2404. Assignment is done via parameter *FT-target output 1* **1350** or *FT-target output 2* **1351**.
90 Obj 0x3003 DigOut 1 [4] to to 94 Obj 0x3003 DigOut 5	Sources of CAN objects. Required for communication module CM with CAN interface
100 to 194	Operation modes inverted (LOW active).

[1] Refer to application manual "Electronic Gear".
[2] Refer to application manual "Positioning".
[3] Refer to application manual "Function Table".
[4] Refer to Operating Instructions on extension modules with CAN interface.

16.3.1 Digital message

The signals selected for parameters *Op.Mode Digital Output 1* **530,** *Digital Operation* **554** and *Op.Mode Digital Output 3* **532** can be linked to one another.

Signal digital output 1		
175 -	Digital Signal 1	Signal selected via *Op.Mode Digital Output 1* **530**.

Signal at multifunction output MFO1		
176 -	Digital Signal 2	Signal selected via *Digital Operation* **554**. Adjustment: *Operation Mode* **550** = 1 - Digital

Signal at digital output 3 (relay output)		
177 -	Digital Signal 3	Signal selected via *Op.Mode Digital Output 3* **532**.

With extension module:

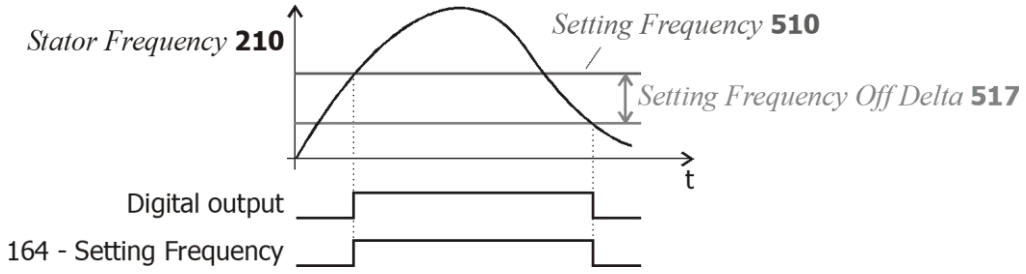
Signal at digital output 1 of an extension module		
181 -	Digital message 4, EM-Module	Signal selected via *Op.Mode EM-S1OUTD* **533** .

Signal at digital output 2 of an extension module		
182 -	Digital message 5, EM-Module	Signal selected via *Op.Mode EM-S2OUTD* **534** .

16.3.2 Setting Frequency

If Operation Mode 4 - "Setting Frequency" is selected for a digital output , the relevant output will be active once the actual value *Stator Frequency* **210** is higher than the value of *Setting Frequency* **510**.
The output will be switched again once the *Stator Frequency* **210** drops below the value "*Setting Frequency* **510** minus *Setting Frequency Off Delta* **517**". Once the output stages are switched off (e.g. via STO), the digital signal "Setting Frequency" is set to zero, regardless of the actual frequency.
Signal source 164 - "Setting frequency" can be linked to the functions of the frequency inverter.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
510	Setting Frequency	0.00 Hz	599.00 Hz	3.00 Hz
517	Setting Frequency Off Delta	0.00 Hz	599.00 Hz	2.00 Hz



Once *Setting Frequency Off Delta* **517** > *Setting Frequency* **510**, the output will not turned off anymore after first activation. Make sure you use suitable values during parameterization.

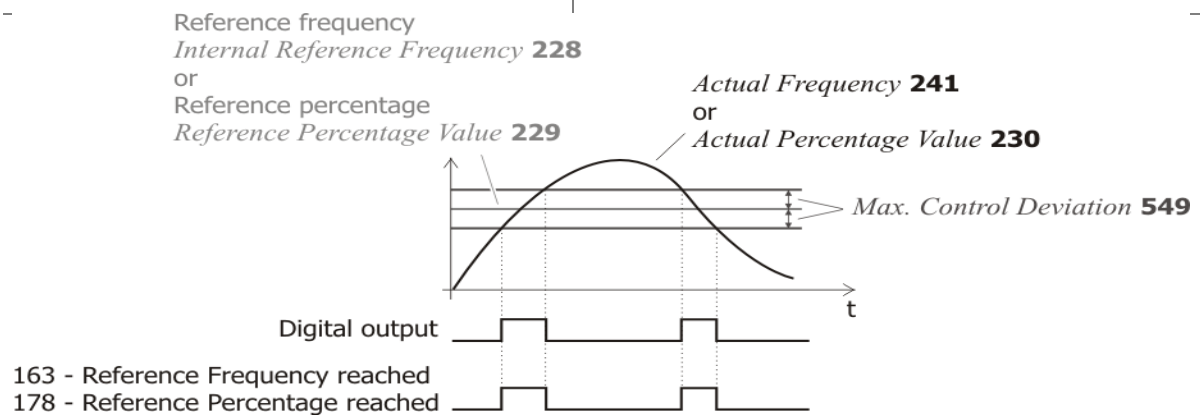
OP.Mode Digital Output 1 **530**	or	4 - Setting frequency
OP.Mode Digital Output 2 **531**	or	
OP.Mode Digital Output 3 **532**		
With extension module:		
OP.Mode EM-S1OUTD **533**	or	
OP.Mode EM-S1OUTD **534**		
Setting Frequency510		set value [Hz].
For linking to functions		164 - Setting frequency

16.3.3 Reference value reached

In Operation Mode 5 - "Reference Frequency reached" for a digital output , a message will be generated via the relevant output once the actual frequency has reached the setpoint.
In Operation Mode 6 - "Reference Percentage reached" for a digital output , a message is generated via the corresponding output when the actual percentage has reached the reference value.
Signal source 163 - "Reference frequency reached" or 178 - "Reference percentage reached" can be linked to the functions of the frequency inverter.
The hysteresis can be defined as a percentage of the adjustable range (Max - Min) via the parameter *Max. Control Deviation* **549** .

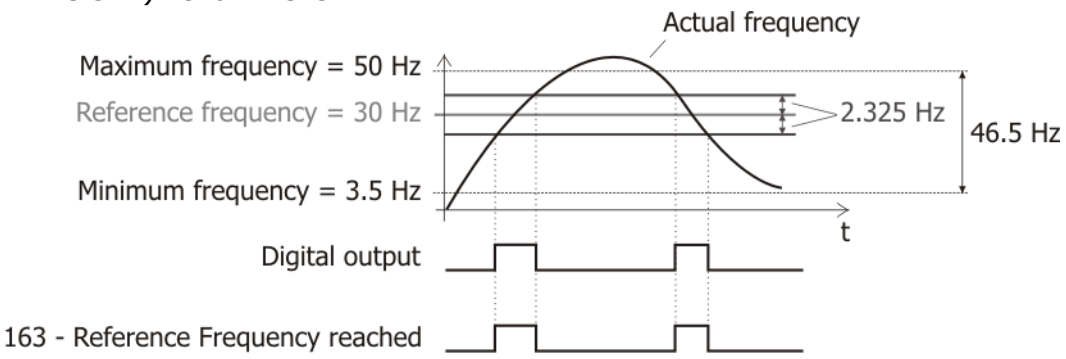
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
549	Max. Control Deviation	0.01%	20.00%	5.00%

OP.Mode Digital Output 1 **530**	or	5 - Reference Frequency reached or 6 - Reference Percentage reached (*Configuration* **30** = x11, x30)
OP.Mode Digital Output 2 **531**	or	
OP.Mode Digital Output 3 **532**		
With extension module:		
OP.Mode EM-S1OUTD **533**	or	
OP.Mode EM-S1OUTD **534**		
Max. Control Deviation **549**		set value [%].
For linking to functions		163 - Reference Frequency reached or 178 - Reference Percentage reached (*Configuration* **30** = x11, x30)



Example:

$$\text{Max. Control Deviation [Hz]} = \Delta f \times \textit{Max. Control Deviation } \textbf{549}\ [\%]$$
$$= (\textit{Maximum Frequency } \textbf{419} - \textit{Minimum Frequency } \textbf{418}) \times \textit{Max. Control Deviation } \textbf{549}\ [\%]$$
$$= (50\,\text{Hz} - 3.5\,\text{Hz}) \times 5\% = 2.325\,\text{Hz}$$



16.3.4 Flux forming finished

If *Operation Mode* **30** is selected for a digital output, the corresponding output becomes active when the flux formation is finished. The time for the flux formation results from the operating state of the machine and the set parameters for magnetizing the machine. The magnetizing can be defined via the starting behavior and is influenced by the amount of the set starting current.

16.3.5 Brake release

The Brake release function in *Operation Mode* **41** enables the activation of a corresponding unit via the digital control output. The function uses both the control commands via the contact inputs and the set starting and stopping behavior for controlling the digital output.
According to the configured starting behavior, the output is switched on when the magnetizing of the motor is finished. Once the *Brake Release Time* **625** has elapsed, the drive will be accelerated.
The stopping behavior of the drive depends on the configuration of the parameters *Operation Mode* **630**. This is described in chapter 13.2.
If stopping behavior 2 or 5 with stop function is selected, the drive is controlled to zero speed and the digital output is not switched off. In the other operation modes of the stop behavior, the control of the brake is possible. At the start of a free coasting of the drive, the digital output is switched off.
This is similar to the behavior in the case of the stopping behavior with shutdown. The drive is decelerated and supplied with current for the set holding time. Within the set holding time, the control output is switched off and thus the brake activated.

Control of Brake	
Stopping behavior 0	Operation Mode "41-Brake release" switches off the digital output assigned to the function immediately. The mechanical brake is activated.
Stopping behavior 1, 3, 4, 6, 7	Operation Mode "41-Brake release" switches off the digital output assigned to the function once the Switch-off threshold stop function 637 is reached. The mechanical brake is activated.
Stopping behavior 2, 5	Operation Mode "41-Brake release" leaves the digital output assigned to the function switched on. The mechanical brake remains open.

16.3.6 Current limitation

Operation Modes 15 to 19 link the digital outputs and the relay output to the functions of the intelligent current limits. The reduction of power by the set figure in percent of the rated current depends on the selected operation mode. Accordingly, the event for intervention of the current limitation can be output via the operation modes of the digital outputs. If the function of the intelligent current limits is deactivated within the sensorless control, operation modes 16 to 19 are switched off in the same way.

16.3.7 External fan

Operation Mode 43 enables control of an external fan. Via the digital output, the fan is switched on if the controller is released and Start clockwise or Start anticlockwise are switched on, or if the *Switch-On Temperature* **39** for the internal fan was reached.

16.3.8 Warning mask

The warning mask signals, via a digital signal, if a pre-configured warning is present. The warning mask is configured via *Create Warning Mask* **536**. Warnings and controller status messages can be combined. This enables internal or external control using a common output signal. The display of **269** *Warning* and **275** *Controller Status* is not influenced via the warning mask.
Select one of the settings 1 … 43 to activate messages.
Select one of the Operation Modes 101 … 143, if certain warnings are not to be reported.

Create Warning Mask 536		Function
0 -	No change	Configured warning mask is not modified.
1 -	Activate everything	The warnings and controller status messages stated are linked in the warning mask.
2 -	Activate all warnings	The warnings reports stated are linked in the warning mask.
3 -	Activate all controller states	The controller status reports stated are linked in the warning mask.
10 -	Warning Ixt	The frequency inverter is overloaded
11 -	Warning short-term Ixt	Overload reserve for 1 s minus the *Warning Limit Short Term Ixt* **405** was reached.
12 -	Warning long-term Ixt	Overload reserve for 60 s minus the *Warning Limit Long Term Ixt* **406** was reached.
13 -	Warning heat sink temperature	Max. heat sink temperature TK of 80 °C minus the *Warning Limit Heat Sink Temp.* **407** was reached.
14 -	Warning inside temperature	Max. Inside Temperature T_i of 65 °C minus *Warning Limit Inside Temp.* **408** reached.
15 -	Warning limit	The controller stated in *Controller Status* **355** limits the reference value.
16 -	Warning Init	Frequency inverter is being initialized
17 -	Motor temperature warning	Waring behavior as per configured *Motor Temp. Operation Mode* **570** at max. motor temperature T_{PTC}.
18 -	Warning Mains Failure	Phase *Supervision* **576** reports mains failure.
19 -	Warning Motor Protection	*Operation Mode* **571** for motor circuit breaker was triggered.
20 -	Warning Fmax	The *Maximum Frequency* **419** was exceeded. The frequency limitation is active
21 -	Warning Analog Input MFI1A	The input signal is lower than 1V/2mA according to the operation mode *Error/Warning Behavior* **453**.
22 -	Warning Analog Input EM-S1INA	The input signal at the analog input of an extension module is lower than 1V/2mA according to the operation mode *Error -/Warning Behavior* **453**.
23 -	Warning System Bus	A slave on the system bus reports a fault; warning is only relevant with the EM-SYS option.
24 -	Warning Udc	The DC link voltage has reached the type-dependent minimum value.
25 -	Warning, application	A warning application is signaled.
30 -	Controller Udc Dynamic Operation	Controller is active according to the *Operation Mode* **670** for the voltage controller.
31 -	Controller shutdown	The output frequency in the case of a power failure is below the *Shutdown threshold* **675**.
32 -	Controller mains failure	Failure of the mains voltage and power regulation active according to *Operation Mode* **670** for the voltage controller.
33 -	Controller Udc limitation	The DC link voltage has exceeded the *Reference DC-Link Limitation* **680**.
34 -	Controller Voltage Pre-Control	The *Dyn. Voltage Pre-Control* **605** accelerates the control characteristics.
35 -	Controller I abs	The output current is limited
36 -	Controller Torque Limitation	The output power or the torque are limited by the speed controller
37 -	Controller Torque Control	Switch-over of field-oriented control between speed and torque-controlled control method.

Create Warning Mask 536	Function
38 - Ramp stop	The *Operation mode* **620** selected in starting behavior limits the output current.
39 - Contr. intel. curr. lim. LT-Ixt	Overload limit of the long-term Ixt (60s) reached, intelligent current limits active
40 - Contr. intel. curr. lim. ST-Ixt	Overload limit of the short-term Ixt (1s) reached, intelligent current limits active.
41 - Contr. intel. curr. lim. Tc	Max. heat sink temperature T_K reached, *Operation Mode* **573** for intelligent current limits active.
42 - Contr. intel. curr. lim. motor temp.	Max. motor temperature T_{PTC} reached, *Operation Mode* **573** for intelligent current limits active.
43 - Controller Frequ. Limitation	The reference frequency has reached the *Maximum Frequency* **419**. The frequency limitation is active.
101 to 143	Removal or deactivation of the operation mode within the warning mask

The current warning mask can be read via parameter *Actual Warning Mask* **537**. The above Operation Modes of parameter *Create Warning Mask* **536** are encoded in the *Actual Warning Mask* **537**. The code is calculated by hexadecimal addition of the individual operation modes and the corresponding abbreviation

Warning code				Create Warning Mask 536	
A	FFFF	FFFF	-	1 -	Activate everything
A	0000	FFFF	-	2 -	Activate all warnings
A	FFFF	0000	-	3 -	Activate all controller states
A	0000	0001	Ixt	10 -	Warning Ixt
A	0000	0002	IxtSt	11 -	Warning short-term Ixt
A	0000	0004	IxtLt	12 -	Warning long-term Ixt
A	0000	0008	Tc	13 -	Warning heat sink temperature
A	0000	0010	Ti	14 -	Warning inside temperature
A	0000	0020	Lim	15 -	Warning limit
A	0000	0040	INIT	16 -	Warning Init
A	0000	0080	MTemp	17 -	Motor temperature warning
A	0000	0100	Mains	18 -	Warning mains failure
A	0000	0200	PMS	19 -	Warning motor circuit breaker
A	0000	0400	Flim	20 -	Warning Fmax
A	0000	0800	A1	21 -	Warning analog input MFI1A
A	0000	1000	A2	22 -	Warning analog input MFI2A
A	0000	2000	Sysbus	23 -	Warning system bus
A	0000	4000	UDC	24 -	Warning Udc
A	0000	8000	WARN2	25 -	Warning, application
A	0001	0000	UDdyn	30 -	Controller Udc dynamic operation
A	0002	0000	UDstop	31 -	Controller shutdown
A	0004	0000	UDctr	32 -	Controller mains failure
A	0008	0000	UDlim	33 -	Controller Udc limitation
A	0010	0000	Boost	34 -	Controller voltage pre-control
A	0020	0000	Ilim	35 -	Controller I abs
A	0040	0000	Tlim	36 -	Controller torque limitation
A	0080	0000	Tctr	37 -	Controller torque control
A	0100	0000	Rstp	38 -	Ramp stop
A	0200	0000	IxtLtlim	39 -	Contr. intel. curr. lim. LT-Ixt
A	0400	0000	IxtStlim	40 -	Contr. intel. curr. lim. ST-Ixt
A	0800	0000	Tclim	41 -	Contr. intel. curr. lim. Tc
A	1000	0000	MtempLim	42 -	Contr. intel. curr. lim. motor temp.
A	2000	0000	Flim	43 -	Controller Freq. Limitation

Output signals
The output of a warning is signaled.

157 - 25 -	Warning mask	1) 2)	Output of warning activated in *Create Warning Mask* **536**.

1) For linking to frequency inverter functions
2) For output via a digital output.

Parameters *Warning* **269** and *Warning* **356** (Error Environment) display the warnings independent of the created warning mask.
Parameters *Controller Status* **275** and *Controller Status* **355** (Error Environment) display the controller status independent of the created warning mask.

16.3.9 Warning mask, application

The application warning mask signals, via a digital signal, if a pre-configured warning is present. The application warning mask is configured via *Create Appl. Warning Mask* **626**.
As soon as limit switches are reached or contouring error thresholds are exceeded, a warning can be issued. The warning signal refers to the parameter values set in error/warning behavior. Depending on the application, any number of warnings can be configured. This enables internal and/or external control using a common output signal. The display of *Application Warnings* **273** is not influenced via the warning mask.

Create Appl. Warning Mask 626		Function
0 -	no change	The configured warning mask is not changed.
2 -	Activate all warnings	The warnings reports stated are linked in the warning mask.
10 -	Warning V-belt	Operation Mode 581 signals no-load operation of the application.
11 -	Warning pos. SW limit switch 1)	Warning message indicating that the positive SW limit switch has been reached (parameter *Pos. SW Limit Switch* **1145**).
12 -	Warning neg. SW limit switch 1)	Warning message indicating that the negative SW limit switch has been reached (parameter *Neg. SW Limit Switch* **1146**).
13 -	Warning pos. HW limit switch 1)	Warning message indicating that the positive HW limit switch has been reached.
14 -	Warning neg. HW limit switch 1)	Warning message indicating that the negative HW limit switch has been reached.
15 -	Warning Contouring Error 1)	Warning message, indicating that the contouring error monitoring range adjusted with parameter *Warning Threshold* **1105** has been left.
16 -	Warning Encoder	An encoder with data track can generate a warning. Selection is not effective in the case of encoders without data track.
17 -	User Warning 1	The signal set at digital input *User Warning 1* **1363** is active.
18 -	User Warning 2	The signal set at digital input *User Warning 2* **1364** is active.
102 -	Deactivate all warnings	All warnings are deactivated.
110 -	Deactivate warning V-Belt	Warning 10 is deactivated.
111 -	Deactivate warning pos. SW limit switch	Warning 11 is deactivated.
112 -	Deactivate warning neg. SW limit switch	Warning 12 is deactivated.
113 -	Deactivate warning pos. HW limit switch	Warning 13 is deactivated.
114 -	Deactivate warning neg. HW limit switch	Warning 14 is deactivated.
115 -	Deactivate Warning Contouring Error	Warning 15 is deactivated.
116 -	Deactivate Warning Encoder	Warning 16 is deactivated.
117 -	Deactivate User Warning 1	Warning 17 is deactivated.
118 -	Deactivate User Warning 2	Warning 18 is deactivated.

1) Refer to the application manual "Positioning".

The current application warning mask can be read via parameter *Actual Appl. Warning Mask* **627**. The Operation Modes of parameter *Create Appl. Warning Mask* **626** are encoded in the *Actual Appl. Warning Mask* **627**. The code is calculated by hexadecimal addition of the individual operation modes and the corresponding abbreviation

Warning code			Create Appl. Warning Mask 626	
A	003F	-	2 -	Activate all warnings
A	0001	BELT	10 -	Warning V-belt
A	0002	SW-LIM CW	11 -	Warning pos. SW limit switch
A	0004	SW-LIM CCW	12 -	Warning neg. SW limit switch
A	0008	HW-LIM CW	13 -	Warning pos. HW limit switch
A	0010	HW-LIM CCW	14 -	Warning neg. HW limit switch
A	0020	CONT	15 -	Warning position controller
A	0040	Enc	16 -	Warning Encoder
A	0080	User 1	17 -	User Warnig 1
A	0100	User 2	18 -	User Warnig 2

Output signals

The output of a warning is signaled.

215 - 27 -	Warning mask, application	1) 2)	Output of warning activated in *Create Appl. Warning Mask* **626**.

1) For linking to frequency inverter functions
2) For output via a digital output.

Parameter *Application Warnings* **273** displays the application warning regardless of the warning mask created. In the error environment, *Application Warning Status* **367** displays the current warnings of the positioning functions.

16.4 Digital Inputs

The assignment of the control signals to the available software functions can be adapted to the application in question. Depending on the *Configuration* **30** selected, the default assignment or selection of the operation mode differ. In addition to the available digital control inputs, further internal logic signals are available as sources.

Each of the individual software functions is assigned to the various signal sources via parameterizable inputs. This enables a flexible use of the digital control signals.

Digital Inputs			Function
6 -	On		Signal input is switched on.
7 -	off		Signal input is switched off.
13 -	Technology Controller Start		Start command technology controller (configuration 111, 211 or 411)
70 -	FI release	1)	Signal at digital inputs S1IND/STOA (X210A.3) and S7IND/STOB (X210B.2). Safety function STO - "Safe Torque Off" is linked permanently.
71 -	S2IND		Signal at digital input S2IND (X210A.4) or remote operation via communication interface.
72 -	S3IND		Signal at digital input S3IND (X210A.5) or remote operation via communication interface.
73 -	S4IND		Signal at digital input S4IND (X210A.6) or remote operation via communication interface.
74 -	S5IND		Signal at digital input S5IND (X210A.7) or remote operation via communication interface.
75 -	S6IND		Signal at digital input S6IND (X210B.1) or remote operation via communication interface.
76 -	MFI1D		Signal at multifunction input MFI1 (X210B.6) in *Operation Mode* **452** = "3 - Digital Input" or remove operation via communication interface.
157 -	Warning mask		The defined warning mask of parameter *Create Warning Mask* **536** signals a critical operating point.
158 -	Timer 1		Output signal of the time function according to the input link *Timer 1* **83**.
159 -	Timer 2		Output signal of the time function according to the input link *Timer 2* **84**.
160 -	Standby Message		Frequency inverter is initialized and ready for operation.
161 -	Run Signal		Signal enable STO (S1IND/STOA and S7IND/STOB) and a start command are present, output frequency available.
162 -	Error Signal		Monitoring function signals an operational fault.
163 -	Reference frequency reached		Signal indicating when *Actual Frequency* **241** has reached the reference frequency.
164 -	Setting Frequency		Signal indicating when the actual value *Stator Frequency* **210** exceeds the value of *Setting Frequency* **510**.

Digital Inputs		Function	
165 -	Warning Ixt	The monitoring functions report an overload of the frequency inverter	
166 -	Heat sink temperature warning	Max. heat sink temperature T_K of 80 °C minus the *Warning Limit Heat Sink Temp. Tk* **407** reached.	
167 -	Warning Inside Temperature	Max. inside temperature T_i of 65 °C minus the *Warning Limit Inside Temp.* **408** reached.	
168 -	Warning Motor Temperature	Warning behavior according to parameterized *Motor Temp. Operation Mode* **570** at max. motor temperature $T_{PTC.}$	
169 -	General Warning	Signal indicating that *Warnings* **269** are displayed at critical operating points.	
170 -	Warning overtemperature	The value – "80 °C minus *Warning Limit Heat Sink Temp. Tk* **407**" or – "65 °C minus *Warning Limit Inside Temp. Ti* **408**" was reached.	
171 -	Output Comparator 1	The comparison according to the selected *OP.Mode Comparator 1* **540** is true.	
172 -	Negated Output Comparator 1	Operation mode 171 with inverted logic (LOW active)	
173 -	Output Comparator 2	The comparison according to the selected *OP.Mode Comparator 2* **543** is true.	
174 -	Negated Output Comparator 2	Operation mode 173 with inverted logic (LOW active)	
175 -	Digital Signal 1	Signal according to parameterized *OP.Mode Digital Output 1* **530**.	
176 -	Digital Signal 2	Signal according to parameterized *Digital Operation* **554** at multifunction output MFO1.	
177 -	Digital Signal 3	Signal according to parameterized *OP.Mode Digital Output 3* **532**.	
178 -	Reference Percentage reached	Signal indicating that *Actual Percentage Value* **230** has reached *the Reference Percentage Value* **229** .	
179 -	Power Failure	Failure of mains voltage and mains support active according to *Operation Mode* **670** for the voltage controller.	
180 -	Warning Motor Protection	Parameterized *Operation Mode* **571** of motor circuit breaker triggered.	
181 -	Digital Signal 4, EM-Module	Signal according to operation mode for the digital output of an extension module	
182 -	Digital Signal 5, EM-Module	Signal according to operation mode for the digital output of an extension module	
215 -	Warning mask, application	The defined warning mask of parameter *Create Appl. Warning Mask* **626** signals a critical operating point.	
216 -	Warning, application	All warnings application are deactivated. Display is effected via parameter *Application Warnings* **273**.	
270 to 276		Operation modes 70 to 76 of the digital inputs inverted (LOW active).	
282 -	Target Position Reached	*Reference orientation* **469** of axis positioning was reached or	
		Target Position / Distance **1202** of a positioning operation was reached (the current act. position is within the range set in parameter *Target Window* **1165** for a minimum period of *Target Window Time* **1166**.	2)
284 -	STOA inverted	Inverted signal status on digital input S1IND/STOA (first shut-down path STOA of safety function STO - "Safe Torque Off").	3)
285 -	STOB inverted	Inverted signal status on digital input S7IND/STOB (second shut-down path STOB of safety function STO - "Safe Torque Off").	
292 -	STOA	Signal status on digital input S1IND/STOA (first shut-down path STOA of safety function STO - "Safe Torque Off").	
293 -	STOB	Signal status on digital input S7IND/STOB (second shut-down path STOB of safety function STO - "Safe Torque Off").	
320 -	EM-S1IND	Signal at digital input 1 of an extension module EM or remote operation via communication interface.	4)
321 -	EM-S2IND	Signal at digital input 2 of an extension module EM or remote operation via communication interface.	
322 -	EM-S3IND	Signal at digital input 3 of an extension module EM or remote operation via communication interface.	
520 -	EM-S1IND inverted	Operation mode 320 inverted.	
521 -	EM-S2IND inverted	Operation mode 321 inverted.	
522 -	EM-S3IND inverted	Operation mode 322 inverted.	
526 -	S2IND (Hardware)	Digital input S2IND (X210A.4)	5)
527 -	S3IND (Hardware)	Digital input S3IND (X210A.5)	

Digital Inputs			Function
528 -	S4IND (Hardware)		Digital input S4IND (X210A.6)
529 -	S5IND (Hardware)		Digital input S5IND (X210A.7)
530 -	S6IND (Hardware)		Digital input S6IND (X210B.1)
531 -	MFI1D (Hardware)		Multifunction input MFI1 (X210B.6) in *Operation Mode* **452** = 3 – Digital input.
532 -	EM-S1IND (Hardware)		Digital input 1 of an extension module EM.
533 -	EM-S2IND (Hardware)		Digital input 2 of an extension module EM.
534 -	EM-S3IND (Hardware)		Digital input 3 of an extension module EM.
538 to 546			Operation modes 526 to 534 of the digital inputs inverted (LOW active).
604 -	Warning position controller	6)	Contouring error supervision message. The range set with parameter *Warning Threshold* **1105** was left.
614 -	Homing Done		Homing was started and the reference position for a positioning operation was set.
615 -	Homing Requested		Homing was started Signal will be reset once homing is completed.
616 -	Phasing done		Message of phasing function. For positioning in combination with the function of the electronic gear, the value *Phasing: Offset* **1125** was reached.
624 -	In gear	7)	Synchronization of the electronic gear is reached. The slave drive is engaged and operates at a synchronous angle with the master.
640 to 655	Out-PZD3Boolean to Out-PZD18Boolean	8)	Process data for Profibus communication. Module CM-PDP-V1 with Profibus interface required.
691 -	Index Contr.: Warn. Phase Error	9)	The phase error of the index control exceeded the *Warning Level* **597**.
692 -	Index Contr.: Warn. Period		Index signal period too short during index control.
700 -	RxPDO1 Boolean1	10)	Signal if an optional extension module EM with system bus is used.
701 -	RxPDO1 Boolean2		Signal if an optional extension module EM with system bus is used.
702 -	RxPDO1 Boolean3		Signal if an optional extension module EM with system bus is used.
703 -	RxPDO1 Boolean4		Signal if an optional extension module EM with system bus is used.
710 to 713			Operation modes 700 to 703 for RxPDO2 with an extension module EM with system bus.
720 to 723			Operation modes 700 to 703 for RxPDO3 with an extension module EM with system bus.
730 -	Sysbus emergency		Signal if an optional extension module EM with system bus is used.
750 -	OUT-PZD3 Boolean	11)	Process data for Profibus communication. Module CM-PDP with Profibus interface required.
751 -	OUT-PZD4 Boolean		Process data for Profibus communication. Module CM-PDP with Profibus interface required.
752 -	OUT-PZD5 Boolean		Process data for Profibus communication. Module CM-PDP with Profibus interface required.
753 -	OUT-PZD6 Boolean		Process data for Profibus communication. Module CM-PDP with Profibus interface required.
810 to 814	Obj 0x3003 DigOut 1 to Obj 0x3003 DigOut 5	12)	Sources of CAN objects for CANopen communication. Communication module CM with CAN interface required.
832 to 847	Obj 0x3005 Demux Out 1 to Obj 0x3005 Demux Out 16		Sources at output of demultiplexer for CANopen communication. Communication module CM with CAN interface required.
876 -	Position Comparator Out	13)	The current actual value is in the range between *On-Position* **1243** and *Off-Position* **1244**.
877 -	Output position comparator inverted		Operation mode 876 inverted.
887 -	MBC: Start Clockwise		Message clockwise of positioning controller.
888 -	MBC: Start Anticlockwise		Message anticlockwise of positioning controller.
891 -	Motion-Block Digital Signal 1		Message on status of a travel order during a positioning operation. The requirements set for parameter Digital Signal 1 **1218** were met. "Start", "Reference value reached" and "End" of a motion block were evaluated.
892 -	Motion-Block Digital Signal		Message on status of a travel order during a positioning operation. The requirements set for parameter *Digital Signal 2* **1219** were met. "Start", "Reference value reached" and "End" of a motion block were evaluated.

Digital Inputs			Function
893 -	Motion-Block Digital Signal 3		Message on status of a travel order during a positioning operation. The requirements set for parameter *Digital Signal 3* **1247** were met. "Start", "Reference value reached" and "End" of a motion block were evaluated.
894 -	Motion-Block Digital Signal 4		Message on status of a travel order during a positioning operation. The requirements set for parameter *Digital Signal 4* **1248** were met. "Start", "Reference value reached" and "End" of a motion block were evaluated.
895 to 898			Operation modes 891 to 894 inverted (LOW active).
910 to 925	Output DeMux bit 0 to Output DeMux bit 15	14)	Bit 0 to Bit 15 on output of de-multiplexer; de-multiplexed process data signal via system bus or Profibus on input of multiplexers (parameter *DeMux Input* **1253**).
2401 to 2416	FT-output buffer 1 to FT-output buffer 16	15)	Output signals of FT-instructions of table of functions.

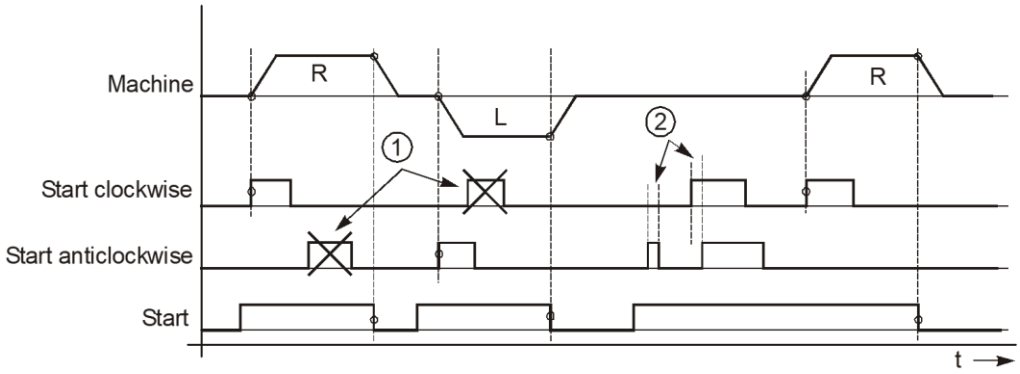
1) Refer to application manual "Safe Torque Off STO".
2) Refer to application manual "Positioning".
3) Refer to application manual "Safe Torque Off STO".
4) Refer to operating instructions on extension modules with digital inputs.
5) The digital signal is independent from the configuration of the parameter *Local/Remote* **412**.
6) Refer to application manual "Positioning".
7) Refer to application manuals "Positioning" and "Electronic Gear".
8) Refer to operating instructions on extension modules with Profibus.
9) Refer to application manual "Electronic Gear".
10) Refer to operating instructions on extension modules with System Bus.
11) Refer to operating instructions on extension modules with Profibus interface.
12) Refer to operating instructions on extension modules with CAN interface.
13) Refer to application manual "Positioning".
14) Refer to operating instructions on extension module with System Bus or Profibus interface.
15) Refer to application manual "Function Table".

16.4.1 Start command

Parameters *Start Clockwise* **68** and *Start Anticlockwise* **69** can be linked to the available digital control inputs or the internal logic signals. The drive is only accelerated according to the control method after a start command.
The logic functions are used for the specification of the direction of rotation, but also for using the parameterized *Operation Mode* **620** for the starting behavior and *Operation Mode* **630** for the stopping behavior.

16.4.2 3-wire control

In the case of 3-wire control, the drive is controlled using digital pulses. The drive is prepared for starting via the logic state of the signal *Start 3-Wire-Ctrl* **87** and started by a Start Clockwise pulse (parameter *Start Clockwise* **68**) or a Start Anticlockwise pules (*parameter Start-Anticlockwise* **69**). The drive is stopped by turning the signal *Start 3-Wire-Ctrl* **87** off.
The control signals for Start clockwise and Start anticlockwise are pulses. The functions Start clockwise and Start anticlockwise for the drive are latching-type functions when signal *Start 3-Wire-Ctrl* **87** is turned on. Latching is canceled when the latching signal is switched off.



(R) Clockwise
(L) Anticlockwise
(1) Signals are ignored
(2) Time t < 32 ms

The drive is started according to the configured starting behavior if the signal *Start 3-Wire-Ctrl* **87** is on and a positive signal edge for Start clockwise or Start anticlockwise is detected.
Once the drive has started, new edges (1) on the start signals will be ignored.
If the start signal is shorter than 32 ms (2) or if both start signals were switched on within 32 ms (2) the drive will be switched off according to the configured stopping behavior.
3-wire control is activated with parameter *Local/Remote* **412**:

Local/Remote 412	Function
5 - Ctrl. 3-wire, direction Cont.	3-wire; control of sense of rotation and signal *3-Wire Ctrl* **87** via contacts.
46 - Ctrl. 3-Wire+KP, Dir. Cont. +KP	3-wire and control unit; control of direction of rotation and signal *3-Wire Ctrl* **87** via contacts or control unit.

For further operation modes of parameter *Local/Remote* **412**, see Chapter 19.3.

16.4.3 Error Acknowledgment

The frequency inverters feature various monitoring functions which can be adapted via the error and warning behavior. Switching the frequency inverter off at the various operating points should be avoided by an application-related parameterization. If there is a fault switch-off, this message can be acknowledged via parameter *Program* **34** or the logic signal linked with parameter *Error Acknowledgment* **103** .

16.4.4 Timer

The time functions can be selected via parameters *Operation Mode Timer 1* **790** and *Operation Mode Timer 2* **793**. The sources of the logic signals are selected via parameters *Timer 1* **83** and *Timer 2* **84** and processed according to the configured timer function.

16.4.5 Thermocontact

The monitoring of the motor temperature is a part of the error and warning behavior which can be configured as required. Parameter *Therm. Contact* **204** links the digital input signal to the *defined Motor Temp. Operation Mode* **570**, described in Chapter 14.6 "Motor temperature". The temperature monitoring via a digital input checks the input signal for the threshold value. Accordingly, a thermic contact or an additional circuit must be used if a temperature-dependent resistor is used.

16.4.6 n-/M control change-over

The field-oriented control procedures in configurations 230, 330, 430, 530 and 630 contain the functions for speed or torque-dependent control of the drive. The change-over can be done in ongoing operation, as an additional functionality monitors the transition between the two control systems. The speed controller or the torque controller is active, depending on the *n-/M-Control Change-Over* **164**.

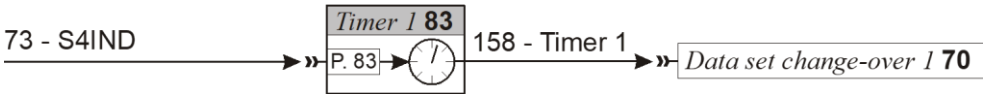
16.4.7 Switch data set

Parameter values can be stored in four different data sets. This enables the use of various parameter values depending on the current operation point of the frequency inverter. The change-over between the four data sets is done via the logic signals assigned to parameters *Data Set Change-Over 1* **70** and *Data Set Change-Over 2* **71**.
The actual value parameter *Active Data Set* **249** shows the selected data set.

Control		
Data Set Change-Over 1 **70**	*Data Set Change-Over 2* **71**	**Function / active data set**
0	0	Data set 1 (DS1)
1	0	Data set 2 (DS2)
1	1	Data set 3 (DS3)
0	1	Data set 4 (DS4)

0 = Contact open 1 = Contact closed

When *Configuration* **30** = `110`, `111`, `310`, `330`, `410`, `411`, `430`, `510`, `511`, `530`, `610`, `611` or `630` is selected, a timer function is connected by default between digital input S4IND and *Data Set Change-Over 1*.



Data Set Change-Over 1 is linked to the Timer 1:
Data Set Change-Over 1 **70** = `158 - Timer 1`

Timer 1 is linked to digital input S4IND (terminal X210A.6):
Timer 1 **83** = 73 – S4IND

By default, *Data Set Change-Over 1* is not affected by *Timer 1*:

- Signal delay *Time 1 Timer 1* **791** = 0.00 s/m/h
- Signal duration *Time 2 Timer 1* **792** = 0.00 s/m/h

16.4.8 Fixed Value Change-Over

Depending on the selected configuration, the setpoints are defined via the assignment of the *Reference Frequency Source* **475** or *Reference Percentage Source* **476.** Accordingly, there can be a change between the fixed values by connection of the logic signals with parameters *Fixed Frequency Change-Over 1* **66**, *Fixed Frequency Change-Over 2* **67** or parameters *Fixed Percent Change-Over 1* **75**, *Fixed Percent Change-Over 2 2* **76**.
By combining the logic states of the fixed frequency change-over modes 1 and 2, fixed frequencies 1 through 4 can be selected:

Fixed Frequency Control		
Fixed Frequency Change-Over 1 **66**	*Fixed Frequency Change-Over 2* **67**	**Function/active fixed value**
0	0	*Fixed Frequency 1* **480**
1	0	*Fixed Frequency 2* **481**
1	1	*Fixed Frequency 3* **482**
0	1	*Fixed Frequency 4* **483**

0 = Contact open 1 = Contact closed

By combining the logic states of the fixed percentage change-over modes 1 and 2, fixed percentages 1 through 4 can be selected:

Fixed percentage control		
Fixed Percent Change-Over 1 **75**	*Fixed Percent Change-Over 2* **76**	**Function/active fixed value**
0	0	*Fixed Percentage 1* **520**
1	0	*Fixed Percentage 2* **521**
1	1	*Fixed Percentage 3* **522**
0	1	*Fixed Percentage 4* **523**

0 = Contact open 1 = Contact closed

16.4.9 Motor potentiometer

Parameters *Reference Frequency Source* **475** and *Reference Percentage Source* **476** contain operation modes with motor potentiometer. *Operation Mode* **474** defines the behavior of the motor potentiometer function and parameters *Frequency Motorpoti Up* **62**, *Frequency Motorpot. Down* **63** or *Percent Motorpoti Up* **72**, *Percent Motorpoti Down Ab* **73** the link to the available logic signals.

Motor Potentiometer Control		
Motorpoti Up	**Motorpoti Down**	**Function**
0	0	Output signal does not change
1	0	Output value rises at set ramp
0	1	Output value drops at set ramp
1	1	Output value is reset to initial value

0 = Contact open 1 = Contact closed

16.4.10 Handshake Traverse Function

Via Parameter *Handshake Traverse Function* **49** the signal source is selected for specification of the direction of rotation of the slave drive of the traverse function. The Traverse Function is switched on via parameter *Operation Mode* **435**.

16.4.11 User Warning

For parameterization of external warnings, you can use parameters *User Warnig 1* **1363** and *User Warnig 2* **1364** . Parameterization of an a user warning error enables triggering a warning in the device via a digital signal in the event of a critical state. This warning is displayed in *Application Warnings* **273** can be transmitted to a higher-level control. Please also refer to parameter *Create Appl. Warning Mask* **626** and the explanations in Chapter 16.3.9.
2 independent warnings can be parameterized via *User Warnig 1* **1363** and *User Warnig 2* **1364**.

16.4.12 External Error

Parameterization of an external error enables switching off or shutting down several frequency inverters at a time if a fault occurs in the plant or the drive. If an error occurs in a frequency inverter, the error signal can be transmitted via a bus system and the required reaction can be triggered in another frequency inverter. Parameter *External Error* **183** can be assigned the logic signal or digital input signal which is to trigger the external error.
Via Parameter *Op Mode ext. Error* **535** the response to an external error can be configured.

Operation Mode 535	Function
0 - disabled	No response to external errors.
1 - Error switch-off	The drive is switched off and the error message „F1454 External Error" is output if the logic signal or digital input signal for parameter *External Error* **183** is present.
2 - Shutdown, error	The drive is stopped at the current deceleration ramp and the error message „F1454 External Error" is output if the logic signal or digital input signal for parameter *External Error* **183** is present.
3 - Emergency-stop, error	The drive is stopped at the current emergency stop ramp and the error message „F1454 External Error" is output if the logic signal or digital input signal for parameter *External Error* **183** is present.

For parameterization of external warnings, you can use parameters *User Warnig 1* **1363** and *User Warnig 2* **1364** . Please refer to Chapter 16.3.9 for more details.

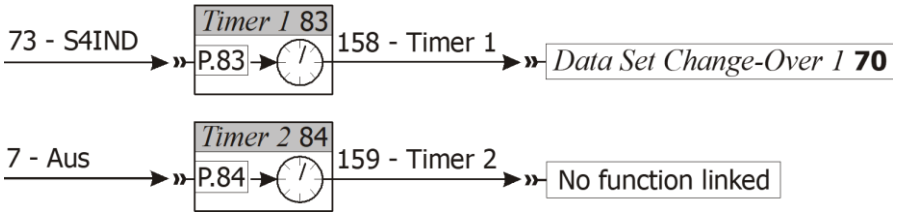
16.5 Function Modules

16.5.1 Timer

The timer function can be linked to various functions for time-control of digital signals.
Parameters *Operation Mode Timer 1* **790** and *Operation Mode Timer 2* **793** define the evaluation of the digital input signals and the unit of time of the time function.

Operation mode Timer 790, 793	Function
0 - off	Signal output is switched off.
1 - Normal, Rising Edge, Sec.	Positive signal edge starts timer (trigger), time 1 delays the output signal, time 2 defines the signal period
2 - Retrigger, Rising Edge, Sec.	Positive signal edge starts timer (trigger), next positive signal edge within time 1 starts the signal delay again (Retrigger), time 2 defines the signal period
3 - AND-Connect., Rising Edge, Sec.	Positive signal edge starts timer (trigger), if no input signal is received within time 1 the signal delay starts again (Retrigger), if no input signal is received within time 2, the signal period is terminated
11 to 13	Operation modes 1...3, negative signal edge starts timer.
101 to 113	Operation modes 1...3, [in minutes].
201 to 213	Operation modes 1...3, [in hours].

By default, the functions are linked according to the following illustration:



The sources of digital signals (z. B. 73 - S4IND) are selected with parameters *Timer 1* **83** and *Timer 2* **84**. By default, Timer 1 is linked to digital input 4 and Timer 2 is off.
The timer output signal can be assigned to a frequency inverter feature or a digital output. By default, *Data Set Change-Over 1* **70** is linked to Timer 1 and Timer 2 is not assigned.

NOTICE

Default settings: *Time 2 Timer 1* **792** = 0. Signals at digital input S4IND are forwarded to Data Set Change-Over 1 without delay.

Function	Parameter for input signal	Operation mode	Time constants	Output signal of function	
Timer 1	*Timer 1* **83**	*Operation Mode Timer 1* **790**	*Time 1 Timer 1* **791** *Time 2 Timer 1* **792**	158 [1] - 23 [2] -	Timer 1
Timer 2	*Timer 2* **84**	*Operation Mode Timer 2* **793**	*Time 1 Timer 2* **794** *Time 2 Timer 2* **795**	159 [1] - 24 [2] -	Timer 2

[1] For linking to frequency inverter functions
[2] For output via a digital output.

16.5.1.1 Timer – Time Constant

The logic sequence of input and output signals is to be set separately for both timer functions via the time constants. The default parameter values result in a direct link of the input and output signal without a delay.

Before starting the timer, select the operation mode and set the time constants in order to avoid non-defined states.

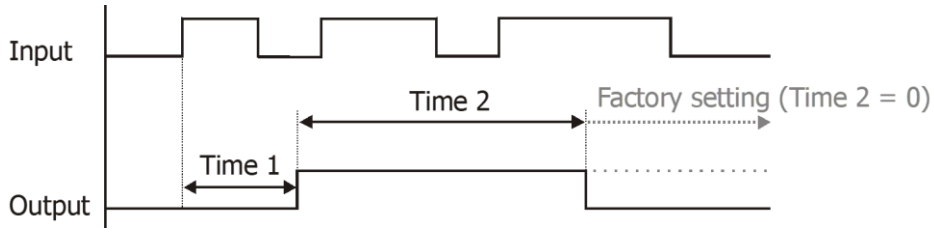
Select operation mode for:	Set time constants in:
Operation Mode Timer 1 **790**	*Time 1 Timer 1* **791** (signal delay) *Time 2 Timer 1* **792** (signal duration)
Operation Mode Timer 2 **793**	*Time 1 Timer 2* **794** (signal delay) *Time 2 Timer 2* **795** (signal duration)

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
791	Time 1 Timer 1, signal delay	0.00 s/m/h	650.00 s/m/h	0.00 s/m/h
792	Time 2 Timer 1, signal duration	0.00 s/m/h	650.00 s/m/h	0.00 s/m/h
794	Time 1 Timer 2, signal delay	0.00 s/m/h	650.00 s/m/h	0.00 s/m/h
795	Time 2 Timer 2, signal duration	0.00 s/m/h	650.00 s/m/h	0.00 s/m/h

Examples of the timer function depending on the selected operation mode and the input signal:

Normal, positive edge

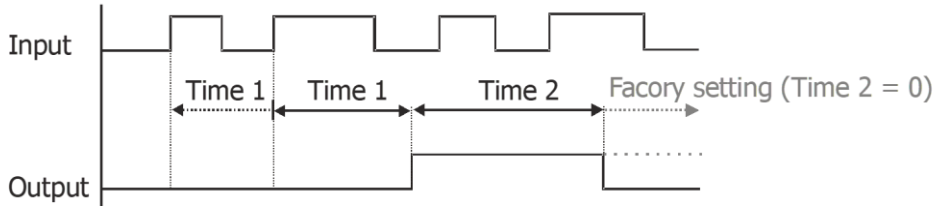
Parameter *Operation Mode Timer 1* **790** or *Operation Mode Timer 2* **793 =** 1



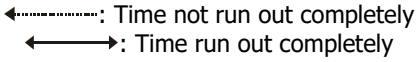
As soon as the positive signal edge is received at the input, time 1 is started. Once the Time 1 (signal delay) has elapsed, the output signal will be switched for Time 2 (signal duration).
In the settings for signal duration (*Time 2 Timer 1* **792** = 0 and *Time 2 Timer 2* **795** = 0), the output signal will not be reset.

Retrigger, positive edge

Parameter *Operation Mode Timer 1* **790** or *Operation Mode Timer 2* **793**= 2

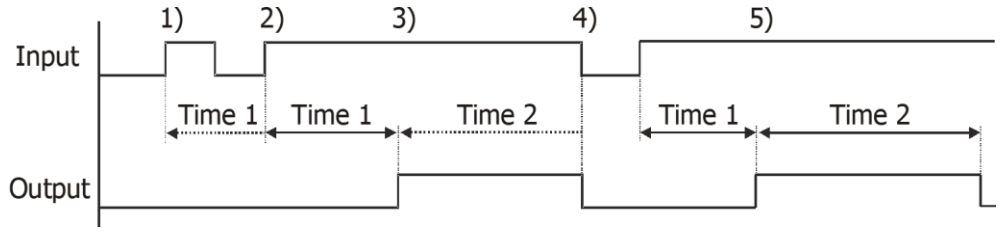


As soon as the positive signal edge is received at the input, time 1 is started. If a positive signal edge is detected within the signal delay (Time 1), Time 1 will start again (Retrigger). Once the Time 1 (signal delay) has elapsed, the output signal will be switched for Time 2 (signal duration).
In the settings for signal duration (*Time 2 Timer 1* **792** = 0 and *Time 2 Timer 2* **795** = 0), the output signal will not be reset.

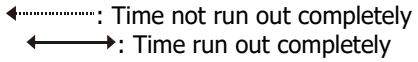


AND connection, positive edge

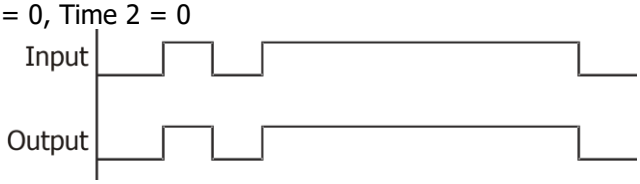
Parameter *Operation Mode Timer 1* **790** or *Operation Mode Timer 2* **793**= 3



1) As soon as the positive signal edge is received at the input, time 1 is started.
2) If a positive signal edge is detected within the signal delay (Time 1), Time 1 will start again (Retrigger).
3) Once the Time 1 (signal delay) has elapsed, the output signal will be switched for Time 2 (signal duration).
4) Within the signal duration time 2, the output is switched off by the input signal (AND connection).
5) If the input signal is present during the whole signal duration (Time 2), the output signal remains on in this time.



Factory settings: Time 1 = 0, Time 2 = 0



In the default settings, the output signal will follow the input signal.

16.5.2 Comparator

With the help of software functions Comparator 1 and 2, various comparisons of actual values with percentage-adjustable fixed values can be done.
The actual values to be compared can be selected from the following table with the parameters *OP.Mode Comparator 1* **540** *and OP.Mode Comparator 2* **543**.
If an extension module is connected, further operation modes are available.

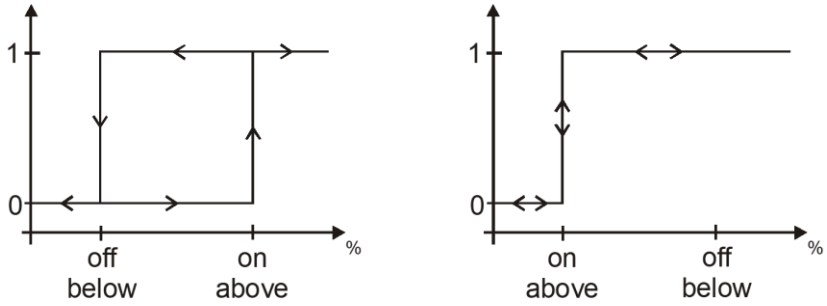
Operation mode 540, 543	Function
0 - off	Comparator is switched off.
1 - Absolute current	*R.m.s Current* **211** > *Rated Current* **371**.
2 - Abs. Active Current	*Active Current* **214 >** *Rated Current* **371**.
3 - Abs. Stator Frequency	*Stator Frequency* **210** > *Maximum Frequency* **419.**

Operation mode 540, 543	Function
4 - Abs. Actual Speed 1	*Encoder 1 Speed* **218** > max. speed *(calculated from Maximum Frequency* **419** and *No. of Pole Pairs* **373)** .
5 - Abs. Actual Repetition Freq.	*Repetition Frequency Input* **252 >** *Maximum Frequency* **419.**
6 - Winding Temperature, Temp. Follow-Up	*Winding Temperature* **226 >** Temperature 100 °C.
7 - Abs. Actual Frequency	*Actual Frequency* **241 >** *Maximum Frequency* **419.**
9 - DC-Link Voltage	*DC-Link Voltage* **222 >** direct voltage 1000 V.
10 - Abs. Isq	*Isq* **216 >** *Rated Current* **371.**
11 - Abs Filtered Active Current	*Active Current* **214 >** *Rated Current* **371.**
12 - Abs. Internal Ref. Frequency	*Internal Reference Frequency* **228 >** *Maximum Frequency* **419.**
13 - Abs. Ref. Percentage Value	*Reference Percentage Value* **229 >** *Maximum Reference Percentage* **519.**
14 - Abs. Actual Percentage Value	*Actual Percentage Value* **230 >** *Maximum Reference Percentage* **519.**
15 - Analog Input MFI1A Abs. value	*Analog Input MFI1A* **251 >** input signal 100%.
100 to 107, 111, 112	Operation modes with signs (+/-).

The switch-on and switch-off thresholds for Comparators 1 and 2 are set via parameters *Comparator On above* **541**, 544 and *Comparator Off below* **542**, 545.
The percentage limits of the corresponding reference values are indicated.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
541	Comparator 1 On above	- 300.00%	300.00%	100.00%
542	Comparator 1 Off below	- 300.00%	300.00%	50.00%
544	Comparator 2 On above	- 300.00%	300.00%	100.00%
545	Comparator 2 Off below	- 300.00%	300.00%	50.00%

The setting of the percentage limits of the comparators enables the following logical links. The comparison with signs is possible in the corresponding operation modes of the comparators.



Example:

OP.Mode Comparator 1 **540** = Abs. Actual Frequency
Comparator On above **541** = 80.00 % (referred to *Maximum Frequency* **419**)
Comparator Off below **542** = 50,00 % (referred to *Maximum Frequency* **419**)
Maximum Frequency **419** = 50.00 Hz
Comparator is switched on when Actual Frequency 241 > 40.00 Hz
Comparator is switched off when Actual Frequency 241 > 25.00 Hz

Output signals

The result of the comparison is reported via digital signals.

Comparator 1

171 -	Output Comparator 1	1)	The comparison according to the selected *OP.Mode Comparator 1* **540** – is true.
20 -	Comparator 1	2)	
172 -	Negated Output Comparator 1	1)	The comparison according to the selected *OP.Mode Comparator 1* **540** – is true. The output level of the comparator is inverted.

Comparator 2

173 -	Output Comparator 2	1)	The comparison according to the selected *OP.Mode Comparator 2* **543** – is true.
21 -	Comparator 2	2)	
174 -	Negated Output Comparator 2	1)	The comparison according to the selected *OP.Mode Comparator 2* **543** – is true. The output level of the comparator is inverted.

1) For linking to frequency inverter functions
2) For output via a digital output.

16.5.3 Table of functions

With the table of functions, external analog or digital signals and internal logic signals of the frequency inverter can be linked to one another. Apart from standard AND, OR and XOR combinations, various complex logic functions such as RS Flip Flop are available. The corresponding output value can be used for other logic instructions and digital outputs. Logic instructions can be combined to one another so that any complex links can be realized.
Up to 32 instructions enable flexible adjustment for linking different input signals.
Analog functions include, for example, comparisons of analog input values, mathematical functions, PID control functions, filters, control of positioning functions limitations, switches and counters.

Example:

A drive is to start if

- release is given AND S5IND is set
  OR
- release is given AND S6IND and MFI1D are set.

For a detailed description, refer to the application manual "Function Table".

16.5.4 Multiplexer/demultiplexer

The multiplexer/demultiplexer enables the transfer of various digital signals between an overriding controller and frequency inverters via field bus or between frequency inverters via the system bus. For parameterization of the multiplexer and demultiplexer using the VTable application, the commissioning and diagnosis software VPlus, version 4.0.2 or higher is required.

Multiplexer:

The multiplexer features 16 inputs for logic signals or digital input signals.
On the output, the logic signal `927 - Output MUX` for the inputs of the TxPDO process data of the system bus or for PZDx-IN process data of the Profibus can be used.

Operation mode		Factory setting	
1252	Mux inputs	7 -	off

Parameters Mux Input Index (write) **1250** and *Mux Input Index (read)* **1251** for the input signals of the multiplexer enable parameterization via the control unit KP500 or the application VTable in VPlus.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1250	Mux input index (write) 1)	0	33	1
1251	Mux input index (read)	0	33	1

1)

non-volatile (fixed parameterization):		Volatile:	
0:	all indices in EEPROM	17:	all indices in RAM
1…16:	On index in EEPROM	18…33:	Index 1…16 in RAM

Setting "0" for *Mux Input Index (write)* **1250** will change all data in EEPROM and RAM.
In the case of non-volatile storage (0..16), the changed values are still available when power supply is switched on again.
In the case of volatile storage (17…33), the data is only stored in RAM. If the unit is switched off, this data is lost and the data required are loaded from EEPROM.

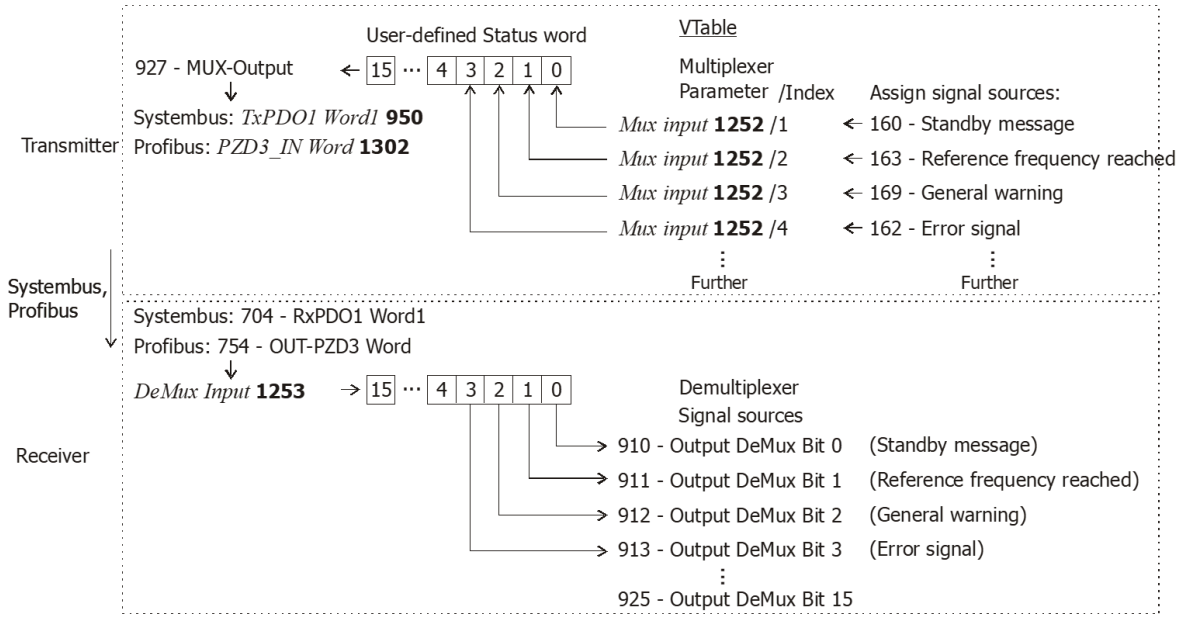
Demultiplexer:

The demultiplexer features an input *DeMux Input* **1253**whose signal can be for the process data RxPDO of the system bus or OUT-PZDx of Profibus.

On the output of the demultiplexer, the logic signals „910 – Output DeMux Bit 0" to „925 – Output DeMux Bit15" are available, e.g. for control of FT-instructions.

Operation Modes for DeMux Input 1253	
9 -	Zero
704 … 727 -	RxPDO Word
740, 741 -	Remote control word , remote state word
754 … 757 -	OUT-PZD word
900 -	Controller Status
927 -	Output MUX
Demultiplexer outputs	
910 … 925 -	Output DeMux Bit 0 ... output DeMux Bit 15

Example: Transfer of a user-defined status word from a slave to a master via system bus or Profibus, parameterization of multiplexer and demultiplexer using PC application VTable in Vplus.



Settings on transmitter:

In VPlus, start application VTable via the button bar.

In VTable assign the required signal sources for sending to parameter *Mux Input* **1252** index 1 to index 16. (a setting for index 0 results in this setting being taken over for all other indices.)

Assign signal source „927 – Output MUX" to a TxPDO process data parameter of the system bus or a PZDx-IN process data parameter of Profibus.

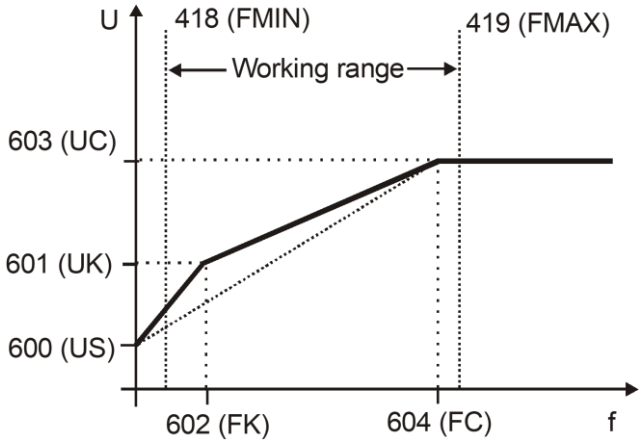
Settings on receiver:

Assign the corresponding RxPDO signal sources of the system bus or OUT-PZD signal sources of Profibus to parameter *DeMux Input* **1253**.

The transmitted signals are available at the receiver as signal sources 910 to 925.

17 V/f characteristic

The sensorless control in configurations `110` and `111` is based on the proportional change of output voltage compared to the output frequency according to the configured characteristic.
By setting the V/f-characteristic, the voltage of the connected 3-phase motor is controlled according to the frequency. The torque to be applied by the motor at the corresponding operating point demands the control of the output voltage proportional to the frequency. At a constant output voltage / output frequency ratio of the frequency inverter, the magnetization is constant in the nominal operating range of the 3-phase motor. The rating point of the motor or end point of the V/f-characteristic is set via the guided commissioning with parameter *Cut-Off Voltage* **603** and parameter *Cut-Off Frequency* **604**.
The lower frequency range, where an increased voltage is necessary for the start of the drive, is critical. The voltage at output frequency = `zero` is set with the parameter *Starting Voltage* **600**. A voltage increase deviating from the linear course of the V/f characteristic can be defined by parameters *Voltage Rise* **601** and *Rise Frequency* **602**. The parameter value percentage is calculated from the linear V/f characteristic. Via parameters *Minimum Frequency* **418** and *Maximum Frequency* **419**, the working range and/or V/f characteristic are defined.



(FMIN): *Minimum Frequency* **418**, (FMAX): *Maximum Frequency* **419**,
(US): *Starting Voltage* **600**,
(UK): *Voltage Rise* **601**, (FK): *Rise Frequency* **602**
(UC): *Cut-Off Voltage* **603**, (FC): *Cut-Off Frequency* **604**

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
600	Starting voltage	0.0 V	100.0 V	5.0 V
601	Voltage rise	-100 %	200 %	10 %
602	Rise frequency	0 %	100 %	20 %
603	Cut-off voltage	60.0 V	560.0 V	400.0 V
604	Cut-off frequency	0.00 Hz	599.00 Hz	50.00 Hz

The guided commissioning takes the parameterized rated motor values and reference data of the frequency inverter into account when it comes to pre-setting the V/f-characteristic. In the case of asynchronous machines, the speed can be increased at a constant torque if the motor winding can be switched over from star to delta connection. If the data for delta connection indicated on the rating plate of the three-phase motor were entered, the cut-off frequency is increased automatically by the square root of three.

The default *Cut-Off Voltage* **603** (UC) and *Cut-Off Frequency* **604** (FC) are derived from the motor data *Rated Voltage* **370** *and Rated Frequency* **375**. With the parameterized *Starting Voltage* **600** (US), the linear equation of the V/f-characteristic results.

$$U = \left(\frac{UC - US}{FC - 0} \right) \cdot f + US = \left(\frac{400{,}0\ V - 5{,}0\ V}{50{,}00\ Hz - 0{,}00\ Hz} \right) \cdot f + 5{,}0\ V$$

The *Rise Frequency* **602** (FK) is entered as a percentage of the *Cut-Off Frequency* **604** (FC), the default value is f=10 Hz. The output voltage for the default *Voltage Rise* **601** (UK) is calculated as U=92.4V.

$$U = \left[\left(\frac{UC - US}{FC - 0} \right) \cdot (FK \cdot FC) + US \right] \cdot (1 + UK) = \left[\left(\frac{400\ V - 5\ V}{50\ Hz - 0\ Hz} \right) \cdot (0{,}2 \cdot 50\ Hz) + 5\ V \right] \cdot 1{,}1 = \underline{\underline{92{,}4\ V}}$$

Dynamic voltage pre-control

The *Dyn. Voltage Pre-Control* **605** accelerates the control behavior of the current limit controller (parameter *Operation Mode* **610**) and the voltage controller (parameter *Operation Mode* **670**). The output voltage value resulting from the U/F characteristic is changed by addition of the calculated voltage pre-control.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
605	Dyn. Voltage Pre-Control	0 %	200 %	100 %

18 Control functions

The frequency inverters provide a selection of established control methods in *Configuration* **30**. The selected control structure can parameterized as required and optimized for the application by further functions.

18.1 Intelligent current limits

The current limits to be set according to the application avoid inadmissible loading of the connected load and prevent a fault switch-off of the frequency inverter. The function extends the current controller available in the control system. The specified overload reserve of the frequency inverter can be utilized optimally using the intelligent current limits, particularly in applications with dynamic load changes. The criterion to be selected via parameter *Operation Mode* **573** defines the threshold to the activation of the intelligent current limit. The parameterized rated motor current or the reference current of the frequency inverter is synchronized as the limit value of the intelligent current limits.

Operation Mode 573	Function
0 - off	The function is switched off.
1 - Ixt	Limitation to the overload of the frequency inverter (Ixt).
10 - Tc	Limitation to the maximum heat sink temperature (T_C)
11 - Ixt + Tc	Operation mode 1 and 10 (Ixt + T_C)
20 - Motor temp.	Limitation to motor temperature (T_{Motor})
21 - Motor temp.+ Ixt	Operation mode 20 and 1 (T_{Motor} + Ixt)
30 - Tc + Motor temp.	Operation mode 10 and 20 (T_C + T_{Motor})
31 - Tc + Motor temp. + Ixt	Operation mode 10, 20 and 1 (T_C + T_{Motor} + Ixt).

The threshold selected via *parameter Operation Mode* **573** is monitored by the intelligent current limits. In the operation modes with motor and heat sink temperature monitoring, the reduction of power selected with the parameter *Power Limit* **574** is done when the threshold value has been reached. This is achieved by a reduction of the output current and the speed in motor operation. The load behavior of the connected machine must be a function of the speed to ensure a sensible use of the intelligent current limits. The total time of the power reduction as a result of an increased motor or heat sink temperature contains not only the cooling time, but also the additionally defined *Limitation Time* **575**.
The definition of the power limit should be selected as small as possible in order to give the drive sufficient time to cool down. The reference value is the rated output of the frequency inverter or the set rated power of the motor.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
574	Power Limit	40.00%	95.00%	80.00%
575	Limitation Time	5 min	300 min	15 min

In the operation modes with overload reserve (Ixt), the output current will be reduced if the threshold is exceeded. A distinction is made in this context between long-time and short-time overload reserve. After the short-term overload (1s) has been used up, the output current is reduced to the long-term overload current matching the present switching frequency. After the long-term overload current has been used up (60s), the output current is reduced to the rated current which also depends on the switching frequency.
If the output current has already been reduced due to the fact that the long-term overload has been used up, the short-term overload is no longer available even if it has not been used up beforehand. The defined overload reserve (Ixt) of the frequency inverter is available again after 10 minutes of operation at reduced power.

Output signals

Reaching of a limit – selected in *Operation Mode* **573 –** can be signaled via digital outputs.

15 -	Warning current limitation	The intelligent current limits limit the output current.
16 -	Controller current limit. long term Ixt	The overload reserve for 60 s has been used up and the output current is being limited.

17 -	Controller current limit. short term Ixt	The overload reserve for 1 s has been used up and the output current is being limited.
18 -	Controller current limit Tk	Max. heat sink temperature TK reached. Intelligent current limits are active.
19 -	Controller current limit. motor temp.	Max. heat sink temperature TPTC reached. Intelligent current limits are active.

18.2 Voltage controller

The voltage controller contains the functions necessary for monitoring the DC link voltage.

- The DC link voltage which rises in generator operation or in the braking process of the 3-phase machine is controlled to the set limit value by the voltage controller.
- The power failure regulation uses the rotation energy of the drive to bridge short-term power failures.

The voltage controller is set with the parameter *Operation Mode* **670** in accordance with the application.

Operation Mode 670	Function
0 - off	The function is switched off. Brake and motor chopper are active and switch at the thresholds parameterized with **P.506** and **P.507**.
1 - DC link limitation active	Overvoltage controller switched on. Brake and motor chopper are active and switch at the thresholds parameterized with **P.506** and **P.507**. Factory setting.
2 - Mains Support active	Mains failure regulation turned on. Brake and motor chopper are active and switch at the thresholds parameterized with **P.506** and **P.507**. Can be used for quick shutdown.
3 - Udc-Limit. & Mains Supp. active	Overvoltage controller and power failure regulation switched on, with motor chopper.
12 - Mains support active, without chopper	Mains failure regulation turned on. During mains support, the brake and motor chopper are deactivated. In all other cases, the brake and motor chopper are active and switch at the thresholds parameterized with **P.506** and **P.507**.
13 - Udc-Limit. & Mains Supp. active without chopper	Overvoltage controller and power failure regulationswitched on. During mains support, the brake and motor chopper are deactivated. In all other cases, the brake and motor chopper are active and switch at the thresholds parameterized with **P.506** and **P.507**.

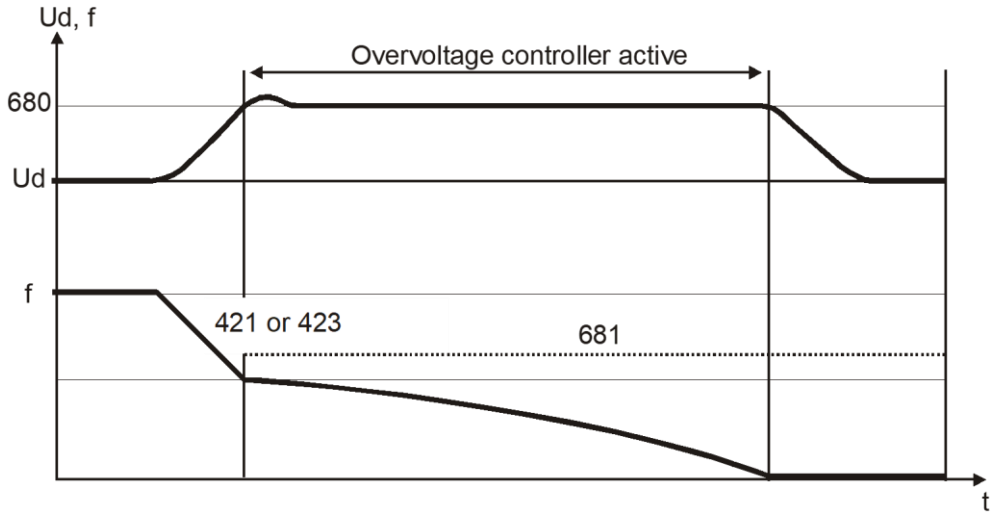
In ACU 510 and 610, mains failure regulation is effected via the DC link capacitor for a maximum of 1 second. In the case of long mains failures, mains failure regulation cannot be guaranteed.

The function motor chopper is available in the field-oriented control methods (in configurations `210`, `230`, `310`, `330`, `410`, `411` and `430`).
When an operation mode with motor chopper is selected, set *Trigger Threshold* **507** < (*Reference DC-Link Limitation* **680** – 10 V). Refer to Chapter 19.7.1.

For synchronous motors (*Configuration* **30 =** `610`), the motor chopper feature is deactivated to prevent the motor from being damaged. The other functions of the voltage controller are not affected by this.
For asynchronous motors in V/f control (*Configuration* **30 =** `110`), the motor chopper feature is deactivated. The other functions of the voltage controller are not affected by this.

The brake chopper is active depending on the setting of *Operation Mode* **670.** For parameterization of the trigger threshold, refer to Chapter 19.7.1.

Operation mode overvoltage control,
Voltage controller: Parameter *Operation Mode* **670 =** `1`



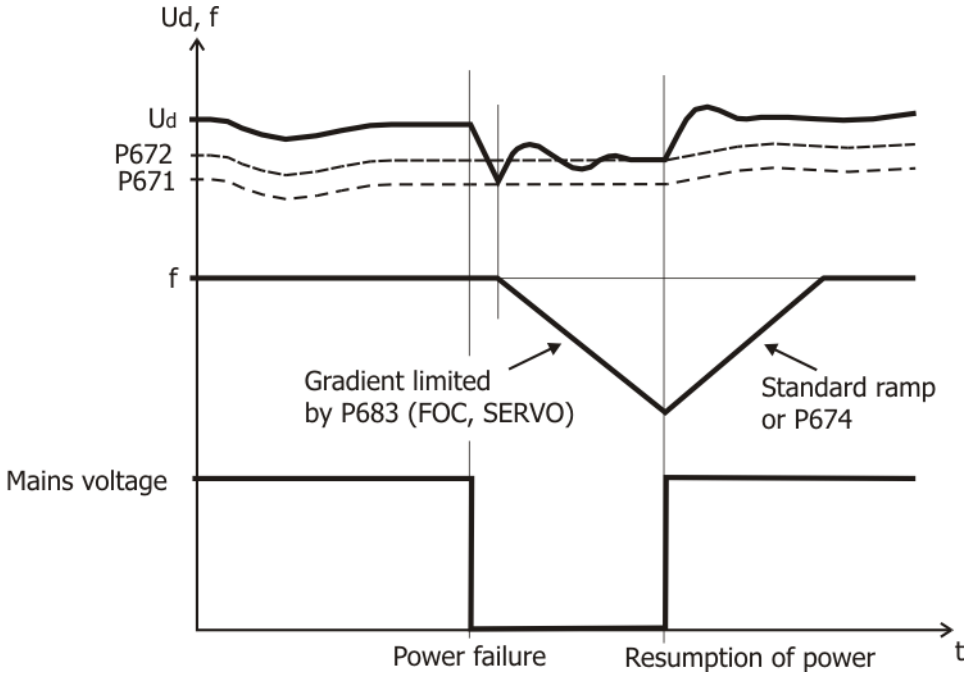
The overvoltage controller prevents a switch-off of the frequency inverter in generator operation. The reduction of the drive speed by a ramp gradient selected via the parameter *Deceleration (Clockwise)* **421** and *Deceleration Anticlockwise* **423** can lead to an overvoltage in the DC link. If the voltage exceeds the figure set by the parameter *Reference DC-Link Limitation* **680**, the deceleration is reduced in such a way that the DC link voltage is regulated to the set value. If the DC link voltage cannot be regulated to the set reference value by the reduction of the deceleration, the deceleration is stopped and the output frequency raised. The output frequency is calculated by addition of the parameter value *Max. Frequency Rise* **681** to the frequency at the operating point of the controller intervention.

Parameter		Setting			
No.	**Description**	**ACU**	**Min.**	**Max.**	**Factory setting**
680	Reference DC link limitation	210	225.0 V	387.5 V	380.0 V
		410	425.0 V	775.0 V	760.0 V
		510	550.0 V	875.0 V	860.0 V
		610	725.0 V	1175.0 V	1160.0 V
681	max. frequency rise	all	0.00 Hz	599.00 Hz	10.00 Hz

For reliable operation of the overvoltage control, Bonfiglioli Vectron GmbH recommends setting the motor chopper *Trigger Threshold* **507 <** (*Reference DC-Link Limitation* **680** – 10 V). Refer to Chapter 19.7.1.

Operation mode power failure regulation

Voltage controller: Parameter *Operation Mode* **670 =** 2



With mains failure regulation, short-term power failures can be bridged. Mains failure is detected when the DC link voltage has dropped below the set value of parameter *Mains Failure Threshold* **671.** If a mains failure is detected, the controller tries to regulate the DC link voltage to the value set with parameter *Reference Mains Support Value* **672.** To that end, the output frequency is continuously reduced and the motor with its rotating masses is switched over to generator operation. In field-oriented control methods (2xx, 4xx, 5xx), the output frequency reduction is done at a current not exceeding the maximum set with parameter *Gen. Ref. Current Limit* **683**.

Gen. Ref. Current Limit **683** is active in Configuration `210`, `410`, `510` and `610` (FOR and SERVO).

The threshold values of the voltage controller are calculated starting with the current DC link voltage with parameters *Mains Failure Threshold* **671** and *Reference Mains Support Value* **672**.

Output signals

Mains failure and mains support are signaled via digital signals.

179 -	Power Failure	1)	Failure of the mains voltage and power regulation – selected via *Operation Mode* **670** of voltage controller.
13 -	Power Failure	2)	

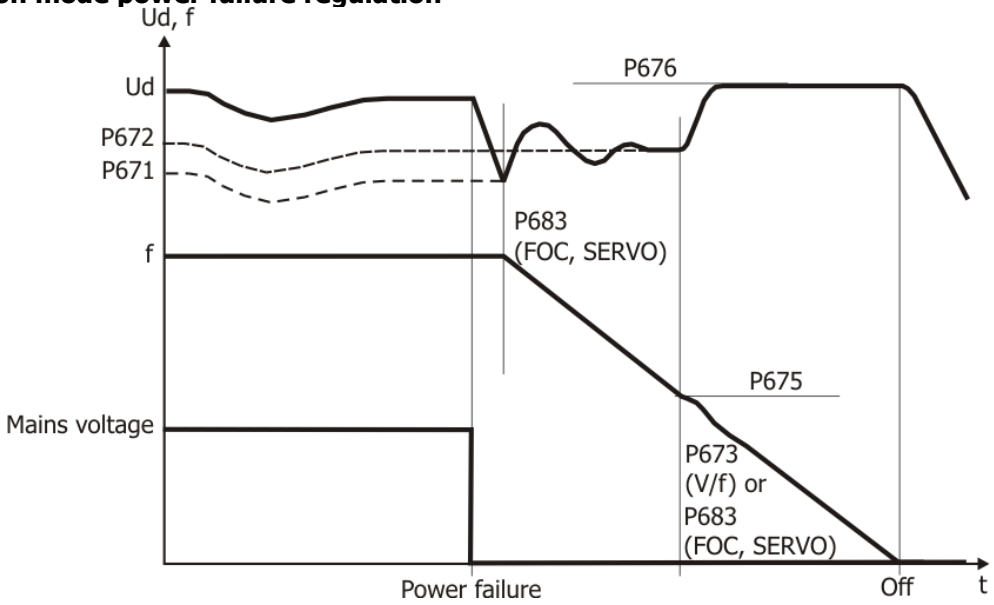
1) For linking to frequency inverter functions
2) For output via a digital output.

If the mains voltage is restored before a switch-off is effected by the mains undervoltage detection system, the drive is accelerated to its reference frequency at the set acceleration or according to parameter *Acceleration on Mains Resumption* **674**. If the value of parameter *Acceleration on Mains Resumption* **674** is set to the default value of `0.00 Hz/s`, the drive is accelerated at the values set for the ramp parameters *Acceleration (Clockwise)* **420** or *Acceleration Anticlockwise* **422**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
671	Mains failure threshold	-200.0 V	-50.0 V	-100.0 V
672	Reference mains support value	-200.0 V	-10.0 V	-40.0 V

The frequency inverter reacts to the signals at the control inputs both when the power failure regulation is switched on and in normal operation. A control via externally supplied control signals is only possible in the case of a no-break supply. As an alternative, supply of the control signals through the frequency inverter is to be used.

Operation mode power failure regulation



The DC link voltage which is available in the case of a power failure is supplied by the motor. The output frequency is continuously reduced and the motor with its rotating masses is switched over to generator operation. The reduction of the output frequency is done at a current not exceeding the maximum set with parameter *Gen. Ref. Current Limit* **683** or the ramp *Mains Support Deceleration* **673**. *Mains Support Deceleration* **673** is active only if the actual frequency is lower than the *Shutdown Threshold* **675.**
The time required until the motor has come to a standstill results from the regenerative energy of the system which results in an increase in the DC link voltage. The DC link voltage set with the parameter *Reference Shutdown Value* **676** is used by the voltage controller as a control figure and kept constant. The voltage rise enables optimization of the braking behavior and the time until the drive has come to a standstill. The behavior of the controller can be compared to `stopping behavior 2` (Shutdown and Stop), as the voltage controller brings the drive to a standstill at the maximum deceleration ramp and supplies it with the remaining DC link voltage.
If the DC-Link Voltage is restored before the drive has stopped, but after dropping below the *Shutdown Threshold* **675**, the drive will be decelerated until it stops.
If the mains voltage is restored after the shutdown of the drive but before the undervoltage switch-off has been reached, the frequency inverter signals a fault. The control unit displays the error signal "F0702".
If the mains failure without shutdown (*Shutdown Threshold* **675** = `0 Hz`) takes so long that the frequency has been reduced to 0 Hz, the drive is accelerated to the reference frequency when the mains supply is restored.
If the mains failure with or without shutdown takes so long that the frequency inverter shuts off completely (LED's = OFF), the frequency inverter will be in the "Standby" state when the mains supply is restored. If the inverter is released again, the drive will start. If the drive is to start automatically after restoration of the mains supply if the inverter is released permanently, *Operation Mode* **651** of Auto Start must be switched on.

Parameter		Setting			
No.	**Description**	**ACU**	**Min.**	**Max.**	**Factory setting**
675	Shutdown threshold	all	0.00 Hz	599.00 Hz	0.00 Hz
676	Reference shutdown value	210	225.0 V	387.5 V	365.0 V
		410	425.0 V	775.0 V	730.0 V
		510	550.0 V	875.0 V	830.0 V
		610	725.0 V	1175.0 V	1130.0 V

The *Shutdown Threshold* **676** becomes effective below the frequency value *Shutdown Threshold* **675**.

The voltage controller uses the limit values of the DC link voltage. *Acceleration on Mains Resumption* **674** replaces - if the default value is changed - the set ramp parameter values *Acceleration (Clockwise)* **420** or *Acceleration Anticlockwise* **422**. The voltage control in a mains failure changes from the frequency limit *Shutdown Threshold* **675** from *Reference Mains Support Value* **672** to *Reference Shutdown Value* **676**. The value of *Gen. Ref. Current Limit* **683** (2xx, 4xx, 5xx) or the ramp *Mains Support Deceleration* **673** (V/f) defines the maximum deceleration gradient to the *Reference Shutdown Value* **676**. *Mains Support Deceleration* **673** is only active if the actual frequency is smaller than *Shutdown Threshold* **675.**

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
683	Gen. Ref. Current Limit	0.0 A	o·I_{FIN}	I_{FIN}
673	Mains support deceleration	0.01 Hz/s	9999.99 Hz/s	50.00 Hz/s
674	Acceleration on mains resumption	0.00 Hz/s	9999.99 Hz/s	0.00 Hz/s

Mains Support Deceleration **673** is active in Configuration 1xx (V/f).
Gen. Ref. Current Limit **683** is active in Configuration 2xx, 4xx, 5xx and 6xx (FOR and SERVO).

The proportional and integrating component of the current controller can be set via parameters *Amplification* **677** and *Integral Time* **678**. The control functions are deactivated by setting the parameters to `0`. The controllers are P and I controllers in the corresponding settings.

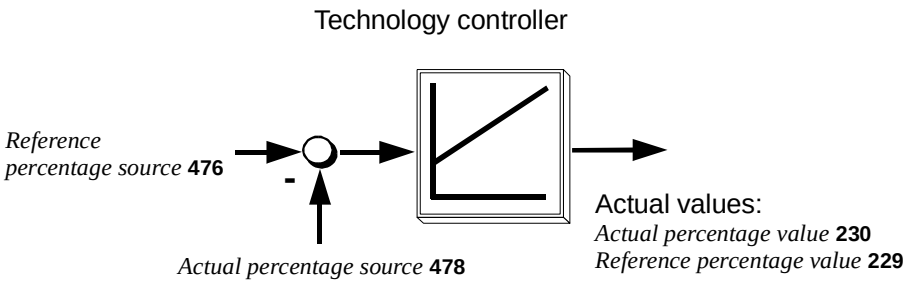
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
677	Amplification	0.00	30.00	1 [1)]
				2 [2)]
678	Integral Time	0 ms	10000 ms	8 ms [1)]
				23 ms [2)]

The factory settings depend on the selected configuration and control procedure. According to the setup of parameter *Configuration* **30**, there is the following assignment.
[1)] Configurations 1xx
[2)] Configurations 4xx, 2xx, 5xx, 6xx

18.3 Technology controller

The technology controller, the behavior of which corresponds to a PID controller, is available as an additional function in configuration `111`, `211`, `411`, `511` and `611`. The connection of reference and actual value of the application with the functions of the frequency inverter enables process control without further components. In this way, applications such as pressure, volume flow or speed control can be implemented easily. The configuration of the reference percentage source and the assignment of the actual percentage source are to be considered.

Structural image: Technology controller



Note the chapters indicated in the table:

Parameter	**Chapter**
Controller setpoint: *Reference Percentage Source* **476**	15.5
Displays the current controller setpoint: *Reference Percentage Value* **229**	20.1
Actual controller value: *Actual Percentage Source* **478** is:	18.3 (this Chapter)
- Analog signal at multifunction input: *Operation Mode* **452**	16.1
- Frequency signal at digital input: *Operation Mode* **496**	15.10.3
Displays the current actual controller value: *Actual Percentage Value* **230**	20.1

For the reference value, the technology controller also demands the assignment of an analog application figure with parameter *Actual Percentage Source* **478**. The difference between reference and actual value is used by the technology controller to control the drive system. The measured actual value is mapped via a signal converter onto the input signal of the reference percentage source.

Actual Percentage Source 478	Function
1 - Analog Input MFI1A	The analog signal on multifunction input 1 in analog *Operation Mode* **452**.
32 - Repetition frequency input (F3)	The frequency signal on the digital input corresponding to the selected *Operation Mode* **496**.

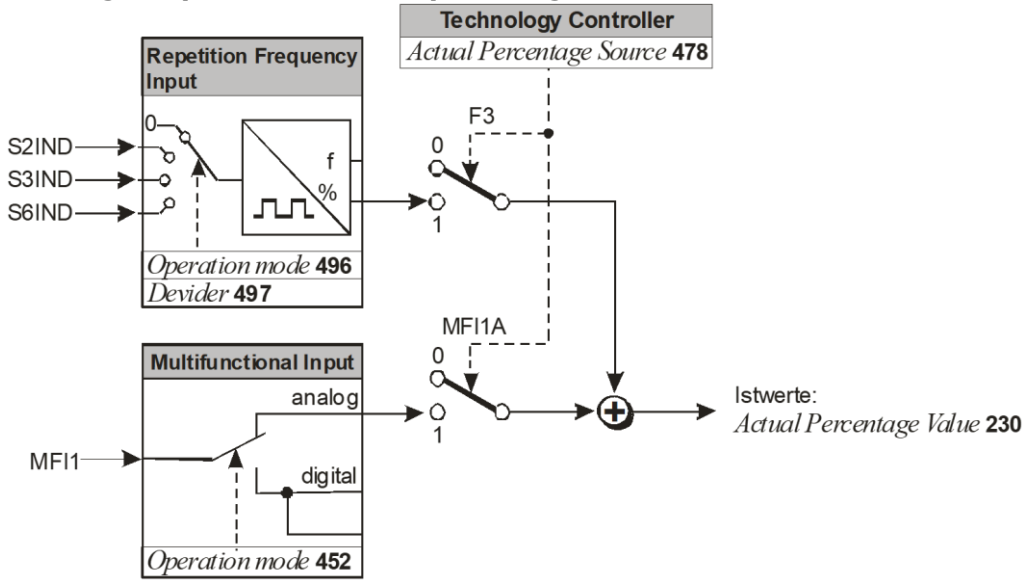
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
58	Technology Controller Release	Selection		6 - On

Via parameter *Technology Controller Release* **58**, you can stop the technology controller. The current P and D portions are kept at the last value before shutdown. The output value and the I portion will be deleted when *Technology Controller Release* **58** is turned off.

Note the default link of parameter *Start Clockwise* **68** to the logic signal of the technology controller:
Start Clockwise **68** = "`13 - Technology Controller Start`".
This link must not be changed. The technology controller becomes active with the controller release at digital input S1IND/STOA.

Actual values

Structural image: Inputs for reference percentage source



The function selected via the parameter *Operation Mode* **440** defines the behavior of the technology controller.

Operation Mode 440	Function
0 - off	The technology controller is switched off, the reference value specification is done via the reference percentage channel.
1 - Standard	For pressure and volume flow control with linear operating behavior and actual value monitoring
2 - Liquid Level 1	Liquid Level control at defined motor speed with actual value missing
3 - Liquid Level 2	Liquid Level control at defined motor speed with actual value missing or high control deviation
4 - Speed controller	Speed control with analog feedback of the actual speed
5 - Indirect Volume Flow Control	Volume flow control with square rooted actual value.

The behavior of the technology controller corresponds to a PID controller with portions
Proportional component *Amplification* **444**

- Integral component *Integral Time* **445**
- Differential component *Derivative Time* **618**

The sign of the amplification defines the control direction, i.e. if the actual value increases and the sign of the amplification is positive, the output frequency is reduces (e.g. pressure control). With a rising actual value and negative sign of the amplification, the output frequency is increased (e.g. in temperature control systems, refrigerating machines, condensers).

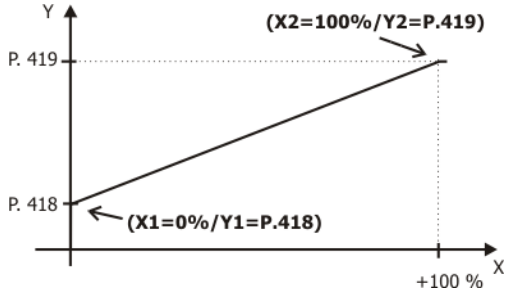
The integral component can be used in order to reduce the stationary error (deviation between actual value and setpoint) over time. If the integral component is too dynamic[1], the system may become unstable and vibrate. If the integral component is too passive[2], the stationary error is not compensated sufficiently.
For this reason, the integral portion must be adjusted plant-specifically.
By default, the differential component is set to *Derivative Time* **618** = `0 ms`, i.e. it is deactivated.
If the compensation behavior of the PI controller (or P controller) is too slow, quicker compensation can be reached by activating and adjusting the differential component (*Derivative Time* **618**). However, if the differential component is activated, the system has a higher tendency toward vibration. For this reason, the differential component should be activated and changed carefully.
Bonfiglioli Vectron GmbH recommends setting the times *Integral Time* **445** for the integral component and *Derivative Time* **618** for the differential component to a value which exceeds the sampling time which is 2 ms for the ACU device.
Parameter *Max. P-Component* **442** limits the frequency change at the controller output. This prevents vibrations of the system if steep acceleration ramps were selected.
Parameter *Hysteresis* **443** enables suppressing changes of the integral component outside of a certain range (hysteresis range). This enables a more passive behavior of the technology controller. This may be useful if the stator frequency cannot follow the reference frequency of the technology controller. The *Hysteresis* **443** is referred, as a percentage, to the *Rated Frequency* **375**, i.e. typically `50 Hz`.
The hysteresis is a limiting factor at the input of the integral component. High differences between the current stator frequency and the technology controller output are limited in this way, excessive integrating of the integral component is prevented.

$\left\|\frac{f_{tech} - f_{stator}}{Rated\ frequency\ 375}\right\| \geq Hysteresis\ 443$	The deviation Δ between the technology controller reference frequency (f_{tech}) and the stator frequency (f_{stator}) is to large. The integrator is stopped.
$\left\|\frac{f_{tech} - f_{stator}}{Rated\ frequenz\ 375}\right\| < Hysteresis\ 443$	The stator frequency (f_{stator}) can follow the technology controller reference frequency (f_{tech}) sufficiently. The deviation Δ is small enough.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
441	Fixed frequency	-599.00 Hz	599.00 Hz	0.00 Hz
442	max. P component	0.01 Hz	599.00 Hz	50.00 Hz
443	Hysteresis	0.01 %	100.00 %	10.00 %
444	Amplification	-15.00	+15.00	1.00
445	Integral Time	0 ms	32767 ms	200 ms
446	Ind. volume flow control factor	0.10	2.00	1.00
618	Derivative action time	0 ms	1000 ms	0 ms

In Operation Modes `1`, `2`, `3` and `5` the output frequency is shifted on the y-axis by the *Minimum Frequency* **418**. The technology controller output value in percent thus is:

- 0 % = *Minimum Frequency* **418**
- 100 % = *Maximum Frequency* **419**



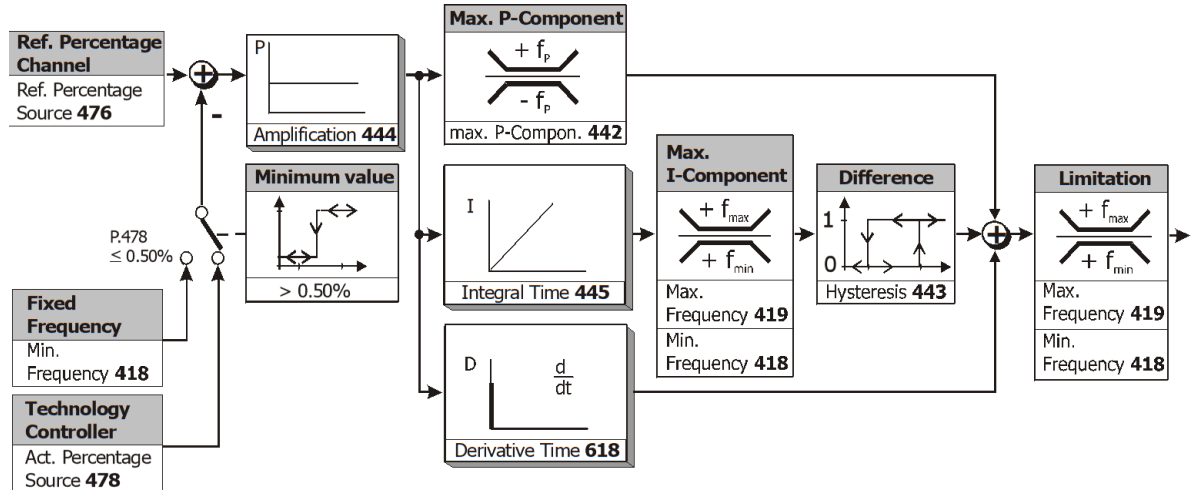
[1] Dynamic behavior: Quick compensation of deviations.
[2] Passive behavior: Slow compensation of deviations.

The parameterization of the technology controller in the individual data sets enables an adaptation to various operating points of the application with the data set change-over via control contacts.

The technology controller works in clockwise motor sense of rotation. The sense of rotation can be reversed via parameter *Change Sense of Rotation* **1199**. See Chapter 11.2.8.

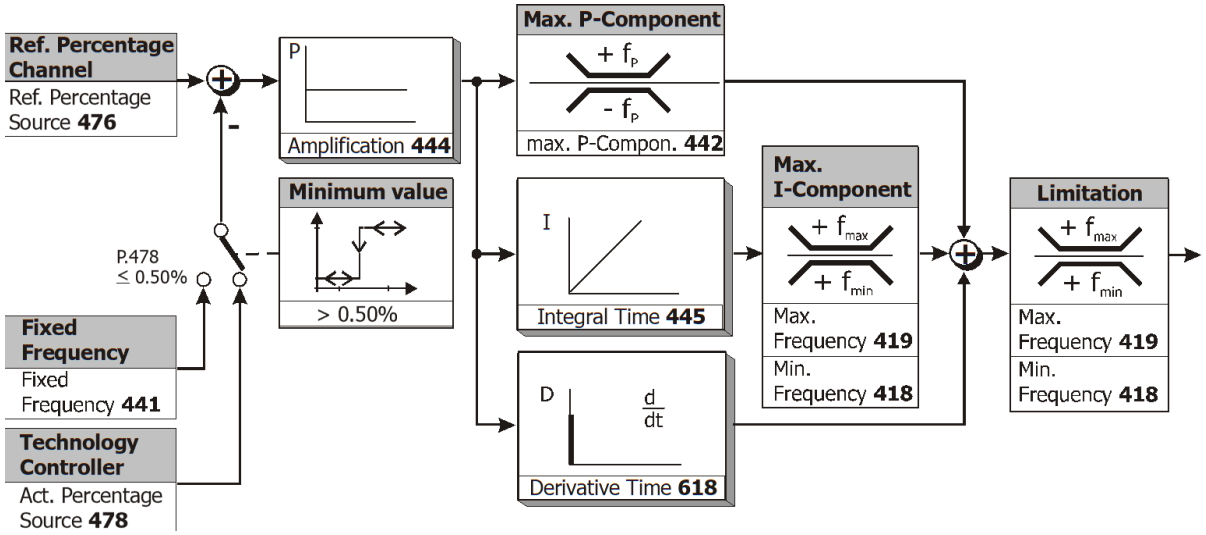
Operation Mode Standard, Parameter Operation Mode 440 = 1

This operation mode can be used, for example, for pressure or volumetric flow control with linear operation behavior.
The minimum value monitoring prevents an acceleration of the drive if the actual value is missing.
If the actual value is missing (< 0.5%) the output frequency is guided to the *Minimum Frequency* **418**. This is done using the set *Deceleration (Clockwise)* **421**. If the actual value is available again, the controller continues operation automatically.



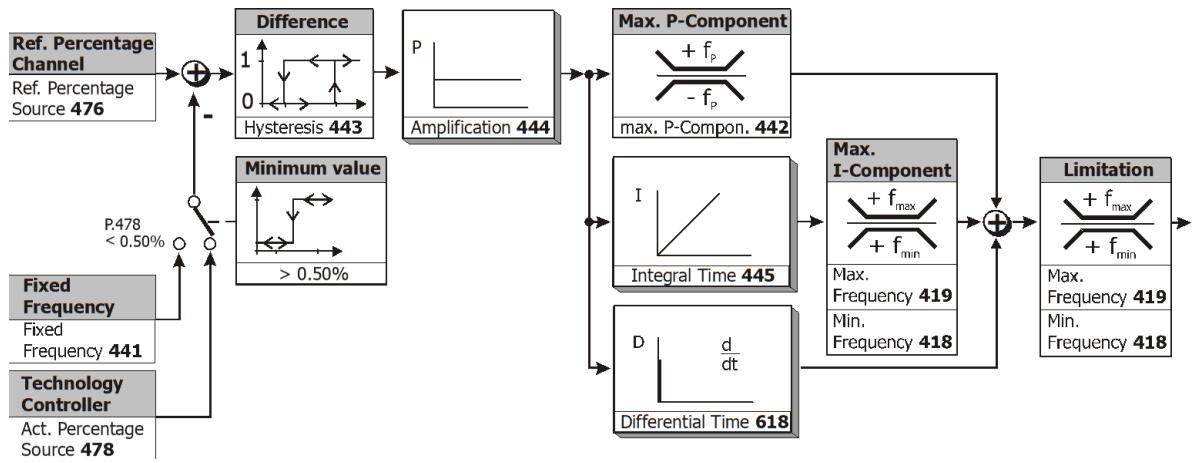
Operation Mode Liquid Level 1, Parameter Operation Mode 440 = 2

This operation mode can be used, for example, for Liquid Level control.
If the actual value is missing, the function brings the output frequency to an adjustable value.
The minimum value monitoring prevents an acceleration of the drive if the actual value is missing.
If the actual value is missing (< 0.5%) the output frequency is guided to the *Fixed Frequency* **441**. This is done using the set *Deceleration (Clockwise)* **421**.
The Fixed Frequency **441** must be in the range between *Minimum Frequency* **418** and *Maximum Frequency* **419**. If the *Fixed Frequency* **441** is smaller than the *Minimum Frequency* **418**, the output frequency is guided to the *Minimum Frequency* **418**. The frequency will not drop below the *Minimum Frequency* **418**.
If the actual value is available again, the controller continues operation automatically. The integral component is reset once the actual value is restored.



Operation Mode Liquid Level 2, Parameter Operation Mode 440 = 3

This operation mode can be used, for example, for Liquid Level control.
The minimum value monitoring prevents an acceleration of the drive if the actual value is missing.
If the actual value is missing (< 0.5%) the output frequency is guided to the *Fixed Frequency* **441**. This is done using the set *Deceleration (Clockwise)* **421**.
If there is no control deviation (actual value =reference value) or if the control deviation is negative (actual value>reference value), the output frequency is guided to *Minimum Frequency* **418**. This **i**s done using the selected controller settings. In addition, the ramp is limited *by Deceleration (Clockwise)* **421**. If *Minimum Frequency* **418** = `0`, the output stage will be turned off in this case.
The drive accelerates as soon as an actual value is present again or the control deviation exceeds the positive *Hysteresis* **443**. The drive stops if actual value ≥ setpoint, the controller output has reached `0 Hz` and *Minimum Frequency* **418** = `0`.



NOTICE

Excessive motor heat-up

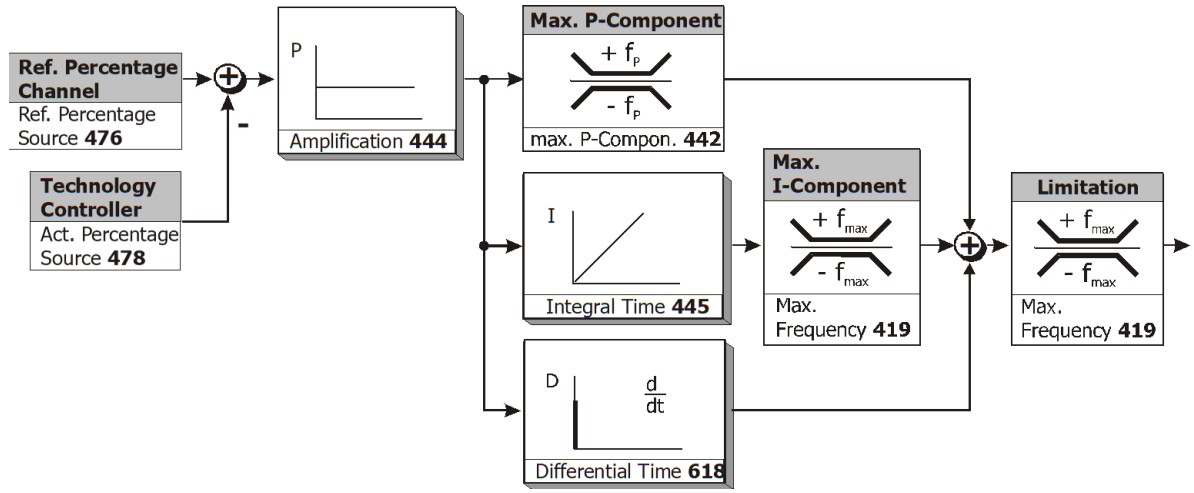
When *Operation Mode* **440** is set to "`4-Speed Controller`", *Minimum Frequency* **418** has no limiting effect. In Configurations `411`, `511` and `611` this can result in longer operation of the motor in current impression mode (current frequency < *Frequency Limit* **624**) and therefore in excessive motor heat-up.

- Prevent excessive motor heat-up by long current impression operation.

Operation Mode "`4-Speed Controller`" can result in reversal of the drive.

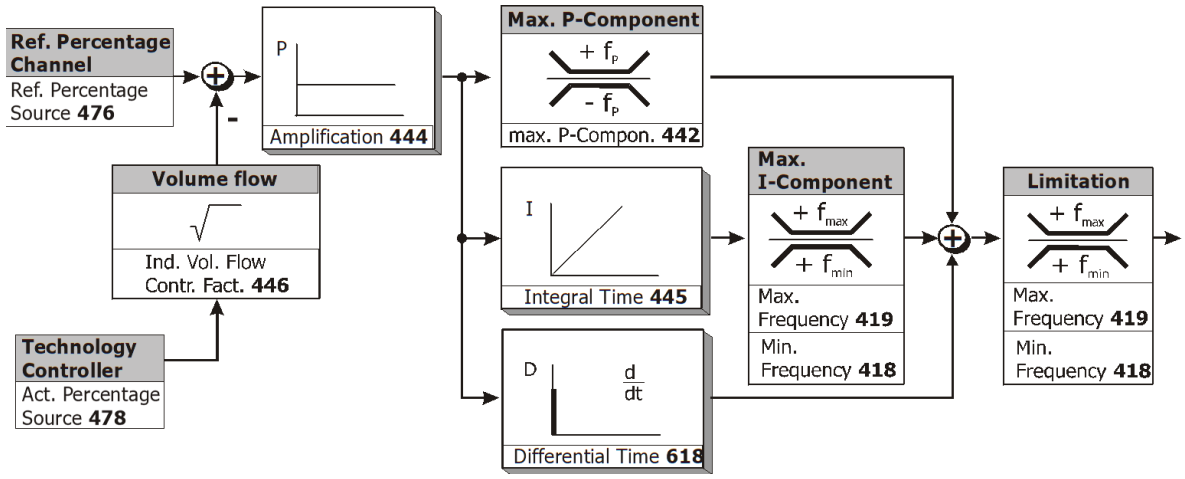
Operation Mode Speed Controller, parameter Operation Mode 440 = 4

This operation mode is suited for speed controls with an analog actual value transmitter (e.g. analog speedometer via analog input or HTL encoder via frequency input). The motor is accelerated or decelerated according to the control deviation.
The output frequency is limited by the *Maximum Frequency* **419**.

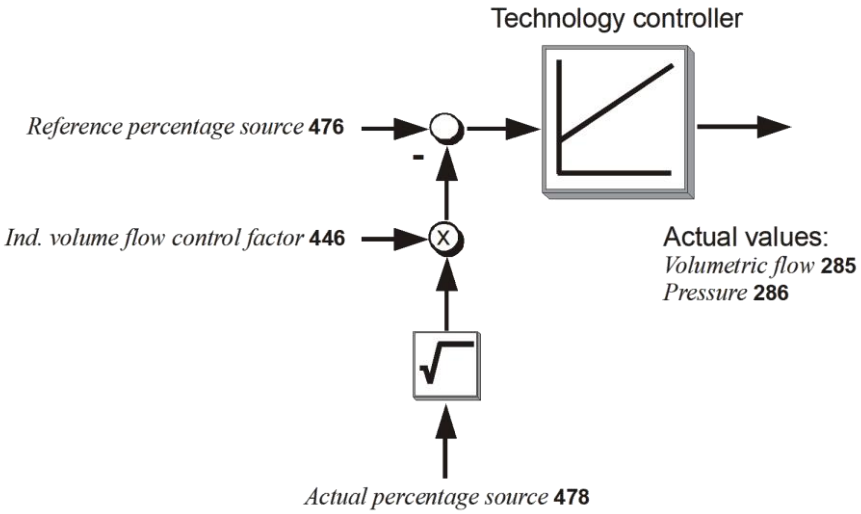


Operation Mode Indirect Volume Flow Control, parameter Operation Mode 440 = 5

This operation mode is suitable for volume flow control based on pressure measurement.
The square rooted actual value enables, for example, direct measurement of the active pressure in the system via the intake nozzle of the fan. The active pressure has a square proportion to the volume flow and thus forms the control figure for the volume flow control. The calculation corresponds to the "Law of Proportionality" which is generally valid for centrifugal machines.
Adjustment to the application and measurement is done via *Ind. Volume Flow Control Factor* **446**. The actual values are calculated from the system data to be parameterized, reference pressure and volume flow, according to the bad point method, as described in chapter 20.4.2.
The output frequency is limited by *Minimum Frequency* **418** and *Maximum Frequency* **419**.



Structural image: Indirect Volume Flow Control



18.4 Functions of sensorless control

The configurations of the sensorless control contain the following additional functions, which supplement the behavior according to the parameterized V/f characteristic.

18.4.1 Slip compensation

The load-dependent difference between the reference speed and the actual speed of the 3-phase motor is referred to as "the slip". This dependency can be compensated by the current measurement in the output phases of the frequency inverter.

Activation of *Operation Mode* **660** for the slip compensation enables speed control without feedback. The stator frequency and speed are corrected as a function of the load.

Slip compensation is turned on during guided commissioning. The *Stator Resistance* **377** is required to ensure a correct function and is measured during guided commissioning.

If guided commissioning is not performed, slip compensation can also be activated manually. In this case enter the *Stator Resistance* **377** manually, refer to motor data sheet.

Operation Mode 660	Function
0 - off	The slip compensation is deactivated.
1 - On	The load-dependent slip speed is compensated

The control behavior of the slip compensation can only be optimized via the parameters in the case of specific applications. Parameter *Amplification* **661** determines the correction of the speed and the effect of the slip compensation proportionally to the change of load. *Max. Slip Ramp* **662** defines the max. frequency change per second in order to avoid an overload in the case of a load change.

Parameter *Minimum Frequency* **663** determines the frequency as from which the slip compensation becomes active.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
661	Amplification	0.0 %	300.0 %	100.0 %
662	Max. slip ramp	0.01 Hz/s	650.00 Hz/s	5.00 Hz/s
663	Minimum frequency	0.01 Hz	599.00 Hz	0.01 Hz

18.4.2 Current limit value controller

Via a load-dependent speed control, the current limit value controller ensures that the drive system is not overloaded. This is extended by the intelligent current limits described in the previous chapter. The current limit value controller reduces the load on the drive, e.g. during acceleration, by stopping the acceleration ramp. The switch-off of the frequency inverter which happens when the acceleration ramps have been set at an excessive gradient is prevented in this way.
The current limit value controller is switched on and off via parameter *Operation Mode* **610**.

Operation Mode 610	Function
0 - off	The current limit value controller functions and the intelligent current limits have been deactivated.
1 - On	The current limit value controller is active.

Behavior in motor operation:

If the current set via parameter *Current Limit* **613** is exceeded, the activated current limit value controller will reduce the output frequency until the current limit is no longer exceeded. The output frequency is reduced as a maximum to the frequency set by the parameter *Frequency Limit* **614**. If the current value drops below the *Current Limit* **613** the output frequency is increased to the setpoint again.

Behavior in generator operation:

If the current set via parameter *Current Limit* **613** is exceeded, the activated current limit value controller will increase the output frequency until the current limit is no longer exceeded. The output frequency is increased, as a maximum, to the set *Maximum Frequency* **419**. If the current value drops below the *Current Limit* **613**, the output frequency is reduced to the required reference value again.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
613	Current Limit	0.0 A	o·I_{FIN}	o·I_{FIN}
614	Frequency Limit	0.00 Hz	599.00 Hz	0.00 Hz

The control behavior of the current limit controller can be set via the proportional component, parameter *Amplification* **611**, and the integrating component, parameter *Integral Time* **612**. If an optimization of the controller parameters is necessary in exceptional cases, a setting should be made by way of erratic changes of parameter *Current Limit* **613**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
611	Amplification	0.01	30.00	1.00
612	Integral Time	1 ms	10000 ms	24 ms

The dynamism of the current limit value controller and the voltage controller is influenced by the setting of the parameter *Dyn. Voltage Pre-Control* **605**.

18.4.3 Impedance selection for SynRM

The inductance of the motors' iron axis and of the motors' air axis is set via the parameters **P.1051** and **P.1052** or they can be set via the parameter *Selection of Look Up Table* **1044**.
The following table shows the applicable settings for the parameter **P.1044**.

Selection of Look Up Table **1044**	Function
0 - Constant Inductances P.1051, P.1052	The function is deactivated. The constant inductances from **P.1051** and **P.1052** are used.
99 - Variable 1D-Look Up Tab. P.1055, P.1056 (index 1-9)	The function is activated; the lookup table defined in **P.1055** and **P.1056**.

With **P.1044**, the inductance is adapted to the motor saturation.

Also refer to chapter 19.9 "Maximum Torque per Ampere: MTPA (P.1003)".

18.5 Functions of field-oriented control

The field-oriented control systems are based on a cascade control and the calculation of a complex machine model. In the course of the guided commissioning, a map of the connected machine is produced by the parameter identification and transferred to various parameters. Some of these parameters are visible and can be optimized for various operating points.

18.5.1 Current controller

The inner control loop of the field-oriented control comprises two current controllers. The field-oriented control thus impresses the motor current into the machine via two components to be controlled.
This is done by:

- controlling the flux-forming current value I_{sd}
- controlling the torque-forming current value I_{sq}

By separate regulation of these two parameters, a decoupling of the system equivalent to an externally excited direct current machine is achieved.
The set-up of the two current controllers is identical and enables joint setting of amplification as well as the integral time for both controllers. Parameters *Amplification* **700** and *Integral Time* **701** are available for this. The proportional and integration and component of the current controllers can be switched off by setting the parameters to zero.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
700	Amplification	0.00	8.00	0.13
701	Integral Time	0.00 ms	10.00 ms	10.00 ms

The guided commissioning has selected the parameters of the current controller in such a way that they can be used without having to be changed in most applications.
If, in exceptional cases, an optimization of the behavior of the current controllers is to be done, the reference value jump during the flux-formation phase can be used for this. With suitable parameterization, the reference value of the flux-forming current components leaps to *Current during Flux-Formation* **781** and, after elapsing of *Max. Flux-Formation Time* **780,** then changes in a controlled way to the magnetizing current. The operating point necessary for the adjustment demands the setting of parameter *Minimum Frequency* **418** to `0.00 Hz`, as the drive is accelerated after magnetizing. The measurement of the jump reply, which is defined by the ratio of the currents mentioned, should be done in the motor supply line by means of a measuring current transformer of a sufficient bandwidth.

The internally calculated actual value for the flux-forming current component cannot be output via the analog output for this measurement as the time resolution of the measurement is not sufficient.

To set the parameters of the PI controller, the *Amplification* **700** is increased first until the actual value overshoots distinctly during the control process. Now, the amplification is reduced to about fifty percent again and then the *Integral Time* **701** is synchronized until actual value overshoots slightly during the control process.
The settings of the current controllers should not be too dynamic in order to ensure a sufficient reserve range. The control tends to increased oscillations if the reverse range is reduced.
The dimensioning of the current controller parameters by calculation of the time constant is to be done for a switching frequency of 2 kHz. For other switching frequencies, the values are adapted internally so that the setting can remain unchanged for all switching frequencies. The dynamic properties of the current controller improve if the switching and scanning frequency increases.
The fixed time interval for the modulation results in the following scanning frequencies of the current controller via parameter *Switching Frequency* **400**.

Setting	
Switching frequency	**Scanning frequency**
2 kHz [1)]	2 kHz
4 kHz	4 kHz
8 kHz	8 kHz
12 kHz	8 kHz
16 kHz	8 kHz

[1)] This switching frequency can be set for the parameter *Min. Switching Frequency* **401**.

18.5.2 Advanced current controller

In some machines, it may be necessary to set different amplification factors for different current ranges.

Definition:

- Current < *Current below P.777 is in effect* **776** → *Amplification low Current* **777**
- *Current above P.700 is in effect* **775** > Current > *Current below P.700 is in effect* **757** → Amplification **700**
- Current > *Current above P.759 is in effect* **758** → *Amplification high Current* **759**

By default, the parameters are preset such that the parameters are not active and only the basic parameters are active.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
757	Current below P.700 is in effect	0.00	o * I_{FIN}	o * I_{FIN}
758	Current above P.759 is in effect	0.00	o * I_{FIN}	o * I_{FIN}
759	Amplification high Current	0.00	0.00	0.00
775	Current above P.700 is in effect	0.00	o * I_{FIN}	0.00
776	Current below P.777 is in effect	0.00	o * I_{FIN}	0.00
777	Amplification low Current	0.00	0.00	0.00

I_{FIN} = Rated frequency inverter output current
o: Overload capacity of frequency inverter.

The parameters are changed during motor auto setup.

18.5.3 Current controller functions specific to SynRM

In the case of the synchronous reluctance machine the parameters described in 18.5.1 Current controller and 18.5.2 Advanced Current Controller apply to the d-axis and the following parameters apply to the q-axis.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
1081	Amplification q-axis	0.00	8.00	0.13
1082	Integral time q-axis	0.00		10.00 ms
1083	Crosscouple factor q	0.00 %	300.00 %	0.00 %
1084	Current above P.1081 is in effect	0.0 A		0.0 A
1085	Current below P.1086 is in effect	0.0 A		0.0 A
1086	Amplification q low current	0.00	8.00	0.13
1087	Current below P.1081 is in effect	0.0 A		
1088	Current above P.1089 is in effect	0.0 A		
1089	Amplification q high current	0.00	8.00	0.13

The current controller has separate P-gain settings for low, medium and high current in each of the two axis, because of the magnetic anisotropy of the rotor.
In order to provide sufficient control performance in every load point the selected rated current (**P.371**) must meet the load conditions.

- If **P.371** is selected higher than the motor ratings, the setup will find correct P-gain values for high currents, but is not as precise at very low currents.

– If MTPA is used (currents are reduced at low load), it is important to check the setting of the P-gain for low currents (**P.777** and **P.1086**) and increase if needed.

During setup, best results are obtained when *Rated Current* **371** is selected to 1.0 * the name plate rating.

18.5.4 Torque controller

The torque-controlled Configurations `230`, `330`, `430`, `530` and `630` enable sensor-less torque control as an alternative to speed control. Torque control is possible above the *Frequency Limit* **624**. Below the frequency limit, current impression is active at the current reference frequency as the reference frequency. In this case, the torque is not controlled but is set depending on the load behavior and the *Starting Current* **623**. In order to obtain torque controlled starting, the reference frequency should be above the *Frequency Limit* **624**. For example, this is guaranteed if *Minimum Frequency* **418** > *Frequency Limit* **624**.

– f < *Frequency Limit* **624**: Current impression
– f ≥ *Frequency Limit* **624**: Direct Torque Control DMR

The *Frequency Limit* **624** is set automatically during motor commissioning.

18.5.4.1 Torque preset

The reference torque can be specified as follows:
Set parameter *n-/M-Control Change-Over* **164** to "`6 - On`" or link it to a digital signal and turn it on.
Select the torque preset source via parameter *Reference Percentage Source 1* **476**.
For example:

– The reference torque can be set via multifunction input 1 (MFI1A) if the following setting is selected: *Reference Percentage Source 1* **476** = "`1 - Analog value MFI1A`" (factory setting).

100 % torque refer to torque calculated from *Rated mech. power* **376** (motor power) and *Rated Speed* **372** (rated motor speed). Parameter *Torque* **224** shows the actual torque value.

- Select setting of parameter *Operation Mode Search Run* **645** according to the application. Refer to Chapter 13.5.

18.5.4.2 Upper and lower frequency limit in torque control

NOTICE

Unexpected dynamic behavior

If torque control is activated while the torsional frequency is outside the range between *Frequency Upper Limit* **767** and *Frequency Lower Limit* **768**, (e.g. when a machine is started from standstill or a quickly rotating machine is stopped quickly), the permissible speed range will be approached without ramps by means of the speed controller. In this case, the torque is only limited by the limitations of the speed controller (current and torque). For this reason, there may be unexpected dynamic behavior.

In many situations, the speed must be limited at operating points with reduced or without load torque, as the speed is adjusted according to the preset torque and the load behavior. To avoid unwanted speeds (in most cases excessive speed, but sometimes low speeds, too, and to avoid current impression), the speed is limited by the speed controller via *Frequency Upper Limit* **767** and *Frequency Lower Limit* **768**.
As from the limit, the speed is adjusted to the maximum (*Frequency Upper Limit* **767** and *Frequency Lower Limit* **768**) which corresponds to the behavior of the speed controller. In addition, the controller limits the speed to the *Maximum Frequency* **419**. This limitation is done by the speed controller – changes of the speed controller affect the speed behavior in the limit range of the 3 parameters mentioned accordingly.
In current impression mode, the frequency is also limited to the *Minimum Frequency* **418**– in direct torque control mode, this limit is not active.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
767	Frequency upper limit	-599.00 Hz	599.00 Hz	599.00 Hz
768	Frequency lower limit	-599.00 Hz	599.00 Hz	-599.00 Hz

Positive values limit clockwise speed, negative values limit anticlockwise speed. If, for example, both values are positive (> 0 Hz), anticlockwise operation will be disabled.

18.5.4.3 Limit value sources

The limitation of the frequency can be done by setting fixed values and by linking to an analog input parameter. The analog value is limited via parameters *Minimum Reference Percentage* **518** and *Maximum Reference Percentage* **519**, but does not consider the *Gradient Percentage Ramp* **477** of the reference percentage value channel.
The assignment is done for the torque controller via parameters *Frequency Upper Limit Source* **769** and *Frequency Lower Limit Source* **770**.

Operation mode 769, 770	Function
101 - Analog Input MFI1A	Multifunction input 1 in analog Operation Mode **452** is the source.
110 - Fixed Limit	The selected parameter values are taken into account to limit the speed controller.
201 - Inv. Analog Input MFI1A	Operation mode 101, inverted.
210 - Inv. Fixed Limit	Operation mode 110, inverted.

18.5.4.4 Switching over between speed control and torque control

With the signal assigned to parameter *n-/M-Control Change-Over* **164**, you can switch between speed control and torque control. See Chapter 16.4.6.

18.5.5 Speed controller

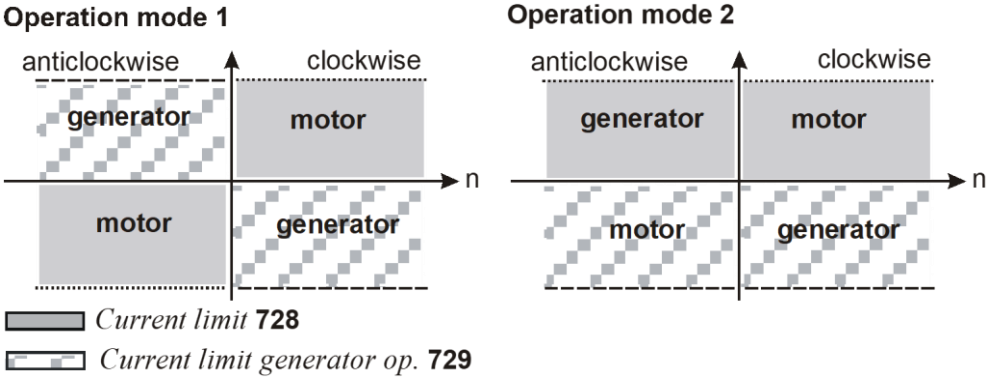
The actual speed source is selected via parameter *Actual Speed Source* **766**. In the default setting, Speed Sensor 1 is used as the source of actual speed. If Speed Sensor 2 of an extension module is to deliver the actual value signal for the speed controller, Speed Sensor 2 must be selected as the source. Alternatively, the speed controller can derive the actual speed value from the machine model in in Configurations 3xx, 4xx, and 6xx (*Parameter Configuration* **30**).

Operation Mode 766		Function
1 -	Speed Sensor 1	The actual speed source is speed sensor 1 of the basic device (factory setting).
2 -	Speed Sensor 2	The actual speed source is speed sensor 2 of an extension module.[1)]
3 -	Machine Model	The speed controller receives the calculated actual speed value from the machine model. Can be set in configurations 4xx and 6xx.
4 -	Speedtracking EC 1	Speedtracking by comparison between the calculated machine model and speed sensor 1 to increase speed accuracy. Can be set in configurations `4xx` and `6xx`. The setting for parameter *Integral Time Speedtracking* **515** is considered.
5 -	Speedtracking EC 2	Speed compensation by comparison between the calculated machine model and speed sensor 2 of an extension module[1)] to increase speed accuracy. Can be set in configurations 4xx and 6xx. The setting for parameter *Integral Time Speedtracking* **515** is considered.
20 -	Speed Observer SynRM	The speed source is the speed observer output frequency. This value is set automatically during the setup of the synchronous reluctance machine.

1) Only available if extension module is installed

The control of the torque-forming current components is done in the outer control loop by the speed controller. Via parameter *Operation Mode* **720**, you can select the operation mode for the speed controller. The operation mode defines the use of the parameterizable limits. These are referred to the direction of rotation and the direction of the torque and depend on the selected configuration.

Operation Mode 720	Function
0 - Speed controller off	The controller is deactivated or the torque-forming component is zero.
1 - Limits for Motor/Generator Op.	The limitation of the speed controller assigns the upper limit to the motor operation of the drive. Independent of the direction of rotation, the same limit is used. The same applies in the case of regenerative operation with the lower limit.
2 - Limits for pos./neg. Torque	The assignment of the limit is done by the sign of the value to be limited. Independent of the motor or generator operating points of the drive, the positive limitation is done by the upper limit. The lower limit is regarded as a negative limitation.



The properties of the speed controller can be adapted for adjustment and optimization of the controller. The Amplification and Integral Time of the speed controller can be set via parameters *Amplification 1* **721** and *Integral Time 1* **722.** For the second speed range, you can set *parameters Amplification 2* **723**, *Integral Time 2* **724**. The distinction between the speed ranges is done based on the value selected with *parameter Speed Control Switch-Over Limit* **738**. Parameters *Amplification 1* **721** and *Integral Time 1* **722** are not considered by the default parameter *Speed Control Switch-Over Limit* **738**. If parameter *Speed Control Switch-Over Limit* **738** is set to a value above `0.00 Hz`, parameters *Amplification 1* **721**, *Integral Time 1* **722** will be active below the limit, and parameters *Amplification 2* **723**, *Integral Time 2* **724** will be active above the limit.

Use the *Filter time constant* **754** to filter the control deviation, if required. In this way, operation with static control deviation and occasional undesired higher deviations can be stabilized. However, this will affect the dynamic behavior when the load changes (speed change or changing torque requirements).

The parameterized amplification at the current operating point can additionally be assessed via the parameter *Backlash Damping* **748**. In particular the small signal behavior in applications with a gearbox can be improved by a value higher than zero percent.

Parameter *Backlash Damping* **748** is available depending on the type of unit.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
721	Amplification 1	0.00	200.00	- [1)]
722	Integral Time 1	0 ms	60000 ms	- [1)]
723	Amplification 2	0.00	200.00	- [1)]
724	Integral Time 2	0 ms	60000 ms	- [1)]
754	Filter time constant	0 ms	128 ms	0 ms
738	Speed Control Switch-Over Limit	0.00 Hz	599 Hz	55.00 Hz
748	Backlash damping	0 %	300 %	100 %

[1)] The default setting is relative to the recommended machine data for the amplification and integral time. This enables a first function test in a large number of applications. Switch-over between settings 1 and 2 for the current frequency range is done by the software according to the selected limit value.

The optimization of the speed controller can be done with the help of a reference value leap. The amount of the leap is defined by the set ramp or limitation. The optimization of the PI controller should be done at the maximum admissible reference figure change rate. First, the amplification is increased until the actual value overshoots distinctly during the control process. This is indicated by a strong oscillation of the speed and by the running noises. In the next step, reduce the amplification slightly (1/2 ...3/4 etc.). Then reduce the integral time (larger I component) until the actual value overshoots only slightly in the control process.
If necessary, check the speed control settings in the case of dynamic operations (acceleration, deceleration). The frequency at which a change-over of the controller parameters takes place can be set via the parameter *Speed Control Switch-Over Limit* **738**.

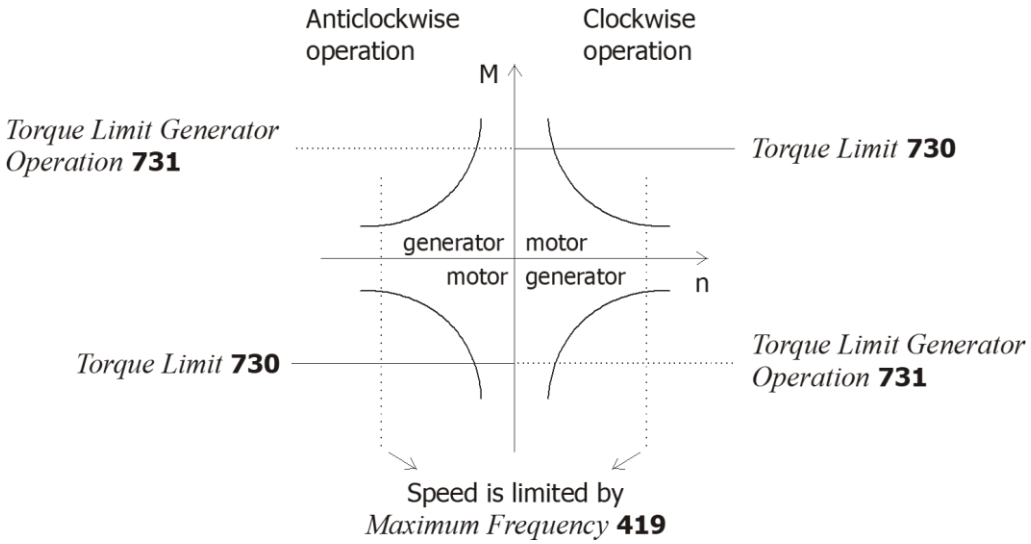
18.5.5.1 Limitation of speed controller

The output signal of the speed controller is the torque-forming current component Isq. The output and the I portion of the speed controller can be limited via parameters *Current Limit* **728**, *Current Limit Generator OP.***729**, *Torque Limit* **730**, *Torque Limit Generator Operation* **731** *and Power Limit* **739**, *Power Limit Generator Operation* **740**. The limits of the proportional portion are set via *parameters P-Comp. Torque Upper Limit* **732** and *P-Comp. Torque Lower Limit* **733**.

- The output value of the controller is limited by an upper and a lower current limit, parameters *Current Limit* **728** and *Current Limit Generator Op.* **729**. The limit figures are entered in Amperes. The current limits of the controller can be linked to the fixed limits and analog input parameters. The assignment is done via the parameters *Isq Limit Source Motor Operation* **734** and *Isq Limit Source Generator Op.* **735**.
- The output value of the controller is limited by an upper and a lower torque limit, parameter *Torque Limit* **730** and parameter *Torque Limit Generator Operation* **731**. The limit values are input as a percentage of the rated motor torque. The assignment of fixed values or analog limit values is done via the parameters *Torque Limit Source Motor OP.***736** and *Torque Limit Source Gen. OP.***737**.
- The **output value** of the P component is limited with parameter *P-Comp. Torque Upper Limit* **732** and *P-Comp. Torque Lower Limit* **733**. The limit values are input as torque limits as a percentage of the rated motor torque.
- The power output by the motor is proportional to the product of speed and torque. This output power can be limited at the controller output with a *Power Limit* **739** and *Power Limit Generator Operation* **740**. The power limits are entered in kilowatt.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
728	Current Limit	0.0 A	$o \cdot I_{FIN}$	$o \cdot I_{FIN}$
729	Current Limit Generator Op.	-0.1 A[1)]	$o \cdot I_{FIN}$	$o \cdot I_{FIN}$
730	Torque Limit	0.00 %	650.00 %	650.00 %
731	Torque Limit Generator Operation	0.00 %	650.00 %	650.00 %
732	P-Comp. Torque Upper Limit	0.00 %	650.00 %	100.00 %
733	P-Comp. Torque Lower Limit	0.00 %	650.00 %	100.00 %
739	Power Limit	0.00 kW	$2 \cdot o \cdot P_{FIN}$	$2 \cdot o \cdot P_{FIN}$
740	Power Limit Generator Operation	0.00 kW	$2 \cdot o \cdot P_{FIN}$	$2 \cdot o \cdot P_{FIN}$

[1)] When the minimum value is set in **P.729**, the value set in **P.728** is used for calculation.



18.5.5.2 Limit value sources

As an alternative to limiting the output values by a fixed value, linking to an analog input value is also possible. The analog value is limited via parameters *Minimum Reference Percentage* **518**, *Maximum Reference Percentage* **519**, but does not consider *the Gradient Percentage Ramp* **477** of the reference percentage channel.

The assignment is done via parameter *Isq Limit Source Motor Operation* **734** and *Isq Limit Source Generator OP.***735** for the torque-forming current component Isq.

The sources for the torque limits can be selected via parameter *Torque Limit Source Motor OP.***736** and *Torque Limit Source Gen. OP.***737**.

Operation mode 736, 737	Function
101 - Analog Input MFI1A	Multifunction input 1 in analog Operation Mode **452** is the source.
105 - Repetition frequency input (F3)	The frequency signal on the repetition frequency input corresponding to *Operation Mode* **496.**
110 - Fixed Limit	The selected parameter figures for limiting the speed controller are taken into account.

The limit values and assignment to different limit value sources are data set related in the configurations. The use of the data record change-over demands an examination of the parameters in question.

18.5.5.3 Integral time speed compensation

For speed compensation and in order to increase the speed accuracy, the integrating component of the speed control can be set via parameter *Integral Time Speedtracking* **515**. The setting is effective in Operation Modes „4 - Speedtracking EC 1" and „5 - Speedtracking EC 2" for Parameter *Actual Speed Source* **766**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
515	Integral Time Speedtracking	1 ms	60 000 ms	5000 ms

18.5.6 Acceleration pre-control

The acceleration pre-control is active in the speed-controlled configurations and can be activated via parameter *Operation Mode* **725**.

Operation Mode 725	Function
0 - off	The control system is not influenced.
1 - On	The acceleration pre-control is active according to the limit values.

The acceleration pre-control controlled parallel to the speed controller reduces the reaction time of the drive system to a change of reference values. The minimum acceleration time defines the modification speed of the reference speed value as from which a torque necessary for acceleration of the drive is pre-controlled. Acceleration of the mass depends on the *Mech. Time Constant* **727** of the system. The value calculated from the increase of the reference value and the multiplication factor of the torque required is added to the output signal of the speed controller.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
726	Minimum acceleration	0.1 Hz/s	6500.0 Hz/s	1.0 Hz/s
727	Mech. Time Constant	1 ms	60000 ms	10 ms

For optimal setting, the acceleration pre-control is switched on and the mechanical time constant is set to the minimum value. The output value of the speed controller is compared to the minimum acceleration time during the acceleration processes. The frequency ramp is to be set to the highest value occurring in operation at which the output figure of the speed controller is not yet limited. Now, the value of the *Minimum Acceleration* **726** is set to half the set acceleration ramp so that it is ensured that the acceleration pre-control is active. The acceleration pre-control is not raised by increasing the *Mech. Time Constant* **727** until the output figure corresponds to the time modification of the drive mechanism during the acceleration processes.

18.5.7 Field controller

The flux-forming current component is controlled by the field controller. The guided commissioning optimizes the parameters of the field controller by measuring the time constant and magnetizing curve of the connected asynchronous motor. The parameters of the field controller are selected such that they can be used without changes in most applications. The proportional and the integrating part of the field controller are to be set via parameters *Amplification* **741** and *Integral Time* **742**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
717	Reference Flux	0.01%	300.00%	100.00%
741	Amplification	0.0	100.0	5.0
742	Integral Time	0.0 ms	1000.0 ms	100.0 ms

Please note that any changes of the field controller should only be made in the base speed range.
If the field controller must be optimized, set the *Field Controller Integral Time* **742 =** *Act. Rotor Time Constant* **227** / 2, i.e. half the rotor time constants. In most applications, this change will be sufficient.
If additional optimization is required, please proceed as follows:

- First set the output frequency (e.g. via reference frequency) such that the actual value *Modulation* **223 =** 80…90 % *Reference Modulation* **750.**
- Now, change parameter *Reference Flux* **717** from 100 % to 90 %**.** While doing so, oscillograph I_{sd}. The course of the signal of the flux-forming current I_{sd} should reach the stationary value after overshooting without oscillation.
- Adjust parameters *Amplification* **741 and** *Integral Time* **742 according** to the application requirements.
- Change the *Reference Flux* **717** back to 100 % and repeat the reference flux jump, while analyzing the changes by means of oscillography. Repeat these steps if necessary.

If a quick transition into field weakening is necessary for the application, the integral time should be reduced.
For good dynamic behavior, choose a relatively high value for *Amplification* **741** of the controller. Note that high overshoot is necessary for good control behavior in controlling of a load with low-pass behavior, for example a 3-phase machine.
Parameter *Reduction Factor Flux* **778** reduces the stall current when a stopping behavior is selected with "Stop" function. This stopping behavior is selected if Parameter *Operation Mode* **630** is set to 2x (20 … 27 – "R->0, Stop, … ") or x2 (2, 12, 22, 32, 42, 52, 62, 72 – " … , R->0, Stop"). The stopping behavior is described in Chapter 13.2 "Stopping behavior".

In these operation modes, the setting for *Reduction Factor Flux* **778** will be effective once the time set in parameter *Holding Time* **638** has elapsed. The resulting stall flux is calculated from the factors *Reference Flux* **717** and *Reduction Factor Flux* **778**. After a start command, the drive will start immediately and the flux will increase to the reference flux while the drive is running.
Due to the reduced flux, a higher torque-forming current component Isq is needed when the drive is starting. The time required to reach the reference flux can be influenced via parameter *Ref. Isd Upper Limit* **743**. This parameter is set to the rated motor current during guided commissioning.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
778	Reduction Factor Flux	20.00%	100.00%	100.00%

18.5.7.1 Limitation of field controller output

The output signal of the field controller, the integrating and proportional component are limited via parameters *Ref. Isd Upper Limit* **743** and *Ref. Isd Lower Limit* **744**. During guided commissioning, parameter *Ref. Isd Upper Limit* **743** is set according to parameter *Rated Current* **371**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
743	Ref. Isd upper limit	0	o·I_{FIN}	I_{FIN}
744	Ref. Isd lower limit	- I_{FIN}	I_{FIN}	0.0

The limits of the field controller define not only the maximum current occurring, but also the dynamic properties of the controller. The upper and lower limits restrict the modification speed of the machine flux and the torque resulting from it. In particular the speed area above the nominal frequency should be observed for the modification of the flux-forming component. The upper limit is to be estimated from the product of the set magnetizing current and the correction factor *Reference Flux* **717**, although the limit must not exceed the overload current of the drive.

18.5.8 Modulation controller

The modulation controller, which is designed as an I regulator, automatically adapts the output value of the frequency inverter to the machine behavior in the basic speed area and in the field weakening area. If the modulation exceeds the figure set with parameter *Reference Modulation* **750**, the field-forming current component and thus the flux in the machine are reduced.
In order to make the best possible use of the voltage available, the figure selected via parameter *Operation Mode* **753** is put into proportion to the DC link voltage. That means that with a high mains voltage there is also a high output voltage available, the drive only reaches the field weakening area later and produces a higher torque.

Operation Mode 753	Function
0 - Usq-Control	The modulation is calculated from the ratio of torque-forming voltage component U_{sq} to the DC link voltage.
1 - U abs. value control	The modulation is calculated from the abs. voltage value / DC link voltage ratio.

The integrating part of the modulation controller is to be set via parameter *Integral Time* **752**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
750	Reference modulator	3.00 %	105.00 %	102.00 %
752	Integral Time	0.0 ms	1000.0 ms	10.0 ms

The percentage setting of the *Reference Modulation* **750** is basically a function of the leakage inductance of the machine. The default value was selected such that in most cases the remaining deviation of 5% is sufficient as a reserve range for the current controller. For the optimization of the controller parameters, the drive is accelerated with a flat ramp into the area of field weakening, so that the modulation controller intervenes. The limit is set via parameter *Reference Modulation* **750**. Then, the control loop can be excited with a jump function by modifying the reference modulation (change-over between 95% and 50%). By means of an oscillography measurement of the flux-forming current component on the analog output of the frequency inverter, the controlling process of the modulation controller can be assessed. The course of the signal of the flux-forming current I_{sd} should reach the stationary value after overshooting without oscillation. An oscillating of the course of the current can be damped by increasing the integral time. Parameter *Integral Time* **752** should roughly correspond to the actual value *Act. Rotor Time Constant* **227**.

18.5.8.1 Limitation of modulation controller

The output signal of the modulation controller is the internal reference flux. The controller output and integrating component are limited via parameter *Reference Imr Lower Limit* **755** and the product of *Rated Magnetising Current* **716** and *Reference Flux* **717.** The upper limiting parameter *Magnetising Current* is to be set to the rated value of the machine. For the lower limit, select a value which also builds up an adequate flux in the machine in the field weakening area. The limitation of the control deviation at the output of the modulation controller prevents a possible oscillation of the control loop in the case of load surges. The parameter *Control Deviation Limitation* **756** is stated as an absolute value and acts both as a positive and a negative limit.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
755	Reference Imr Lower Limit	$0.01 \cdot I_{FIN}$	$o \cdot I_{FIN}$	$0.01 \cdot I_{FIN}$
756	Control Deviation Limitation	0.00 %	100.00 %	10.00 %

19 Special functions

The configurable functions of the corresponding control methods enable another field of application of the frequency inverters. The integration in the application is made easier by special functions.

19.1 Pulse width modulation

The motor noise can be reduced by switching parameter *Switching Frequency* **400**. The switching frequency should be reduced to a maximum ratio of 1:10 to the frequency of the output signal for a sine-shaped output signal. The maximum possible switching frequency depends on the drive output and the ambient conditions. For the required technical data refer to the corresponding table and the device type diagrams.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
400	Switching frequency	2 kHz	16 kHz	2 kHz [1)]
				4 kHz [2)]

The factory setting of parameter *Switching Frequency* **400** depends on the selected parameter *Configuration* **30**:
[1)] Configurations 1xx
[2)] Configurations 2xx / 4xx

The heat losses increase proportionally to the load point of the frequency inverter and the switching frequency. The automatic reduction adjusts the switching frequency to the current operating state of the frequency inverter in order to provide the output performance required for the drive task at the greatest possible dynamics and a low noise level.
The switching frequency is adjusted between the limits set with parameters *Switching Frequency* **400** and *Min. Switching Frequency* **401**. If **P.401** is higher or equal to the **P.400**, automatic reduction will be disabled.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
401	Min. Switching Frequency	2 kHz	16 kHz	2 kHz

The change of the switching frequency depends on the heat sink temperature switch-off limit and the output current. The temperature limit to be exceeded so that the switching frequency is reduced can be set via parameter *Reduction Limit Ti/Tc* **580**. If the heat sink temperature falls below the threshold set via parameter *Reduction Limit Ti/Tc* **580** by 5 °C, the switching frequency is increased again step by step.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
580	Reduction limit Ti/Tk	-25 °C	0 °C	-4 °C

The limit for the switching frequency reduction is influenced by the intelligent current limits depending on the selected *Operation Mode* **573** and the output current. If they have been switched off or provide the full overload current, the switching frequency is reduced when the output current exceeds the limit of 87.5% of the long-term overload current (60s). The switching frequency is increased if the output current drops below the reference current of the next highest switching frequency.

19.2 Fan

The switch-on temperature of the heat sink fan can be set with parameter *Switch-On Temperature* **39**.
If mains voltage is applied to the frequency inverter, and the heat sink temperature exceeds the set temperature, the heat sink fan is switched on. Independent from parameter *Switch-On Temperature* **39**, the heat sink fan will be switched on, as soon as the frequency inverter is switched on and enabled and the start signal is received.

To protect the device, a device error will be triggered once an internal temperature shutdown threshold is reached.

In size 8 devices (>132 kW), the fans will be operated at reduced speed at the beginning. Fan speed will be increased when the heat sink temperature rises. This control cannot be adjusted and reduces noise and power losses at lower inverter power levels.

If the heat sink temperature drops below the set temperature by 5 °C, or if the controller enable signal is inhibited, the heat sink fan is switched of when the minimum ON-time has elapsed.
The minimum ON-time of the heat sink fan is set internally to 1 minute. If the temperature drops below *the Switch-On Temperature* **39** during this time, the heat sink fan will be continue operation until the minimum on time has elapsed.
Operation mode **43** for digital outputs additionally enables the control of an **external** fan. Via the digital output, the fan is switched on if the controller is released and Start clockwise or Start anticlockwise are switched on, or if the *Switch-On Temperature* **39** for the internal fan was reached.
Like in the case of the internal heat sink fan, the minimum ON-time of the external fan is 1 minute.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
39	Switch-On Temperature	0 °C	60 °C	30 °C

19.3 Bus controller

In order to be able to control the drive, the digital controller inputs S1IND/STOA and S7IND/STOB must be connected and set to "High-Signal" in order to enable the output stage.

The frequency inverters can be extended by different options for data communication and can be integrate in an automation and control system in this way. Parameterization and commissioning can be done via the optional communication card, the operating unit or the interface adapter.
Parameter *Local/Remote* **412** defines the operating behavior and enables a change between the control via contacts or the control unit and/or the interface.

Local/Remote 412	Function
0 - Control via contacts	The Start and Stop commands as well as the direction of rotation are controlled via digital signals.
1 - Control via state machine	The Start and Stop commands as well as the direction of rotation are controlled via the DRIVECOM Statemachine of the communication interface.
2 - Control via remote contacts	The Start and Stop commands as well as the direction of rotation are controlled via logic signals through the communication protocol.
3 - Ctrl. KP, direction Contacts	The Start and Stop commands are controlled from the control unit and the direction of rotation is controlled via digital signals.
4 - Ctrl. KP+Cont., direction Cont.	Commands Start and Stop via control unit or digital signals. The statement of the direction of rotation only with the help of the digital signals.
5 - Ctrl. 3-Wire, direction Cont.	3-wire; control of sense of rotation and signal *3-Wire Ctrl.* **87** via contacts.
13 - Control via KP, Direction KP	The Start and Stop commands as well as the direction of rotation are controlled via the control unit.
14 - Control KP+Cont., Direction KP	Commands Start and Stop via control unit or digital signals. The statement of the direction of rotation only with the help of the operating unit.
20 - Control Contacts, Clockw.	Commands Start and Stop via digital signals. Fixed direction of rotation, clockwise rotation only.
23 - Control Keypad, Clockw.	Commands Start and Stop via control unit. Fixed direction of rotation, clockwise rotation only.
24 - Control Cont. + KP, Clockw.	Commands Start and Stop via control unit or digital signals. Fixed direction of rotation, clockwise rotation only.
30 to 34	Operation mode 20 to 24, anticlockwise direction of rotation only.
43 - Ctrl. KP, Dir. Cont. + KP	Commands Start and Stop via control unit. The statement of the direction of rotation comes from the operating unit or via digital signals.
44 - Ctrl. Cont.+KP, Dir. Cont.+KP	Both the Start and Stop commands as well as the sense of rotation can be controlled from either the control unit or via digital signals.
46 - Ctrl. 3-Wire+KP, Dir. Cont.+KP	3-wire and control unit; control of direction of rotation and signal *3-Wire Ctrl* **87** via contacts or control unit.

If the operation mode is changed while the drive is running, the drive will not be stopped if no stop command is present in the new operation mode.

19.4 Brake chopper and brake resistance

The frequency inverters feature a brake chopper transistor. The external brake resistor is connected to terminals Rb1 and Rb2. The parameter *Trigger Threshold* **506** defines the switch-on threshold of the brake chopper. The generator output of the drive, which leads to the increase in the DC link voltage, is converted to heat by the external brake resistor above the limit set via parameter *Trigger Threshold* **506**.

Parameter		Setting			
No.	**Description**	**ACU**	**Min.**	**Max.**	**Factory setting**
506	Trigger Threshold	210	225.0 V	1000.0 V	390.0 V
		410	425.0 V	2000.0 V	780.0 V
		510	550.0 V	2000.0 V	880.0 V
		610	725.0 V	2000.0 V	1180.0 V

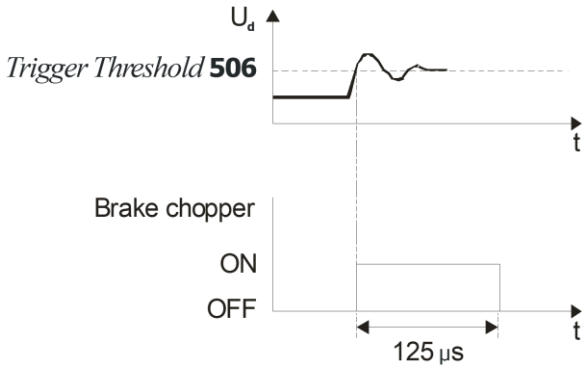
The parameter *Trigger Threshold* **506** is to be set in such a way that it is between the maximum DC link voltage which the mains can generate and the maximum admissible DC link voltage of the frequency inverter.

$$U_{Netz} \cdot 1{,}1 \cdot \sqrt{2} < Ud_{BC} < Ud_{max}$$

If the parameter *Trigger Threshold* **506** is set larger than the maximum admissible DC link voltage, the brake chopper cannot become active, the brake chopper is switched off.
If the parameter *Trigger Threshold* **506** is set to a value below the DC link voltage generated by the mains, error message F0705 (chapter 21.1) is displayed if the start command is issued to the frequency inverter.
If the DC-Link Voltage exceeds a certain threshold, error message F0700 will be triggered (see Chapter 21.1). The threshold depends on the device series:

- ACU 210 device series: 400 V
- ACU 410 device series: 800 V
- ACU 510 device series: 900 V
- ACU 610 device series: 1200 V

The sampling time of the function is 125 µs. The brake chopper remains on for at least 125 µs after the set trigger threshold was exceeded even if the value drops below the trigger threshold within this period again.



Dimensioning of brake resistor

CAUTION

Device damage!

Inappropriate resistance values may result in device damage.

- The resistance of the brake resistor must not be less than the minimum value $R_{b\ min}$ -10%. The values for $R_{b\ min}$ are listed in chapter "5".

The following values must be known for dimensioning:

- Peak braking power $P_{b\ Peak}$ in W

- Resistance R_b in Ω
- On time OT in %

Calculation of peak braking power $P_{b\ Peak}$

$$P_{b\,Spitze} = \frac{J \cdot \left(n_1^{\,2} - n_2^{\,2}\right)}{182 \cdot t_b}$$

$P_{b\ Peak}$ = Peak braking power in W
J = Moment of inertia of drive system kgm²
n_1 = Speed of drive system before the braking operation in rpm
n_2 = Speed of drive system after the braking operation in rpm
t_b = Braking time in s

Calculation of resistance R_b

$$R_b = \frac{U_{d\,BC}^{\,2}}{P_{b\,Spitze}}$$

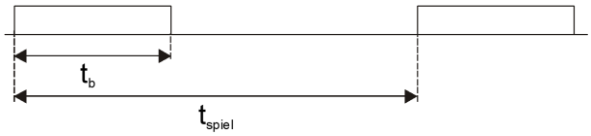
R_b = Resistance in Ω
$U_{d\ BC}$ = Switch-on threshold in V
$P_{b\ Peak}$ = Peak braking power in W

The switch-on threshold $U_{d\ BC}$ is the DC link voltage at which the brake resistor is switched on. The switch-on threshold can be set, as described above, via parameter *Trigger Threshold* **506**.
If the calculated resistance R_b of the brake resistor is between two standard series values, the lower resistance is to be selected.

Calculation of On Time OT

$$ED = \frac{t_b}{t_Z}$$

OT = On Time
t_b = Braking time
t_Z = Cycle time



Example:
t_b = 48 s, t_Z = 120 s

$$ED = \frac{t_b}{t_Z} = 0{,}4 = 40\%$$

In the case of infrequent short braking operations, typical values of the On Time OT are at 10 %, for long braking operations (≥ 120 s) typical values are at 100%. In the case of frequent deceleration and acceleration operations, it is recommended that the On Time OT be calculated according to the above formula.
The calculated values for $P_{b\ Peak}$, R_b and OT can be used by the resistor manufacturers for determining the resistor-specific permanent power.

19.5 Motor circuit breaker

In order to protect the motor against excessive heat-up, monitoring mechanisms are required which will identify potential thermal overloading in due time to prevent the motor from damage. The thermal condition of a motor can be identified in different ways.

1 Direct monitoring via temperature sensors in the winding (see Chapter 19.5.1)
   - PTC
   - KTY
   - PT1000
   - Thermocontact

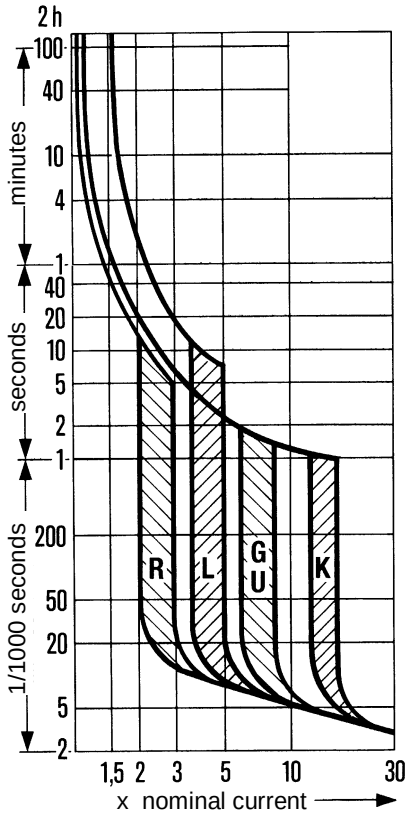
2 Indirect monitoring of motor temperature
   - Monitoring of motor current using the K- characteristic of an integrated motor circuit breaker
   - Thermocontact
   - Modeling of motor heat-up by consideration of temperature-relevant factors via a mathematical model I^2t

The thermal monitoring method is selected based on the type and operating conditions of the motor. Generally, any of the available methods is sufficient for reliable motor protection. A combination of methods from both groups (one from each group) and parallel execution is possible.

19.5.1 Motor circuit breaker

Motor circuit breakers are used for protecting a motor and its supply cable against overheating by overload. Depending on the overload level, they disconnect the motor from power supply immediately in the case of a short-circuit or they disconnect the motor if an overload has occurred for some time.

Conventional motor circuit breakers are commercially available for various applications with different trigger characteristics (L, G/U, R and K), as shown in the diagram on the right. As frequency inverters in most cases are used for supplying motors which are classified as operating equipment with very high starting currents, only the K characteristic was realized in this function.
Unlike the operation of a conventional motor circuit breaker which disconnects the equipment to be protected immediately if the trigger threshold is reached, this function provides the possibility of issuing a warning instead of disconnecting the equipment immediately.
The rated current of the motor circuit breaker refers to the rated motor current stated via parameter *Rated Current* **371** of the corresponding data set.
The rated values of the frequency inverter are to be considered accordingly when it comes to dimensioning the application.



The function of the motor circuit breaker can be linked to different data sets. In this way, it is possible to operate different motors via one frequency inverter. Thus, each motor can be equipped with its own motor circuit breaker. In case a motor is operated via the frequency inverter for which some setting values, e.g. minimum and maximum frequency, are changed via the data set switch-over, only one motor circuit breaker may be installed. This functionality can be differentiated by selecting the parameter *Operation Mode* **571** for single motor operation or multiple motor operation.

Operation Mode **571**		**Function**
0 -	off	The function is deactivated.
1 -	K-Char.,Multi-Motor Op., Err.Sw.Off	In each of the four data sets, the rated values are monitored. Overloading the drive is prevented by the fault switch-off "F0401".
2 -	K-Char.,Single-Motor, Err.Sw.-Off	The rated values in the first data set are used independently of the active data set. Overloading the drive is prevented by the fault switch-off "F0401".
11 -	K-Char.,Multi-Motor Op.,Warning	In each of the four data sets, the rated values are monitored. Overloading the drive mechanism is signaled by a warning message "A0200".
22 -	K-Char.,Single-Motor, Warning	The rated values in the first data set are used independently of the active data set. Overloading the drive mechanism is signaled by a warning message "A0200".
42 -	I²t, Single-Motor, Err.Sw.-Off	see Chapter 19.5.2
51 -	I2t,Multi-Motor Op.,Warning	see Chapter 19.5.2
52 -	I2t,Single-Motor Op.,Warning	see Chapter 19.5.2
61 -	I²t,Multi-Motor Op.,Warning and Err.Sw.-Off	see Chapter 19.5.2
62 -	I²t,Single-Motor Op.,Warning and Err.Sw.-Off	see Chapter 19.5.2
101 -	K-Char.,Multi-Motor Op., Err.Sw.Off, Latching	Like operation modes 1, 2, 11 or 22 In addition, the integrated current will be saved permanently when the device is turned off and set to the saved value upon restart.
102 -	K-Char.,Single-Motor Op., Err.Sw.Off, Latching	
111 -	K-Char.,Multi-Motor Op.,Warning, Latching	
122 -	K-Char.,Single-Motor, Warning, Latching	

Multiple motor operation

Parameter *Operation Mode* **571 =** 1, 11, 101 or 111

In multiple motor operation, it is assumed that each data set is assigned to a corresponding motor. For this, one motor and one motor circuit breaker are assigned to each data set. In this operation mode, the rated values of the active data set are monitored. The current output current of the frequency inverter is only taken into account in the motor circuit breaker activated by the data set. In the motor circuit breakers of the other data sets, zero current is expected, with the result that the thermal decay functions are taken into account. In combination with the data set change-over, the function of the motor circuit breakers is similar to that of motors connected alternately to the mains with their own circuit breakers.
In addition, in Operation Modes 101 and 111, the integrated current will be saved permanently when the device is turned off and set to the saved value upon restart.

Single motor operation

Parameter *Operation Mode* **571 =** 2, 22, 102 or 122

In single motor operation, only one motor circuit breaker, which monitors the output current of the frequency inverter, is active. In the case of a data set change-over, only the switch-off limits derived from the rated machine parameters are changed over. Accumulated thermal values are used after the change-over as well. In the case of the data set change-over, please ensure that the machine data are stated identically for all data sets. In combination with the data set change-over, the function of the motor circuit breaker is similar to that of motors connected alternately to the mains with one common circuit breaker.
In addition, in Operation Modes 102 and 122, the integrated current will be saved permanently when the device is turned off and set to the saved value upon restart.

Reset-proof

Parameter *Operation Mode* **571** = 101, 102, 111 or 122.
The internal state of the motor circuit breaker is saved permanently (reset-proof). These settings are to be used in the case of regular short-time mains failure/disconnection. This guarantees correct motor protection for the application even in the case of short-time mains failure/disconnection.
Motor protection, in particular self-ventilation motors, is improved via a *Frequency Limit* **572** which can be set as a percentage of the rated frequency.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
572	Frequency Limit	0%	300%	0%

Output signals

Digital signals signal that of the function "motor circuit breaker" has been triggered.

180 - 14 -	Warning Motor Protection	1) 2)	Triggering of "motor circuit breaker" function as per *Operation Mode* **571** is reported.

1) For linking to frequency inverter functions
2) For output via a digital output.

In Operation Modes 101, 102, 111 and 122, the function set in parameter *Operation Mode* **571** should be the same in all data sets.

In the calculation of the triggering time, the output current measured in working points below the frequency limit will be valued at a factor between 1 and 2.
This factor is determined depending on the stator frequency. In this way, the higher thermal load of self-ventilated motors in the lower speed range is considered.
The table shows an extract of the factors for a 50 Hz motor.

Stator frequency [Hz]	Frequency Limit **572**								
	300%	200%	150%	**100%**	80%	60%	40%	20%	10%
0	200%	200%	200%	**200%**	200%	200%	200%	200%	200%
5	188%	182%	177%	**168%**	162%	153%	139%	114%	100%
10	177%	168%	160%	**147%**	139%	129%	114%	100%	100%
20	160%	147%	137%	**122%**	114%	106%	100%	100%	100%
30	147%	132%	122%	**109%**	103%	100%	100%	100%	100%
50	129%	114%	106%	**100%**	100%	100%	100%	100%	100%
100	106%	100%	100%	**100%**	100%	100%	100%	100%	100%
150	100%	100%	100%	**100%**	100%	100%	100%	100%	100%

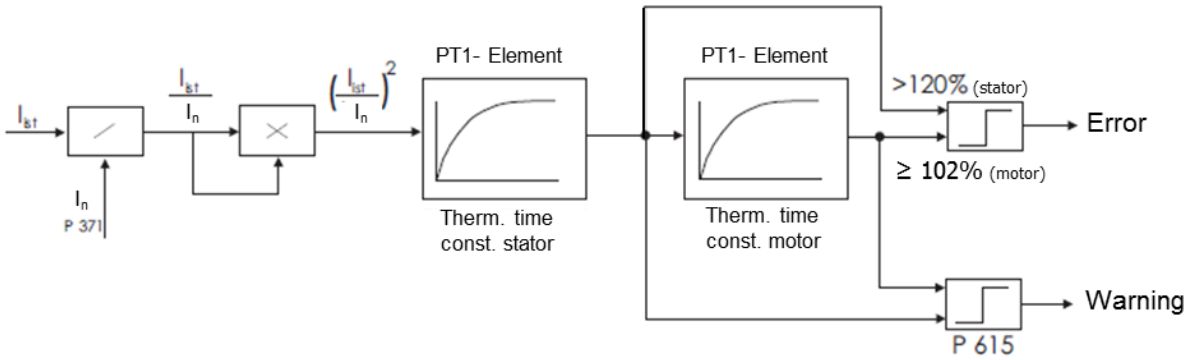
19.5.2 Motor protection by I2t monitoring

I2t monitoring is another way to protect the motor against thermal overload. This motor protection method is mainly used in servo systems.

Wherever synchronous servomotors are used, I2t monitoring is a proven alternative to motor circuit breakers. By integrating measurable or known motor parameters, heat-up is modeled based on a mathematical model.

The I2t monitoring feature can be selected via *Operation Mode* **571**. The settings are data set change-over settings. I²t monitoring is done, as shown in the illustration, via (Iact/Irated)².

The monitored variable is valued via a PT1 element with the thermal time constant of the stator. If the PT1 element output exceeds 120%, an error message will be reported and the inverter will shut down. The 120% threshold ensures the overshooting will not result in immediate shutdown. Permanent exceeding of the 100% load of the stator winding should be avoided in the application.



The output of the first PT1 element is connected to the input of the second PT1 element which contains the thermal time constant of the motor. This output may be loaded at 100% permanently. This corresponds to full thermal loading of the motor. Once 102% are reached, the inverter will shut down and an error will be reported. Both outputs are linked to an adjustable *Warning Limit*.

Operation Mode 571	Function
42 - I²t, Single-Motor, Err.Sw.-Off	The I²t load of the motor is monitored via the rated values from the active data set. Once the fixed error threshold of 100% Motor (120% Stator) is exceeded, there will be an error shutdown "F0401" by the active data set.
51 - I2t,Multi-Motor Op.,Warning	In each of the four data sets, the I²t load of the motors is monitored based on the corresponding rated values. Once the set *Warning Limit I2t* **615** is reached, a warning "A0200" will be triggered by the active data set.
52 - I2t,Single-Motor Op.,Warning	The I²t load of the motor is monitored via the rated values from the active data SE. Once the set *Warning Limit I2t* **615** is reached, a warning "A0200" will be triggered by the active data set.
61 - I²t,Multi-Motor Op.,Warning and Err.Sw.-Off	In each of the four data sets, the I²t load of the motors is monitored based on the corresponding rated values. Once the set *Warning Limit I2t* **615** is reached, a warning "A0200" will be triggered. Once the fixed error threshold of 100% Motor (120% Stator) is exceeded, there will be an error shutdown "F0401". Both events will be triggered by the active data set.

Operation Mode 571	Function
62 - I²t,Single-Motor Op.,Warning and Err.Sw.-Off	The I²t load of the motor is monitored via the rated values from the active data SE. Once the set *Warning Limit I2t* **615** is reached, a warning "A0200" will be triggered. Once the fixed error threshold of 100% $_{Motor}$ (120% $_{Stator}$) is exceeded, there will be an error shutdown "F0401". Both events will be triggered by the active data set.

The thermal time constant for the motor is in the range between a couple of minutes and several hours. This motor-specific parameter is set via *Thermal time constant motor* **608**.

The thermal time constant of the stator is much smaller. To protect the stator winding, additional monitoring is required and defined via the *Thermal time constant stator* **609**. For the time constant values, refer to the relevant motor datasheets. If time constants are estimated, optimum motor protection cannot be guaranteed.

Warning thresholds give the user the chance to respond to imminent I²t error shutdown. Via *Warning Limit I2t* **615**, you can choose a value between 6% and 100% of thermal load.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
608	Thermal time constant motor	1 min	240 min	30 min
609	Thermal time constant stator	1 s	600 s	15 s
615	Warning Limit I²t	6%	100%	80%

Output signals

Digital signals signal that of the function "motor circuit breaker" has been triggered.

180 -	Warning Motor Protection	1)	Triggering of "motor circuit breaker" function as per *Operation Mode* **571** is reported.
14 -		2)	

1) For linking to frequency inverter functions
2) For output via a digital output.

19.6 V-belt monitoring

Continuous monitoring of the load behavior and thus of the connection between the 3-phase machine and the load is the task of the V-belt monitoring system. Parameter *Operation Mode* **581** defines the function behavior if the *Active Current* **214** (sensorless control) or the torque-forming current component *Isq* **216** (field-oriented control method) is below the set *Trigger Limit Iactive* **582** for longer than the parameterized *Delay Time* **583**.

Operation Mode 581	Function
0 - off	The function is deactivated.
1 - Warning	If the active current drops below the threshold value, the warning "A8000" is displayed.
2 - Fault	The unloaded drive is switched off and error signal "F0402" is displayed

The error and warning messages can be read out by means of the digital outputs (Signal 22 - "Warning V-Belt") or reported to a higher-level control system. The *Trigger Limit Iactive* **582** is to be parameterized as a percentage of the *Rated Current* **371** for the application and the possible operating points.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
582	Trigger limit Iactive	0.1%	100.0%	10.0%
583	Delay time	0.1 s	600.0 s	10.0 s

19.7 Functions of field-oriented control

The field-oriented control systems are based on a cascade control and the calculation of a complex machine model. The various control functions can be supplemented by special functions specific to the application.

19.7.1 Motor chopper

The field-oriented control systems contain the function for adapted implementation of the generator energy into heat in the connected three-phase machine. This enables the realization of dynamic speed changes at minimum system costs. The torque and speed behavior of the drive system is not influenced by the parameterized braking behavior. The parameter *Trigger Threshold* **507** of the DC link voltage defines the switch-on threshold of the motor chopper function.

Parameter		Setting			
No.	**Description**	**ACU**	**Min.**	**Max.**	**Factory setting**
507	Trigger Threshold	210	225.0 V	1000.0 V	400.0 V
		410	425.0 V	2000.0 V	800.0 V
		510	550.0 V	2000.0 V	900.0 V
		610	725.0 V	2000.0 V	1200.0 V

The parameter *Trigger Threshold* **507** is to be set in such a way that it is between the maximum DC link voltage which the mains can generate and the maximum admissible DC link voltage of the frequency inverter.

$$U_{Netz} \cdot 1{,}1 \cdot \sqrt{2} < U_{dMC} < Ud_{max}$$

If the parameter *Trigger Threshold* **507** is set larger than the maximum admissible DC link voltage, the motor chopper cannot become active, the motor chopper is switched off.
If the set *Trigger Threshold* **507** is smaller than the maximum DC link voltage the mains can generate, error message F0706 (see Chapter 21.1) is displayed when the frequency inverter is switched on.

The motor chopper function will only work if it was activated via the voltage controller *Operation Mode* **670** . Refer to Chapter 18.2.

For synchronous motors (*Configuration* **30**=5xx or 6xx), the motor chopper feature is deactivated to prevent the motor from being damaged. The other functions of the voltage controller are not affected by this.

Note that, by default, the motor chopper *Trigger Threshold* **507** and brake chopper *Trigger Threshold* **506** are set to different values. When using both functions make sure the set thresholds are suitable for the application.

19.7.2 Temperature Adjustment

The field-oriented control systems are based on the most precise calculation of the machine model possible. The rotor time constant is an important machine variable for the calculation. The figure to be read out via the parameter *Act. Rotor Time Constant* **227** is calculated from the inductance of the rotor circuit and the rotor resistance. The dependence of the rotor time constant on the motor temperature can be taken into account in the case of particularly high precision requirements via a suitable measurement. Via *Operation Mode* **465** for the temperature adjustment, you can select different methods and actual value sources for temperature measurement.

Operation Mode 465	Function
0 - off	The function is deactivated.
1 - Temp. meas. on MFI1A	Temperature synchronization (0 ... 200 °C => 0 ... 10 V / 0 … 20 mA), actual temperature value at multifunction input 1
4 - Temp.meas. upon start	Determination of temperature by frequency inverter via measurement of the winding resistance without external temperature measurement
11 - Vectron temP.meas. on MFI1A	Temperature synchronization; act. temperature value across analog multi-function input. (-26.0 °C … 207.8 °C => 0 ... 10 V / 0 … 20 mA)

Operation mode 1 requires an external temperature measurement system which evaluates the temperature sensor and maps the temperature range from 0...200 °C to an analog voltage or current signal. *Operation Mode* **452** of multifunction input MFI1 must be selected accordingly.

Operation mode 4 is available in configurations 210, 211, 230, 260 and 460. When the signals Controller release and Start clockwise or Start anticlockwise are present, the motor temperature and the rotor time constant are synchronized by means of the measured winding resistance.
For **Operation Mode 11**, an optional temperature measurement board from Bonfiglioli Vectron GmbH is required. This board can be connected to the 20 V power supply on the frequency inverter. This board converts the temperature to an analog voltage or current signal in a range from -26.0 °C to 207.8 °C. The resistance of the measuring resistor KTY84/130 to be used is 1000 Ω at a temperature of 100 °C.
The material used for the rotor winding of the motor is taken into account via the parameter *Temperature Coefficient* **466**. This value defines the change of the rotor resistance as a function of the temperature for a certain material of the rotor winding. Typical temperature coefficients are 39%/100 °K for copper and 36%/100 °K for aluminum at a temperature of 20 °C.
The temperature characteristic within the software is calculated via the aforementioned temperature coefficient and the parameter *Adjusting Temperature* **467**. The adjustment temperature enables an additional optimization of the rotor time constant alongside the parameter *Rated Slip Correction Factor* **718**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
466	Temperature coefficient	0.00%/100 °K	300.00%/100 °K	39.00%/100 °K
467	Adjusting temperature	-50 °C	300 °C	35 °C

The synchronization of the rotor time constant as a function of the winding temperature can be adjusted. The default values should normally be sufficiently precise so that neither an adjustment of the rotor time constants via the parameter *Rated Slip Correction Factor* **718** nor an adjustment of the temperature synchronization via the parameter *Temperature Coefficient* **466** is necessary. If an adjustment is necessary, please remember that the rotor time constant is calculated by the guided commissioning via the machine data. The *Adjusting Temperature* **467** is to be set to the temperature at which the optimization of the extended machine data was carried out. The temperature can be read out via the actual value parameter *Winding Temperature* **226** and can be used in the optimization for the parameter.

19.7.3 Speed sensor monitoring

Failures of the speed sensor lead to a faulty behavior of the drive, as the measured speed forms the foundation of the control system. By default, the speed sensor monitoring system continuously monitors the speed sensor signal, the track signals. If an extension module EM is connected, the number of division marks is monitored additionally. If, while the frequency inverter is released, a faulty signal is recognized for longer than the timeout, a fault switch-off is carried out. If parameter *Operation Mode* **760** is set to zero, the monitoring function is deactivated.

Operation Mode 760	Function
0 - off	The function is deactivated.
2 - Error	A error signal is displayed according to the timeouts set.

The speed sensor monitoring is to be parameterized in the part functions according to the application. The monitoring function becomes active with the release of the frequency inverter and the start command. The timeout defines a monitoring time in which the condition for the fault switch-off must be fulfilled without interruption. If one of the timeouts is set to zero, this monitoring function is deactivated.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
761	Timeout: Signal fault	0 ms	65000 ms	1000 ms
762	Timeout: Track fault	0 ms	65000 ms	1000 ms
763	Timeout: Direction of rotation fault	0 ms	65000 ms	1000 ms
782	Timeout: Drive blocked	0 ms	65000 ms	1000 ms

Timeout: Signal fault

The actual speed measured is compared with the output value of the speed controller. If the actual speed value is exactly zero for the time selected with the parameter *Timeout: Signal fault* **761**, although a reference value is available, the fault is displayed with message "F1430".

Timeout: Track fault

The actual speed measurement monitors the sequence in time of the signals in the quadruple evaluation of the speed sensor operation mode. If the speed sensor signal is faulty for the time selected with the parameter *Timeout: Channel fault* **762**, the fault is displayed with message "F1430".

Timeout: Direction of rotation fault

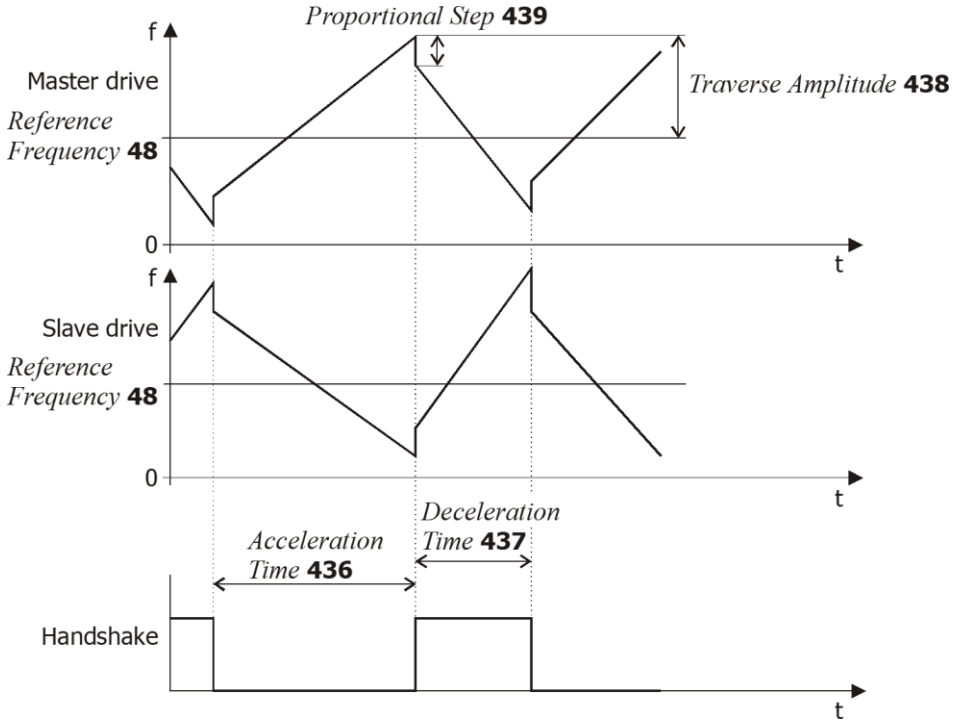
The actual speed measured is compared with the reference speed. If the sign between reference value and actual value differs for the time selected with parameter *Timeout: Direction fault* **763**, the fault is displayed with the message "F1432". The monitoring function is reset when the drive mechanism has moved in the reference value direction by a quarter of a revolution.

Timeout: Drive blocked

The actual speed measured is compared with the output value of the speed controller. If the actual speed value is exactly zero for the time selected with the parameter *Timeout: Drive blocked* **782**, although the drive works at the current limit (**728** *Current Limit*), the fault is displayed with message "F1438".

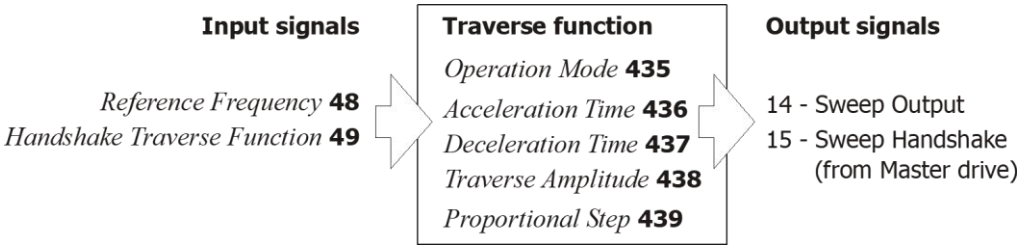
19.8 Traverse function

With the traverse function, the a triangle-shaped frequency signal with the start-up and shut-down times to be set is superimposed on the output frequency. The resulting chronological order of the reference frequency of master drive and slave drive are shown in the following diagrams. The function can be used, for example, for drives which wind up thread on coils in textile machines. To avoid winding errors at the turning point of the thread guide, a proportional jump is performed which causes a quick speed change.



In the case of the master drive, the superimposed traverse frequency is linearly opposite to the limit *Traverse Amplitude* **438** and will then reverse its direction. When the direction is reversed, a proportional jump is carried out. Via a handshake signal, the master drive informs the slave drive that the traverse output has changed its direction. The traverse function of the slave drive has the same gradient as the traverse function of the master drive, but an opposite sign. When the slave drive reaches the limit *Traverse Amplitude* **438** before switch-over of the handshake signal, the frequency is maintained until switch-over is carried out. If the handshake signal is received before the frequency limit is reached, the direction is reversed immediately.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
436	Startup time	0.01 s	320.00 s	5 s
437	Shut-down time	0.01 s	320.00 s	5 s
438	Traverse amplitude	0.01 %	50.00 %	10 %
439	Proportional jump	0.01 %	50.00 %	0.01%



Signal "14 – Output Wobble" is added to the reference frequency value.

Via parameter *Operation Mode* **435**, the drive is configured as a master drive or slave drive.

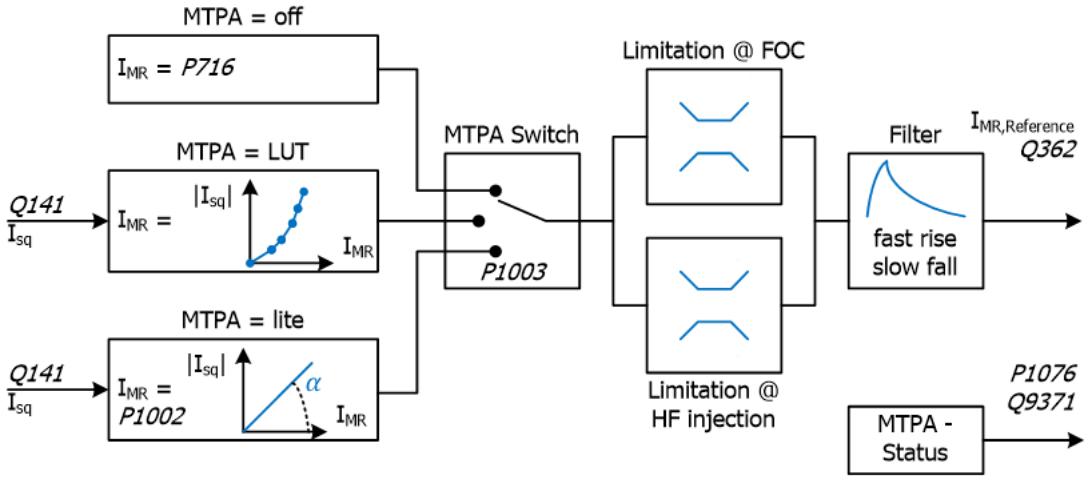
Operation Mode 435	Function
0 - off	The traverse function is deactivated.
1 - Master drive	Operation as master drive.
2 - Slave drive	Operation as slave drive.

For traverse mode, the reference value source is selected via parameter *Reference Frequency* **48**.
Traverse mode becomes active once the *Reference Frequency* **48** is reached for the first time. This frequency is reached via the values for *Acceleration (Clockwise)* **420**, *Acceleration Anticlockwise* **422**, *Deceleration (Clockwise)* **421** and *Deceleration Anticlockwise* **423**. In traverse mode, the values for *Acceleration Time* **436** and *Deceleration Time* **437** are active.
The frequency range for traverse mode is limited by *Minimum Frequency* **418** and *Maximum Frequency* **419**.
During traverse operation, the configured traverse parameter values cannot be changed.
The source of the handshake signal is selected via *Handshake Traverse Function* **49**.

19.9 Maximum Torque per Ampere: MTPA (P.1003) for SynRM

The MTPA function is specific to the synchronous reluctance machine functionality.
It may be unavailable in configurations other than configurations `310` and `330`.
Flux reduction saves ohmic losses and improves the efficiency in part load mode. The flux is adapted with a fast rising and slow falling dual-PT1 filter. In some cases it can be use full to even increase the flux above nominal level (usage of look up tables).

MTPA signal diagram



Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
1002	MTPA-lite angle	45.0 deg	80.0 deg	45.0 deg
1003	Operation Mode MTPA	0	99	0
1076	Status SynRM MTPA	Selection		
1044	Selection of Look Up Table	0		0

Operation Mode MTPA **1003**	Function
0 - MTPA Off	The function is deactivated.
1 - MTPA-lite on; angle = P.1002	The function is activated; the angle is defined in **P.1002**
2 - Variable Lookup table P.1065	The function is activated; the angle is defined in the lookup table defined in **P.1065**.

Please note that **P.1003** and **P.1044** allow further motor-specific settings additional to the settings listed above. In order to use a motor-specific characteristic curve, select the corresponding motor type from the list.

To use a customized MTPA table, use VTable to read and write into index parameter **P.1076**. The table contains the reference value for magnetization in a step size of 10% of nominal current. (for example: Index 1: I_{sd} = 0% I_N, Index 2: I_{sd} = 10% I_N …).
In most applications the setting `1 - MTPA-lite on; angle = P.1002` of **P.1003** produces the best results. Further parameters do not need to be adapted. The MTPA-lite function should be activated when third-party motors are used. The MTPA table must be generated experimentally for third-party motors.
The MTPA-lite function approximates an optimized MTPA table. It will produce better results for some specific partial loads, while producing poorer results for other partial loads.
Using the **P.1003** and the **P.1044**, a setting specific to the respective motor can be chosen from the corresponding list. With **P.1003**, a motor-specific MTPA characteristic is selected. With **P.1044**, the inductance is adapted to the motor saturation.

Status SynRM MTPA **1076**	Function
0 - off: nominal flux (P.716)	The function is deactivated. **P.716** is applied.
1 - off: transition to nominal flux (P.716)	The function is deactivated. Ramp-down to **P.716** is applied.
2 - on: minimum flux limit (P.1067)	The function is activated. The minimum flux limit is defined by the setting of **P.1067**.
3 - on: flux reduced	The function is activated. The flux is reduced.
4 - on: maximum flux limit (P.1068)	The function is activated. The maximum flux limit is defined by the setting of **P.1068**.
5 - on: flux increased	The function is activated. The flux is increased.
6 - on: f < f_lim: nominal flux	The function is activated. The flux is nominal while f < f_lim.
7 - on: f < f_lim: maximum flux limit (P.1068)	The function is activated. The flux is limited by **P.1068** while f < f_lim.
8 - on: f < f_lim: flux increased	The function is activated. The flux is increased while f < f_lim.

19.10 Profibus/Internal Notation converter

With the Profibus/Internal Notation converter ("Convert Profibus/Intern"), you can convert a 16 bit word to an internal 32 bit frequency value and vice versa. This is useful, for example, if several devices are networked via System Bus and only 1 device is provided with a Profibus option for cost reasons. By forwarding the Profibus word via System Bus ("Tunneling"), you can reduce the bandwidth needed in System Bus and make parameterization of the "Gateways" (System Bus Master with Profibus Slave communication module) easier. In this case, the converter is used without Profibus module in one device in order to convert the Profibus notation to an internal reference value.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Factory setting**
1370	In-F-PDP-word 1	Selection		
1371	In-F-PDP-word 2	Selection		
1372	In-F-intern long 1	Selection		
1373	In-F-intern long 2	Selection		
1374	In-F-Convert Reference	0.01 Hz	599.00 Hz	50.00 Hz

Accordingly, the current frequency can be converted to a value based on Profibus notation, for example. The converter can also be used for other purposes, e.g. using the internal PLC programming.
In-F-PDP-word 1 **1370** and *In-F-PDP-word 2* **1371** convert Profibus notation to internal frequency representations. 0x4000 in Profibus notation (=100 %) corresponds to *In-F-Convert Reference* **1374** in Hz.
In-F-intern-long 1 **1372** and *In-F-intern-long 2* **1373** convert internal frequency values to Profibus notation. 0x4000 in Profibus notation (=100 %) corresponds to *In-F-Convert Reference* **1374** in Hz.
Profibus notation is limited to values from -200 % (0x8000) to +200 % (0x7FFF).

0x4000 = 100 % = *In-F-Convert Reference* **1374**
0x7FFF = 200 % = *2x In-F-Convert Reference* **1374**
0x8000 = -200 % = *-2x In-F-Convert Reference* **1374**
0xC000 = -100 % = *-In-F-Convert Reference* **1374**

The values converted in this way are available as internal sources.
774 – Out-F-PDP-Conv1-long1 as output of
In-F-PDP-word 1 **1370** (Profibus not. → frequency)
775 – Out-F-PDP-Conv1-long2 as output of
In-F-PDP-word 2 **1371** (Profibus not. → frequency)
776 – Out-F-PDP-Conv1-word1 as output of
In-F-PDP-long 1 **1372** (Frequency → Profibus not.)
777 – Out-F-PDP-Conv2-word2 as output of
In-F-PDP-long 2 **1373** (Frequency → Profibus not.)

20 Actual values

The various control functions and methods include electrical control variables and various calculated actual values of the machine or system. The different actual values can be read out for operational and error diagnosis via a communication interface or in the "VAL" menu branch of the control unit.

20.1 Actual values of frequency inverter

The modular hardware of the frequency inverter enables application-specific adaptation. Further actual value parameters can be displayed as a function of the selection configuration and the installed expansion cards.

Actual values of frequency inverter

No.	Description	Function
222	DC-Link Voltage	Direct voltage in DC-link.
223	Modulation	Output voltage of the frequency inverter relative to the mains voltage (100% = U_{FIN})
228	Internal Reference Frequency	Sum of the *Reference Frequency Sources* **475** as a reference value from the frequency reference value channel
229	Reference Percentage Value	Sum of the *Reference Percentage Sources* **476** as a reference value from the reference percentage channel
230	Actual Percentage Value	Actual value signal at *Actual Percentage Source* **478**
243	Digital Inputs hardware	Decimally coded status of the six digital inputs and of Multifunction input 1 in *Operation mode* **452** - Digital Input. Represents the status of the physical inputs (also refer to *Digital inputs* **250**).
244	Working Hours Counter	Working hours in which the output stage of the inverter is active.
245	Operation Hours Counter	Operating hours of the frequency inverter in which supply voltage is available.
249	Active Data Set	The data set actively in use according to *Data Set Change-Over 1* **70** and *Data Set Change-Over 2* **71**.
250	Digital Inputs	Decimally coded status of the six digital inputs and of Multifunction input 1 in *Operation mode* **452** - `Digital Input`.
251	Analog Input MFI1A	Input signal at Multifunction input 1 in analog *Operation mode* **452**
252	Repetition Frequency Input	Signal at repetition frequency input according to *Operation mode* **496**.
254	Digital Outputs	Decimally coded status of the two digital outputs and of Multifunction output 1 in *Operation mode* **550** – `Digital`
255	Heat Sink Temperature	Measured heat sink temperature.
256	Inside Temperature	Measured inside temperature.
257	Analog Output MFO1A	Output signal at Multifunction output signal 1 in *Operation mode* **550** – `Analog`.
258	PWM input	Pulse-width modulated signal at PWM input according to *Operation Mode* **496**.
259	Current Error	Error message with error code and abbreviation.
269	Warnings	Warning message with warning code and abbreviation.
273	Application Warnings	Warning message application with warning code and abbreviation.
275	Controller Status	The reference value signal is limited by the controller coded in the controller status.
277	STO Status	Signal status of switch-of paths STOA (digital input S1IND/STOA) and STOB (S7IND/STOB) of safety function "STO – Safe Torque Off").
278	Frequency MFO1F	Output signal on Multifunction output 1 in Operation mode **550** – repetition frequency

In addition to the actual values shown, other actual values are available and can be read out via field bus.
This includes, in particular, parameters *Current Error* **260,** *Warnings* **270** and *Application Warnings* **274** where the relevant message can be read out as hexadecimal code (and without texts). Please refer to the communication manuals.

The actual values can be read out and monitored in the VAL menu branch of the operating unit. The parameter *Control Level* **28** in the PARA menu branch defines the selection of the actual value parameters.

In the actual value display **243**, **250**, the digital inputs cannot be active (permanently "0"). This can be caused by the configuration or functions used (e.g. sensor input or frequency input).

Input	Deactivation mechanism for actual value display
S2IND	PWM / ReP.frequ. Input
S4IND	Track B (speed sensor 1)
S5IND	Track A (speed sensor 1)
S6IND	Track Z (speed sensor 1) or PWM / ReP.frequ. Input
MFI1	Analog input

Setting:

For speed sensor 1, check Parameter *Operation Mode* **490**.
For PWM / ReP.freq. input, check parameter *Operation Mode* **496**.
For MFI1, check Parameter *Operation Mode* **452**.

Actual value:

Encoder 1 Frequency is shown in **217**, speed in **218**.
PWM/rep.freq. input: PWM is shown in **258**, frequency in **252**.

STO Status

Parameter *STO Status* **277** can be used for extended diagnosis of the two inputs STOA and STOB. The statuses of the inputs are shown in bit-encoded form.

Bit	Value	Meaning
0	1	STOA input missing.
1	2	STOB input missing.
2	4	Switch off STOA input.
3	8	Switch off STOB input.
4	16	Timeout STOA.
5	32	Timeout STOB.
6	64	Diagnosis error.
7	128	FI error (fault).

With correct wiring and correct function, only the 2 states "0" (= STO enabled) and "3" (= STO disabled) are typically shown (decimal representation) in parameter *STO Status* **277**.
The signal states at digital inputs STOA and STOB can be linked to functions of the frequency inverter.

292 -	STOA	Signal state at digital input STOA
284 -	STOA inverted	Inverted signal state at digital input STOA
293 -	STOB	Signal state at digital input STOB
285 -	STOB inverted	Inverted signal state at digital input STOB

Refer to Application manual "Safe Torque Off STO".

20.2 Actual values of machine

The frequency inverter controls the behavior of the machine in the various operating points. As a function of the configuration selected and the expansion cards installed, control variables and further actual value parameters of the machine can be displayed.

No.	Description	Function
	Actual values of machine	
210	Stator frequency	The output voltage (motor voltage) of the frequency inverter.
211	R.m.s Current	Calculated effective output current (motor current) of the frequency inverter.
212	Output Voltage	Calculated effective value of linked output voltage (motor voltage) of frequency inverter.
213	Active Power	Active power calculated from the voltage, the current and the control variables.
214	Active Current	Active current calculated from the rated motor parameters, the control variables and the current.

No.	Description	Function
	Actual values of machine	
215	Isd	Current component of the field-oriented control forming the magnetic flux.
216	Isq	Torque-forming current component of field-oriented control.
217	Encoder 1 Frequency	Calculated from the data on speed sensor 1, the *No. of Pole Pairs* **373** and the speed sensor signal
218	Encoder 1 Speed	Calculation from *Encoder 1 Frequency*
221	Slip Frequency	Difference from the synchronous frequency calculated from the rated motor parameters, the control variables and the current.
224	Torque	Torque at the current output frequency calculated from the voltage, the current and the control variables.
225	Rotor Flux	Current magnetic flux relative to the rated motor parameters.
226	Winding Temperature	Measured temperature of the motor winding according to *Operation Mode* **465** for temperature adjustment
227	Act. Rotor Time Constant	Time constant calculated for the operating point of the machine from the rated motor parameters, the rated and control variables
235	Flux-Forming Voltage	Voltage component of the field-oriented control forming the magnetic flux.
236	Torque-Forming Voltage	Voltage component of the field-oriented control forming the torque.
238	Flux Value	Magnetic flux calculated according to the rated values and the operating point of the motor.
239	Reactive Current	Reactive current calculated from the rated motor parameters, the control variables and the current.
240	Actual Speed	Measured or calculated speed of drive.
241	Actual Frequency	Measured or calculated frequency of drive.

The actual values can be read out and monitored in the VAL menu branch of the operating unit. Parameter *Control Level* **28** in PARA menu branch defines the selection of the actual value parameters to be selected.

20.3 Actual value memory

The assessment of the operating behavior and the service of the frequency inverter in the application are facilitated by storing various actual values. The actual value memory guarantees monitoring of the individual variables for a definable period. The parameters of the actual value memory can be read out via a communication interface and displayed via the operating unit. In addition, the operating unit provides monitoring of the peak and mean values in the VAL menu branch.

No.	Description	Function
	Actual value memory	
231	Peak Value Long Term Ixt	utilization of the device-dependent overload of 60 seconds.
232	Peak Value Short Term Ixt	Utilization of the device-dependent overload of 1 second.
287	Peak Value Vdc	The maximum DC link voltage measured.
288	Average Value Vdc	The mean DC link voltage calculated in the period of observation.
289	Peak Value Heat Sink Temp.	The highest measured heat sink temperature of the frequency inverter.
290	Average Value Heat Sink Temp.	The mean heat sink temperature calculated in the period of observation.
291	Peak Value Inside Temperature	the maximum measured inside temperature in the frequency inverter
292	Average Value Inside Temperature	The mean inside temperature calculated in the period of observation.
293	Peak Value Irms	The highest abs. current calculated from the measured motor phases.
294	Average Value Irms	The mean abs. current calculated in the period of observation.
295	Peak Value Active Power pos.	The largest calculated active power in motor operation.
296	Peak Value Active Power neg.	Maximum generator active power calculated from the voltage, the current and the control variables.
297	Average Value Active Power	The mean active power calculated in the period of observation.
301	Energy, positive	The calculated energy to the motor in motor operation.
302	Energy, negative	The calculated energy from the motor in generator operation.

The actual values can be read out and monitored in the VAL menu branch of the operating unit. Parameter *Control Level* **28** in PARA menu branch defines the selection of the actual value parameters to be selected.

Parameter *Reset Memory* **237** which is to be selected in the PARA menu branch of the operating unit enables purposeful resetting of the individual mean and peak values. The peak value and the mean value with the values stored in the period are overwritten with the parameter value zero.

Reset Memory 237	Function
0 - No Reset	Values of actual value memory remain unchanged.
1 - Peak Value Long Term Ixt	Reset *Peak Value Long Term Ixt* **231**
2 - Peak Value Short Term Ixt	Reset *Peak Value Short Term Ixt* **232**
3 - Peak value Vdc	Reset *Peak Value Vdc* **287**.
4 - Average value Vdc	Delete *Average Value Vdc* **288**.
5 - Peak value Tc	Reset *Peak Value Heat Sink Temp.* **289**.
6 - Average Tc	Delete *Average Value Heat Sink Temp.* **290**.
7 - Peak value Ti	Reset *Peak Value Inside Temperature* **291**.
8 - Average Ti	Delete *Average Value Inside Temperature* **292**.
9 - Peak Value Irms	Reset *Peak Value Irms* **293**.
10 - Average Value Irms	Delete *Average Value Irms* **294**.
11 - Peak value Pactive pos.	Reset *Peak Value Active Power pos.* **295**.
12 - Peak value Pactive neg.	Reset *Peak Value Active Power neg.* **296**.
13 - Average Pactive	Delete *Average Value Active Power* **297**.
16 - Energy, positive	Reset parameter *Energy, positive* **301**.
17 - Energy, negative	Reset parameter *Energy, negative* **302**.
100 - All peak values	Reset all saved peak values.
101 - All average values	Delete average values and saved values.
102 - All values	Delete the entire actual value memory.

20.4 Actual values of the system

The calculation of the actual figures of the system is based on the parameterized system data. Specific to the application, the parameters are calculated from the factors, electrical variables and the controls. The correct display of the actual figures is a function of the data of the system to be parameterized.

20.4.1 Actual value system

The drive can be monitored via actual value *Actual Value System* **242**.
The *Actual Frequency* **241** to be monitored is multiplied by the *Factor Actual Value System* **389** and can be read out via parameter *Actual Value System* **242**, i.e. *Actual Frequency* **241** x *Factor Actual Value System* **389** = *Actual Value System* **242**.

Actual Value System		
No.	**Description**	**Function**
242	Actual Value System	Calculated frequency of drive.

20.4.2 Volumetric Flow and Pressure

Parameterization of factors *Nominal Volumetric Flow* **397** and *Nominal Pressure* **398** is necessary when the corresponding actual values *Volumetric Flow* **285** and *Pressure* **286** are used for drive monitoring. The conversion is done using the electrical control parameters. *Volumetric Flow* **285** and *Pressure* **286** are referred to the *Active Current* **214** in the case of the sensorless control methods. In the case of the field-oriented control methods, they are referred to the torque-forming current component *Isq* **216**.

Volumetric Flow and Pressure		
No.	**Description**	**Function**
285	Volumetric Flow	Calculated volumetric flow in m³/h.
286	Pressure	Pressure calculated according to the characteristic with the unit kPa.

21 Error protocol

The various control methods and the hardware of the frequency inverter include functions which continuously monitor the application. The operational and error diagnosis is facilitated by the information stored in the error protocol.

21.1 List of errors

The last 16 error signals are stored in chronological order and *No. of Errors* **362** shows the number of errors which have occurred since initial commissioning of the frequency inverter. The error code FXXXX is displayed in menu branch VAL of the control unit. For the meaning of the error code, refer to the following chapter 21.1. Via the PC user interface, the number of operation hours (h), operation minutes (m) and the error signal can additionally be read out. The current operating hours can be read out via *Operation Hours Counter* **245**. The error message can be acknowledged via the keys of the operating unit and according to *Error Acknowledgment* **103**.

List of errors		
No.	**Description**	**Function**
310	Last Error	hhhhh:mm ; FXXXX error message.
311	Last Error but one	hhhhh:mm ; FXXXX error message.
312 to 325		Error 3 to error 16.
362	No. of Errors	Number of errors occurred after the initial commissioning of the frequency inverter.

The error and warning behavior of the frequency inverter can be set in various ways. The automatic error acknowledgment enables acknowledgment of the faults Overcurrent F0500, Overcurrent F0507 and Overvoltage F0700 without intervention by an overriding control system or the user. The *No. of self acknowledged Errors* **363** shows the total number of automatic error acknowledgments.

List of errors		
No.	**Description**	**Function**
363	No. of self acknowledged Errors	Total number of automatic error acknowledgment with synchronization.

Error messages

The error code saved after a fault consists of the error group FXX and the code number XX.

Key		Meaning
Error messages		
F00	00	No fault has occurred.
Overload		
F01	00	Frequency inverter overloaded.
	02	Frequency inverter overloaded (60 s), check load behavior
	03	Short-term overload (1 s), check motor and application parameters
Heat sink		
F02	00	Heat sink temperature too high, check cooling system and fan.
	01	Temperature sensor defective or ambient temperature too low.
Interior		
F03	00	Interior temperature too high, check cooling system and fan.
	01	Interior temperature too low, check control cabinet heating.
Motor connection		
F04	00	Motor temperature too high or sensor defective, check connection S6IND.
	01	Motor circuit breaker tripped, check drive.
	02	V-belt monitoring reports no load on the drive.
	03	Phase failure, check motor and wiring.
	04	Control Deviation Position Controller Refer to Positioning application manual.
	05	Start monitoring. Check brake & limiting parameters, such as *Current Limit* **728**, intelligent current limits, etc.
Output current		
F05	00	Overloaded, check load situation and ramps.
	01	Instantaneous output current value too high. Check load.
	02	Dynamic phase current limitation. Check load.
	03	Short circuit or earth fault, check motor and wiring.
	04	Overloaded, check load situation and current value limit controller.

Key		Meaning
	05	Asymmetric motor current, check current and wiring.
	06	Motor phase current too high, check motor and wiring.
	07	Message from phase monitoring, check motor and wiring.
DC-Link Voltage		
F07	00	DC link voltage too high, check deceleration ramps and connected brake resistor.
	01	DC link voltage too low, check mains voltage.
	02	Mains failure, check mains voltage and circuit.
	03	Phase failure, check mains fuse and circuit.
	04	*Reference DC-Link Limitation* **680** too small, check mains voltage.
	05	Brake chopper *Trigger Threshold* **506** too small, check mains voltage
	06	Motor chopper *Trigger Threshold* **507** too small, check mains voltage
Electronic voltage		
F08	01	Electronics voltage DC 24 V too low, check control terminal.
	04	Electronic voltage too high, check wiring of control terminals.
Brake chopper		
F10	10	Also refer to Chapter 19.4.
Output frequency		
F11	00	Output frequency too high, check control signals and settings.
	01	Max. frequency achieved by control, check deceleration ramps and connected brake resistor.
	10	Frequency limit See application manual "Hoisting Gear Drives".
Safety function STO		
F12	01	Diagnosis error of function STO; at least one of the shut-down paths STOA and STOB is defective. Check the devices connected to the shut-down paths; check wiring and EMC.
	04	Software self-diagnosis has detected an internal error. Please contact your local Bonfiglioli subsidiary.
	05	Error signal of 5-second monitoring. Shut-down paths STOA and STOB were not actuated at the same time, but with an offset of more than 5 seconds. Check addressing of shut-down paths or control of protection provision.
Motor connection		
F13	00	Earth fault on output, check motor and wiring.
	01	Set *IDC Compensation Limit* **415** reached, check motor and cabling, increase limit, if necessary
	10	Minimum current monitoring, check motor and wiring.
Control connection		
F14	01	Reference value at multifunction input 1 faulty, check signal.
	02	Reference value signal at EM-S1INA defective, check signal.
	07	Overcurrent at multifunction input 1, check signal.
	21	Resolver error. Check resolver connection and speed.
	22	Resolver counting error. Check resolver connection.
	23	Resolver, wrong no. of pole pairs. Check no. of pole pairs parameters.
	24	Resolver connection error. Check resolver connection.
	30	Encoder signal defective, check connections S4IND and S5IND.
	31	One track of the speed sensor signal is missing, check connections.
	32	Direction of rotation of speed sensor wrong, check connections.
	33	Encoder 2: Division Marks Fault Check encoder settings.
	34	Too few encoder division marks Check encoder settings.
	35	Too many encoder division marks. Check encoder settings.
	36	Encoder 1 Division Marks Fault Correct *Division Marks* **491** of speed sensor 1; also refer to Chapter 11.4.2.
	37	Speed sensor was deactivated. A speed sensor must be activated in configurations 210, 211 and 230. Set evaluation for parameter *Operation Mode* **490** (not "0 – off"). If an extension module is installed and setting "2 – speed sensor 2" is selected for parameter *Actual Speed Source* **766**, you will have to set an evaluation for parameter *Operation Mode* **493** (speed sensor 2).
	38	Motor blocked. For the time set in **782** *Timeout: Drive blocked* the drive will work at the current limit (**728** *Current Limit*). Check encoder/resolver settings. Check if parameter **728** *Current Limit* was set too low. In some situations it may be a good idea to increase the value of **782** *Timeout: Drive blocked*. Permanent deactivation of encoder monitoring via **760** *Operation Mode* is not recommended.
	50	KTY temperature monitoring error. Check KTY connection.
	54	External error; drive responded according to parameter setting for *OP.Mode ext. Error* **535**. Error was triggered via the logic signal or digital input signal assigned to parameter *External Error* **183**.

Key		Meaning
Positioning		
F14	4n 5n 6n 7n	Positioning error Refer to Positioning application manual.
Absolute encoder		
F14	8n 9n	Error in absolute encoder capturing. Please refer to EM-ABS-01 instructions.
Positioning		
F15	nn	Positioning error Refer to Positioning application manual.
Absolute encoder		
F17	nn	Error in absolute encoder capturing. Please refer to EM-ABS-01 instructions.
Modbus and VABus		
F20	10	Communication error as defined by parameter *CM: VABus Watchdog Timer* **413**.
CANopen		
F20	21	CAN Bus OFF
	22	CAN Guarding
	23	Error state
	24	SYNC error (SYNC timing)
	25	CAN error state
	26	RxPDO1 length error — Number of received bytes differs from mapping.
	27	RxPDO2 length error — Number of received bytes differs from mapping.
	28	RxPDO3 length error — Number of received bytes differs from mapping.
	2A	CAN RxPDO1 Timeout
	2B	CAN RxPDO2 Timeout
	2C	CAN RxPDO3 Timeout
DeviceNet		
F20	5n	DeviceNet error. Please refer to DeviceNet instructions.
PROFIBUS		
F20	6n	PROFIBUS error. Please refer to PROFIBUS instructions.
System Bus		
F21	nn	Error signal in system bus master with fault in system bus slave, nn = node ID of slave (hex)
F22	00	Communication fault, system bus, Sync timeout telegram
	01	Communication fault, system bus, timeout RxPDO1
	02	Communication fault, system bus, timeout RxPDO2
	03	Communication fault, system bus, timeout RxPDO3
	10	Communication fault, system bus, bus off
CANopen		
F23	nn	Heartbeat error, nn = triggering node.
CM-module identification		
F24	00	Unknown CM Module Verify firmware and CM module compatibility.
EM-module identification		
F25	00	Unknown EM Module Verify firmware and EM module compatibility.
Industrial Ethernet		
F27	nn	Industrial Ethernet error. Please follow instructions on the Ethernet module used.
EtherCAT		
F28	nn	EtherCAT error.
User error VPLC		
F30	3n	Error in internal PLC function caused by user. Please refer to VPLC application manual.
Optional components		
F0A	10	Data transmission from control unit KP 500 to the frequency inverter not possible. At least one file must be stored in the control unit.
F0B	13	The communication module was fitted to slot B without disconnection of the mains voltage, switch mains voltage off.
Internal monitoring		
F0C	40	After 6 warm starts in less than 3 minutes, this error will be triggered. Most probably, the PLC or function table were programmed incorrectly. In addition, the function table will be stopped (**P.1399** = 0 in RAM only).

Output signals in the case of error messages

Errors are reported via digital signals.

162 - 3 -	Error Signal	1) 2)	A monitoring functions reports an error displayed via parameter *Current Error* **259**.

1) For linking to frequency inverter functions
2) For output via a digital output.

In addition to error signals mentioned, there are further error signals. However these messages are only used for internal purposes and are not listed here. If you receive error signals which are not listed here, please contact the BONFILGLIOLI customer service. Please download the parameter file to your PC before contacting us.

21.2 Error environment

The parameters of the error environment help troubleshooting both in the settings of the frequency inverter and also in the complete application. The error environment documents the operational behavior of the frequency inverter at the time of the last four faults.

No.	Description	Function
	Error environment	
330	DC-Link Voltage	Direct voltage in DC-link.
331	Output voltage	Calculated output voltage (motor voltage) of the frequency inverter.
332	Stator frequency	The output voltage (motor voltage) of the frequency inverter.
333	Frequency Speed Sensor 1	Calculated from the data on speed sensor 1, the *No. of Pole Pairs* **373** and the speed sensor signal.
335	Phase Current Ia	Measured current in motor phase U.
336	Phase Current Ib	Measured current in motor phase V.
337	Phase Current Ic	Measured current in motor phase W.
338	R.m.s Current	Calculated effective output current (motor current) of the frequency inverter.
339	Isd/Reactive Current	Current component forming the magnetic flux or the calculated reactive current.
340	Isq/Active Current	Current component forming the torque or the calculated active current.
341	Rotor Magnetizing Current	Magnetizing current relative to the rated motor parameters and the operating point.
342	Torque	Torque calculated from the voltage, the current and the control variables.
343	Analog Input MFI1A	Input signal at Multifunction input 1 in analog *Operation Mode* **452**.
346	Analog Output MFO1A	Output signal at Multifunction output signal 1 in *Operation Mode* **550** – `Analog`.
349	Repetition Frequency Output	Signal at repetition frequency output according to *Operation Mode* **550** – `repetition frequency`
350	Status of Digital Inputs	Decimally coded status of the six digital inputs and of Multifunction input 1 in *Operation mode* **452** - `Digital Input`.
351	Status of Digital Outputs	Decimally coded status of the two digital outputs and of Multifunction output 1 in *Operation Mode* **550** - `Digital`
352	Time since Release	The time of the error in hours (h), minutes (m) and seconds (s) after the release signal: hhhhh:mm:ss . $^{sec}/_{10}$ $^{sec}/_{100}$ $^{sec}/_{1000}$.
353	Heat Sink Temperature	Measured heat sink temperature.
354	Inside Temperature	Measured inside temperature.
355	Controller Status	The reference value signal is limited by the controller coded in the controller status.
356	Warning Status	The warning messages coded in warning status.
357	Int. value 1	Software service parameter.
358	Int. value 2	Software service parameter.
359	Long value 1	Software service parameter.
360	Long value 2	Software service parameter.
367	Application Warning Status	The application warnings coded in warning status.

Parameter *Checksum* **361** shows whether the storage of the error environment was free of errors (OK) or incomplete (NOK).

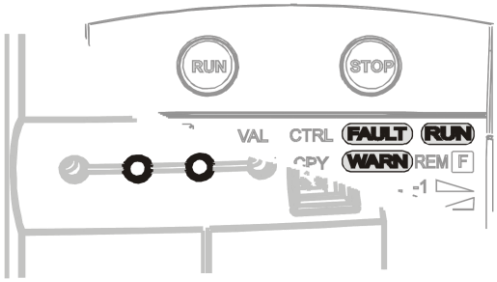
	Error environment	
361	Checksum	Check protocol of the error environment.

22 Operational and error diagnosis

Operation of the frequency inverter and the connected load are monitored continuously. Various functions document the operational behavior and facilitate the operational and error diagnosis.

22.1 Status display

The green and red light-emitting diodes give information about the operating point of the frequency inverter. If the control unit is connected, the status messages are additionally displayed by the display elements RUN, WARN and FAULT.



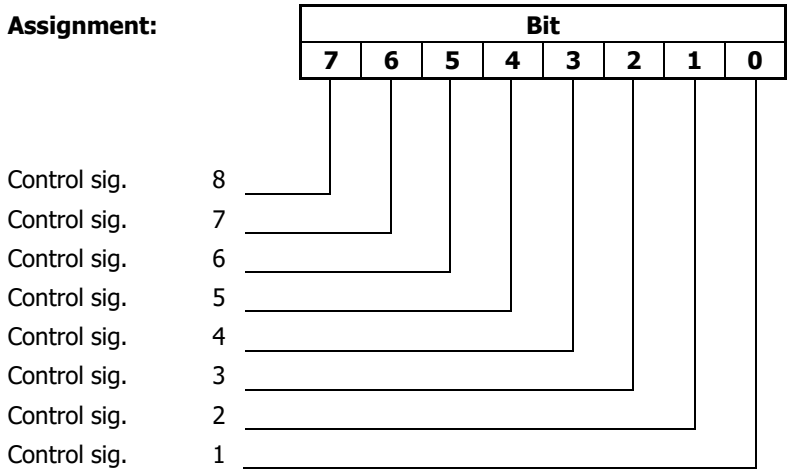
Status indication

green LED	red LED	Display	Description
off	off	-	no supply voltage.
on	on	-	initialization and self-test.
flashing	off	RUN flashing	ready, no output signal.
on	off	RUN	operating message.
on	flashing	RUN + WARN	Operating message, current *Warning* **269**.
flashing	flashing	RUN + WARN	Ready for operation, current *Warning* **269**.
off	flashing	FAULT flashing	*Last Error* **310** of frequency inverter.
off	on	FAULT	*Last Error* **310,** acknowledge fault.

22.2 Status of digital signals

The status display of the digital input and output signals enables checking of the various control signals and their assignment to the corresponding software functions, in particular during commissioning.

Coding of the status of the digital signals



A decimal value is displayed, indicating the status of the digital signals in bits after conversion into a binary figure.

Example:

Decimal value `33` is displayed. Converted into the binary system, the number reads **OOIOOOOI**. Thus, the following contact inputs or outputs are active:

- Control signal at digital input or output 1
- Control signal at digital input or output 6

22.3 Controller Status

The controller status can be used to establish which of the control functions are active. If a several controllers are active at the time, a controller code composed of the sum total of the individual codes is displayed. The display of the controller status by the control unit and the light-emitting diodes can be parameterized via the *Controller-Status Message* **409**.

Coding of the controller status

CXXXX | Controller key

ABCDE | Controller abbreviation

Key				Controller Status
C	00	00	-	No controller active.
C	00	01	UDdyn	Voltage controller is in the rise phase according to *Operation Mode* **670**
C	00	02	UDstop	The output frequency in power failure is below the *Shutdown Threshold* **675**
C	00	04	UDctr	Failure of the mains voltage and power regulation active according to *Operation Mode* **670** of the voltage controller
C	00	08	UDlim	DC-Link voltage exceeded *Reference DC-Link Limitation* **680**.
C	00	10	Boost	The *Dyn. Voltage Pre-Control* **605** accelerates the control system.
C	00	20	Ilim	The output current is limited by the current limit value controller or the speed controller.
C	00	40	Tlim	The output power or the torque are limited by the speed controller
C	00	80	Tctr	Switch-over of field-oriented control between speed and torque-controlled control method.
C	01	00	Rstp	The *Operation Mode* **620** selected in starting behavior limits the output current
C	02	00	IxtLtLim	Overload limit of the long-term Ixt (60s) reached, intelligent current limits active
C	04	00	IxtStLim	Overload limit of the short-term Ixt (1s) reached, intelligent current limits active.
C	08	00	Tclim	Max. heat sink temperature T_K reached, intelligent current limits of *Operation Mode* **573** active.
C	10	00	PTClim	Max. motor temperature T_{PTC} reached, intelligent current limits of *Operation Mode* **573** active
C	20	00	Flim	Reference frequency has reached the *Maximum Frequency* **419**. The frequency limitation is active.

Example:

The controller status is displayed as

C0024 UDctr Ilim

The controller status results from the hexadecimal sum of the controller codes (0004+0020 = 0024). At the same, the power failure regulation and also the current limitation of the speed controller are active.

22.4 Warning Status and Warning Status Application

The current warning is displayed by a message in the warning status and can be used for early reporting of a critical operational condition. If a warning is present, this is indicated by the flashing red LED and the display field WARN of the control unit. If several warnings are present, the warning status is displayed as the sum of the individual warning codes.

The warning masks created through parameters *Create Warning Mask* **536** and *Create Appl. Warning Mask* **626** have no influence on the warnings displayed. Via actual value parameters *Warnings* **269**, *Application Warnings* **273**, *Warning Status* **356** (in error environment) and *Application Warning Status* **367** (in error environment) all warnings present at the time of the error are displayed.

Coding of the warning status

AXXXX | Warning key

ABCDE | Warning abbreviation

Meaning of key displayed by parameter *Warning Status* **356**:

Key				Warning Status
A	00	00	-	No warning present.
A	00	01	Ixt	Frequency inverter overloaded (A0002 or A0004)

A	00	02	IxtSt	Overload for 60 s relative to the nominal output of the frequency inverter
A	00	04	IxtLt	Short-time overload for 1 s relative to the nominal output of the frequency inverter.
A	00	08	Tc	Max. heat sink temperature T_K of 80 °C minus *Warning Limit Heat Sink Temp.* **407** reached.
A	00	10	Ti	Max. inside temperature T_i of 65 °C minus *Warning Limit Inside Tepmp.* **408** reached.
A	00	20	Lim	The controller stated in *Controller Status* **275** is limiting the reference figure.
A	00	40	INIT	Frequency inverter is being initialized
A	00	80	PTC	Warning behavior as per configured *Motor Temp.Operation Mode* **570** at max. motor temperature T_{Motor}.
A	01	00	Mains	*Phase Supervision* **576** reports mains phase failure.
A	02	00	PMS	Motor circuit breaker parameterized in *Operation Mode* **571** tripped.
A	04	00	Flim	The *Maximum Frequency* **419** was exceeded. The frequency limitation is active.
A	08	00	A1	The input signal MFI1A is lower than 1 V / 2 mA according to the operation mode for the *Error/Warning Behavior* **453**.
A	10	00	A2	The input signal is lower than 1 V / 2 mA according to the operation mode for the *Error/Warning Behavior* **453**.
A	20	00	SYS	A slave on the system bus reports a fault; warning is only relevant with the EM-SYS option.
A	40	00	UDC	The DC link voltage has reached the type-dependent minimum value.
A	80	00	WARN2	In *Application Warning Status* **367**, a warning is present.

Example:

The following warning status is displayed:

A008D Ixt IxtLt Tc PTC

The warning status results from the hexadecimal sum of the warning codes (0001+0004+0008+0080 = 008D).

The short-term overload (1 s), warning limit heat sink temperature and warning limit motor temperature warnings are present.

Output signals

Warnings are signaled via digital signals.

169 -	General Warning	1)	Signal when message is output in *Warnings* **269**.
11 -	General warning	2)	

1) For linking to frequency inverter functions
2) For output via a digital output.

Meaning of code displayed by parameter *Application Warning Status* **367**:

Key				Warning Status
A	00	00	NO WARNING	No warning present.
A	00	01	BELT	Warning V-Belt by *Operation Mode* **581**.
A	00	02	SW-LIM CW	Positive SW limit switch was reached (parameter *Pos. SW Limit Switch* **1145**).
A	00	04	SW-LIM CCW	Negative SW limit switch was reached (parameter *Neg. SW Limit Switch* **1146**).
A	00	08	HW-LIM CW	The positive HW limit switch was reached.
A	00	10	HW-LIM CCW	The negative HW limit switch was reached.
A	00	20	CONT	The contouring error monitoring range set with *Warning Threshold* **1105** was left.
A	00	40	Enc	A connected encoder with data track triggered a warning.
A	00	80	User 1	The signal set at digital input *User Warnig 1 1* **1363** is active.
A	01	00	User 2	The signal set at digital input *User Warnig 2 1* **1364** is active.

Output signals

Application Warnings are signaled via digital signals .

216 -	Warning, application	1)	Signal when message is output in *Application Warnings* **273**.
26 -		2)	

1) For linking to frequency inverter functions
2) For output via a digital output.

23 List of parameters

The parameter list is structured according to the menu branches of the control unit. The parameters are listed in ascending numerical order. A headline (shaded) can appear several times, i.e. a subject area may be listed at different places in the table. For better clarity, the parameters have been marked with pictograms:

The parameter is available in the four data sets.

The parameter value is set by the SETUP routine.

This parameter cannot be written when the frequency inverter is in operation.

I_{FIN}, U_{FIN}, P_{FIN}: Rated values of frequency inverter, o: Overload capacity of frequency inverter

(210) Setting in ACU 210 devices
(410) Setting in ACU 410 devices
(510) Setting in ACU 510 devices
(610) Setting in ACU 610 devices

ACU 210 devices: U_{dmax}= 400 V, ACU 410 devices: U_{dmax}=800 V,
ACU 510 devices: U_{dmax}= 900 V, ACU 610 devices: U_{dmax}= 1200 V

In the KP500 control unit, parameter numbers > 999 are shown in hexadecimal form (999, A00 … B5 … C66).

For information on parameters specific to the liquid-cooled devices, see „Operating Instructions Liquid Cooling Supplemental".

23.1 Actual Value Menu (VAL)

No.	Description	Unit	Display range	Chapter
Actual values of machine				
210	Stator frequency	Hz	0.00 ... 999.99	20.2
211	R.m.s Current	A	0.0 ... I_{max}	20.2
212	Output Voltage	V	0.0 ... U_{FIN}	20.2
213	Active Power	kW	0.0 ... P_{max}	20.2
214	Active Current	A	0.0 ... I_{max}	20.2
215	Isd	A	0.0 ... I_{max}	20.2
216	Isq	A	0.0 ... I_{max}	20.2
217	Encoder 1 Frequency	Hz	0.00 ... 999.99	20.2
218	Encoder 1 Speed	1/min	0 ... 60000	20.2
221	Slip Frequency	Hz	0.0 ... 999.99	20.2
Actual values of frequency inverter				
222	DC-Link Voltage	V	0.0 ... U_{dmax}	20.1
223	Modulation	%	0 ... 100	20.1
Actual values of machine				
224	Torque	Nm	± 9999.9	20.2
225	Rotor Flux	%	0 ... 100	20.2
226	Winding Temperature	deg.C	0 ... 999	20.2
227	Act. Rotor Time Constant	ms	0 ... τ_{max}	20.2
Actual values of frequency inverter				
228	Internal ref. frequency	Hz	0.00 ... f_{max}	20.1
229	Reference percentage	%	± 300.00	20.1
230	Actual percentage value	%	± 300.00	20.1
Actual value memory				
231	Peak Value Long Term Ixt	%	0.00 ... 100.00	20.3
232	Peak Value Short Term Ixt	%	0.00 ... 100.00	20.3
Actual values of machine				
235	Flux-forming voltage	V	0.0 ... U_{FIN}	20.2
236	Torque-forming voltage	V	0.0 ... U_{FIN}	20.2
238	Flux Value	%	0.0 ... 100.0	20.2

No.	Description	Unit	Display range	Chapter
239	Reactive Current	A	0.0 ... I_{max}	20.2
240	Actual Speed	1/min	0 ... 60000	20.2
241	Actual Frequency	Hz	0.0 ... 999.99	20.2
Actual values of the system				
242	Actual Value System	Hz	0.0 ... 999.99	20.4.1
Actual values of frequency inverter				
243	Digital Inputs (Hardware)	-	00 ... 255	20.1
244	Working Hours Counter	h	99999	20.1
245	Operation Hours Counter	h	99999	20.1
249	Active Data Set	-	1 ... 4	20.1
250	Digital Inputs	-	00 ... 255	20.1
251	Analog Input MFI1A	%	± 100.00	20.1
252	Repetition frequency input	Hz	0.0 ... 999.99	20.1
254	Digital Outputs	-	00 ... 255	20.1
255	Heat Sink Temperature	deg.C	0 ... T_{kmax}	20.1
256	Inside Temperature	deg.C	0 ... T_{imax}	20.1
257	Analog Output MFO1A	V	0.0 ... 24.0	20.1
258	PWM input	%	0.00 ... 100.00	20.1
259	Current Error	-	FXXXX	20.1
269	Warnings	-	AXXXX	20.1
273	Application Warnings	-	AXXXX	20.1
275	Controller Status	-	CXXXX	20.1
277	STO Status	-	XXXX	20.1
278	Frequency MFO1F	Hz	0.00 ... f_{max}	20.1
Actual values of the system				
285	Volumetric Flow	m3/h	0 ... 99999	20.4.2
286	Pressure	kPa	0.0 ... 999.9	20.4.2
Actual value memory				
287	Peak Value Vdc	V	0.0 ... U_{dmax}	20.3
288	Average Value Vdc	V	0.0 ... U_{dmax}	20.3
289	Peak value heat sink temp.	deg.C	0 ... T_{kmax}	20.3
290	Average value heat sink temp.	deg.C	0 ... T_{kmax}	20.3
291	Peak Value Inside Temperature	deg.C	0 ... T_{imax}	20.3
292	Average Value Inside Temperature	deg.C	0 ... T_{imax}	20.3
293	Peak Value Irms	A	0.0 ... o·I_{FIN}	20.3
294	Average Value Irms	A	0.0 ... o·I_{FIN}	20.3
295	Peak Value Active Power pos.	kW	0.0 ... o·P_{FIN}	20.3
296	Peak value active power neg.	kW	0.0 ... o·P_{FIN}	20.3
297	Average value active power	kW	0.0 ... o·P_{FIN}	20.3
301	Energy, positive	kWh	0 ... 99999	20.3
302	Energy, negative	kWh	0 ... 99999	20.3
List of errors				
310	Last Error	h:m; F	00000:00; FXXXX	21.1
311	Last Error but one	h:m; F	00000:00; FXXXX	21.1
312	Error 3	h:m; F	00000:00; FXXXX	21.1
313	Error 4	h:m; F	00000:00; FXXXX	21.1
314	Error 5	h:m; F	00000:00; FXXXX	21.1
315	Error 6	h:m; F	00000:00; FXXXX	21.1
316	Error 7	h:m; F	00000:00; FXXXX	21.1
317	Error 8	h:m; F	00000:00; FXXXX	21.1
318	Error 9	h:m; F	00000:00; FXXXX	21.1
319	Error 10	h:m; F	00000:00; FXXXX	21.1
320	Error 11	h:m; F	00000:00; FXXXX	21.1
List of errors				
321	Error 12	h:m; F	00000:00; FXXXX	21.1
322	Error 13	h:m; F	00000:00; FXXXX	21.1
323	Error 14	h:m; F	00000:00; FXXXX	21.1
324	Error 15	h:m; F	00000:00; FXXXX	21.1
325	Error 16	h:m; F	00000:00; FXXXX	21.1
Error environment				
330	DC-Link Voltage	V	0.0 ... U_{dmax}	21.2
331	Output voltage	V	0.0 ... U_{FIN}	21.2
332	Stator frequency	Hz	0.00 ... 999.99	21.2

No.	Description	Unit	Display range	Chapter
333	Frequency Speed Sensor 1	Hz	0.00 ... 999.99	21.2
335	Phase Current Ia	A	0.0 ... I_{max}	21.2
336	Phase Current Ib	A	0.0 ... I_{max}	21.2
337	Phase Current Ic	A	0.0 ... I_{max}	21.2
338	R.m.s Current	A	0.0 ... I_{max}	21.2
339	Isd / Reactive Current	A	0.0 ... I_{max}	21.2
340	Isq / Active Current	A	0.0 ... I_{max}	21.2
341	Rotor Magnetizing Current	A	0.0 ... I_{max}	21.2
342	Torque	Nm	± 9999.9	21.2
343	Analog Input MFI1A	%	± 100.00	21.2
346	Analog Output MFO1A	V	0.0 ... 24.0	21.2
349	Repetition Frequency Output	Hz	0.00 ... 999.99	21.2
350	Status of Digital Inputs	-	00 ... 255	22.2
351	Status of Digital Outputs	-	00 ... 255	22.2
352	Time since Release	h:m:s.ms	00000:00:00.000	21.2
353	Heat Sink Temperature	deg.C	0 ... T_{kmax}	21.2
354	Inside Temperature	deg.C	0 ... T_{imax}	21.2
355	Controller Status	-	C0000 ... CFFFF	22.3
356	Warning Status	-	A0000 ... AFFFF	22.4
357	Int. Value 1	-	± 32768	21.2
358	Int. Value 2	-	± 32768	21.2
359	Long Value 1	-	± 2147483647	21.2
360	Long Value 2	-	± 2147483647	21.2
361	Checksum	-	OK / NOK	21.2
List of errors				
362	No. of errors	-	0 ... 32767	21.1
363	No. of self acknowledged Errors	-	0 ... 32767	21.1
Error environment				
367	Application Warning Status	-	A0000 ... AFFFF	22.4
Positioning				
470	Rotations	U	0.000 ... $1 \cdot 10^6$	13.6
Digital Outputs				
537	Actual Warning Mask	-	AXXXXXXXX	16.3.8
627	Actual Appl. Warning Mask	-	AXXXX	16.3.9
Auto set-up				
797	SET-UP Status	-	OK / NOK	9.5

23.2 Parameter Menu (PARA)

No.	Description	Unit	Setting range	Chapter
Inverter data				
0	Serial Number	-	Characters	10.1
1	Optional Modules	-	Characters	10.2
12	Inverter Software Version	-	Characters	10.3
15	Copyright	-	Characters	10.3
27	Set Password	-	0 ... 999	10.4
28	Control Level	-	1 ... 3	10.5
29	User Name	-	32 characters	10.6
30	Configuration	-	Selection	10.7
33	Language	-	Selection	10.8
34	Program	-	0 ... 9999	10.9
37	Release axis positioning	-	Selection	13.6.2
Fan				
39	Switch-On Temperature	deg.C	0 ... 60	19.2
Traverse function				

	No.	Description	Unit	Setting range	Chapter
⊗	48	Reference frequency	-	Selection	19.8
		Digital Inputs			
	49	Handshake Traverse Function	-	Selection	16.4.10
	58	Technology Controller Release	-	Selection	18.3
	62	Frequency motorpoti up	-	Selection	16.4.9
	63	Frequency motorpoti down	-	Selection	16.4.9
	66	Fixed frequency change-over 1	-	Selection	16.4.8
	67	Fixed frequency change-over 2	-	Selection	16.4.8
	68	Start clockwise	-	Selection	16.4.1
	69	Start anticlockwise	-	Selection	16.4.1
	70	Data Set Change-Over 1	-	Selection	16.4.7
	71	Data Set Change-Over 2	-	Selection	16.4.7
	72	Percent Motorpoti Up	-	Selection	16.4.9
	73	Percent Motorpoti Down	-	Selection	16.4.9
	75	Fixed Percent Change-Over 1	-	Selection	16.4.8
	76	Fixed Percent Change-Over 2	-	Selection	16.4.8
	83	Timer 1	-	Selection	16.4.4
	84	Timer 2	-	Selection	16.4.4
	87	Start 3-Wire Ctrl	-	Selection	16.4.2
	103	Error Acknowledgment	-	Selection	16.4.3
	164	n-/M control change-over	-	Selection	16.4.6
	183	External Error	-	Selection	16.4.12
	204	Therm. Contact	-	Selection	16.4.5
		Actual value memory			
	237	Reset memory	-	Selection	20.3
		Guided commissioning			
	369	Motor Type	-	Selection	9.2.3
		Rated motor parameters			
	370	Rated Voltage	V	$0.17 \cdot U_{FIN}$ ... $2 \cdot U_{FIN}$	11.1
	371	Rated Current	A	$0.01 \cdot I_{FIN}$ ... $10 \cdot o \cdot I_{FIN}$	11.1
	372	Rated Speed	RPM	96 ... 60000	11.1
✓	373	No. of pole pairs	-	1 ... 50	11.1
	374	Rated Cosinus Phi	-	0.01 ... 1.00	11.1
	375	Rated Frequency	Hz	10.00 ... 599.00	11.1
	376	Rated Mech. Power	kW	$0.1 \cdot P_{FIN}$ ... $10 \cdot P_{FIN}$	11.1
		Further motor parameters			
✓	377	Stator resistance	mOhm	0 ... 65535	11.2.1
✓	378	Leakage coefficient	%	1.0 ... 20.0	11.2.2
	383	Voltage Constant	mVmin	0.0 ... 850.0	11.2.5
	384	Stator Inductance	mH	0.1 ... 500.0	11.2.6
		System data			
	389	Factor Actual Value System	-	-100.000 ... 100.000	12.1
	397	Nominal Volumetric Flow	m3/h	1 ... 99999	12.2
	398	Nominal pressure	kPa	0.1 ... 999.9	12.2
		Pulse width modulation			
	400	Switching frequency	-	Selection	19.1
	401	Min. Switching Frequency	-	Selection	19.1
		Error/warning behavior			
	405	Warning Limit Short Term Ixt	%	6 ... 100	14.1
	406	Warning Limit Long Term Ixt	%	6 ... 100	14.1
	407	Warning Limit Heat Sink Temp.	deg.C	-25 ... 0	14.2
	408	Warning Limit Inside Temp.	deg.C	-25 ... 0	14.2
	409	Controller-Status Message	-	Selection	14.3
		Bus controller			
	412	Local/Remote	-	Selection	19.3
		Error/warning behavior			
	415	IDC Compensation Limit	V	0.0 ... 1.5	14.4
	417	Frequency Switch-off Limit	Hz	0.00 ... 599.00	14.5
		Frequency Limits			

No.	Description	Unit	Setting range	Chapter
418	Minimum frequency	Hz	0.00 ... 599.00	15.1
419	Maximum frequency	Hz	0.00 ... 599.00	15.1
	Frequency ramps			
420	Acceleration (Clockwise)	Hz/s	0.00 ... 9999.99	15.7
421	Deceleration (Clockwise)	Hz/s	0.01 ... 9999.99	15.7
422	Acceleration Anticlockwise	Hz/s	-0.01 ... 9999.99	15.7
423	Deceleration anticlockwise	Hz/s	-0.01 ... 9999.99	15.7
424	Emergency stop clockwise	Hz/s	0.01 ... 9999.99	15.7
425	Emergency stop anti-clockwise	Hz/s	0.01 ... 9999.99	15.7
426	Maximum leading	Hz	0.01 ... 599.00	15.7
430	Ramp rise time clockwise	ms	0 ... 65000	15.7
431	Ramp fall time clockwise	ms	0 ... 65000	15.7
432	Ramp Rise Time Anticlockwise	ms	0 ... 65000	15.7
433	Ramp Fall Time Anticlockwise	ms	0 ... 65000	15.7
	Traverse function			
435	Operation mode	-	Selection	19.8
436	Acceleration Time	s	0.01 ... 320.00	19.8
437	Deceleration Time	s	0.01 ... 320.00	19.8
438	Traverse Amplitude	%	0.01 ... 50.00	19.8
439	Proportional Step	%	0.01 ... 50.00	19.8
	Technology controller			
440	Operation mode	-	Selection	18.3
441	Fixed frequency	Hz	-599.00 ... 599.00	18.3
442	max. P component	Hz	0.01 ... 599.00	18.3
443	Hysteresis	%	0.01 ... 100.00	18.3
444	Amplification	-	-15.00 ... 15.00	18.3
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448	2nd Blocking Frequency	Hz	0.00 ... 599.00	15.9
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451	Filter time constant	ms	Selection	16.1.1.4
452	Operation mode	-	Selection	16.1
453	Error/Warning Behavior	-	Selection	16.1.1.5
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459	Signal source	-	Selection	13.6.1
460	Positioning distance	U	0.000 ... 1 10^6	13.6.1
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464	Time to wait	ms	0 ... 3.6 10^6	13.6.1
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465	Operation mode	-	Selection	19.7.2

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466	Temperature coefficient	%/100	0.00 ... 300.00	19.7.2
467	Adjusting temperature	deg.C	-50.0 ... 300.0	19.7.2
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474	Operation mode	-	Selection	15.10
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475	Reference frequency source	-	Selection	15.4
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476	Reference Percentage Source	-	Selection	15.5
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478	Actual percentage source	-	Selection	18.3
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479	time constant positioning contr.	ms	1.00 ... 9999.99	13.6.2
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481	Fixed Frequency 2	Hz	-599.00 ... 599.00	15.6.1
482	Fixed Frequency 3	Hz	-599.00 ... 599.00	15.6.1
483	Fixed Frequency 4	Hz	-599.00 ... 599.00	15.6.1
489	JOG frequency	Hz	-599.00 ... 599.00	15.6.2
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490	Operation mode	-	Selection	11.4.1
491	Division Marks	-	1 ... 8192	11.4.2
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496	Operation mode	-	Selection	15.11
497	Divider	-	1 ... 8192	15.11
	Brake Chopper			
506	Trigger Threshold	V	225 ... 1000 *(210)* 425 ... 2000 *(410)* 550 ... 2000 *(510)* 725 ... 2000 *(610)*	19.4
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507	Trigger Threshold	V	225 ... 1000 *(210)* 425 ... 2000 *(410)* 550 ... 2000 *(510)* 725 ... 2000 *(610)*	19.7.1
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512	EC1 Gear Factor Denominator	-	0.01 ... 300.00	11.4.3
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519	Maximum Reference Percentage	%	0.00 ... 300.00	15.3
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		554	Digital Operation	-	Selection	16.3
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		605	Dyn. Voltage Pre-Control	%	0 ... 200	17.1
			Current limit value controller			
		610	Operation mode	-	Selection	18.4.2
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		612	Integral Time	ms	1 ... 10000	18.4.2
		613	Current Limit	A	0.0 ... o·I_{FIN}	18.4.2
✓		614	Frequency Limit	Hz	0.00 ... 599.00	18.4.2

		No.	Description	Unit	Setting range	Chapter
			Error/warning behavior			
		617	max. Temp. Windings	°C	0 ... 200	14.6
			Technology controller			
		618	Derivative time	ms	0 ... 1000	18.3
			Starting behavior			
☑		620	Operation mode	-	Selection	13.1.1
		621	Amplification	-	0.01 ... 10.00	13.1.1
		622	Integral Time	ms	1 ... 30000	13.1.1
☑		623	Starting current	A	0.0 ... o·I_{FIN}	13.1.1.1
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		625	Brake Release Time	ms	-5000 ... 5000	13.1.1.3
			Application Warnings			
		626	Create warning mask application	-	Selection	16.3.9
			Stopping behavior			
		630	Operation mode	-	Selection	13.2
			Direct current brake			
☑		631	Braking current	A	0.00 ... √2·I_{FIN}	13.3
		632	Braking time	s	0.0 ... 200.0	13.3
☑		633	Demagnetizing time	s	0.1 ... 30.0	13.3
		634	Amplification	-	0.00 ... 10.00	13.3
		635	Integral Time	ms	0 ... 1000	13.3
			Stopping behavior			
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		638	Holding time	s	0.0 ... 200.0	13.2.2
			Search run			
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		652	Offset	%	-100.00 ... 100.00	15.11
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☑		660	Operation mode	-	Selection	18.4.1
		661	Amplification	%	0.0 ... 300.0	18.4.1
		662	Max. slip ramp	Hz/s	0.01 ... 650.00	18.4.1
		663	Minimum frequency	Hz	0.01 ... 599.00	18.4.1
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		671	Mains failure threshold	V	-200.0 ... -50.0	18.2
		672	Reference mains support value	V	-200.0 ... -10.0	18.2
		673	Mains support deceleration	Hz/s	0.01 ... 9999.99	18.2
		674	Acceleration on mains resumption	Hz/s	0.00 ... 9999.99	18.2
		675	Shutdown threshold	Hz	0.00 ... 599.00	18.2
		676	Reference shutdown value	V	225.0 ... 387.5 *(210)* 425.0 ... 770.0 *(410)* 550.0 ... 875.0 *(510)* 725.0 ... 1175.0 *(610)*	18.2
		677	Amplification	-	0.00 ... 30.00	18.2
		678	Integral Time	ms	0 ... 10000	18.2

		No.	Description	Unit	Setting range	Chapter
		680	Reference DC link limitation	V	225.0 ... 387.5 *(210)* 425.0 ... 770.0 *(410)* 550.0 ... 875.0 *(510)* 725.0 ... 1175.0 *(610)*	18.2
		681	max. frequency rise	Hz	0.00 ... 599.00	18.2
		683	Gen. Ref. Current Limit	A	0.0 ... o·I_{FIN}	18.2
			Current controller			
☑		700	Amplification	-	0.00 ... 8.00	18.5.1
☑		701	Integral Time	ms	0.00 ... 10.00	18.5.1
			Further motor parameters			
☑		713	Magnetizing current 50% flux	%	1 ... 50	11.2.3
☑		714	Magnetizing current 80% flux	%	1 ... 80	11.2.3
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☑		716	Rated magnetizing current	A	0.01·I_{FIN} ... o·I_{FIN}	11.2.3
			Field controller			
☑		717	Reference Flux	%	0.01 ... 300.00	18.5.6
			Further motor parameters			
☑		718	Rated slip correction factor	%	0.01 ... 300.00	11.2.4
			Frequency Limits			
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		720	Operation mode	-	Selection	18.5.4
☑		721	Amplification 1	-	0.00 ... 200.00	18.5.4
		722	Integral Time 1	ms	0 ... 60000	18.5.4
☑		723	Amplification 2	-	0.00 ... 200.00	18.5.4
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			Acceleration pre-control			
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		726	Minimum acceleration	Hz/s	0.1 ... 6500.0	18.5.5
		727	Mech. Time Constant	ms	1 ... 60000	18.5.5
			Speed controller			
		728	Current Limit	A	0.0 ... o·I_{FIN}	18.5.4.1
		729	Current Limit Generator OP.	A	-0.1 ... o·I_{FIN}	18.5.4.1
		730	Torque Limit	%	0.00 ... 650.00	18.5.4.1
		731	Torque limit generator operation	%	0.00 ... 650.00	18.5.4.1
		732	P-Comp. Torque Upper Limit	%	0.00 ... 650.00	18.5.4.1
		733	P-Comp. Torque Lower Limit	%	0.00 ... 650.00	18.5.4.1
		734	Isq limit source motor operation	-	Selection	18.5.4.2
		735	Isq limit source gen. operation	-	Selection	18.5.4.2
		736	Torque limit source motor operation	-	Selection	18.5.4.2
		737	Torque limit source gen. operation	-	Selection	18.5.4.2
☑		738	Speed Control Switch-Over Limit	Hz	0.00 ... 599.00	18.5.4
		739	Power Limit	kW	0.00 ... 2·o·P_{FIN}	18.5.4.1
		740	Power Limit Generator Operation	kW	0.00 ... 2·o·P_{FIN}	18.5.4.1
			Field controller			
		741	Amplification	-	0.0 ... 100.0	18.5.6
☑		742	Integral Time	ms	0.0 ... 1000.0	18.5.6
☑		743	Ref. Isd upper limit	A	0 ... o·I_{FIN}	0
☑		744	Ref. Isd lower limit	A	-I_{FIN} ... I_{FIN}	0
			Speed controller			
		748	Backlash damping	%	0 ... 300	18.5.4
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No.	Description	Unit	Setting range	Chapter
750	Reference modulator	%	3.00 ... 105.00	18.5.7
752	Integral Time	ms	0.0 ... 1000.00	18.5.7
753	Operation mode	-	Selection	18.5.7
Speed controller				
754	Filter time constant	ms	0...128	18.5.4
Modulation controller				
755	Reference Imr Lower Limit	A	0.01·I_{FIN} ... o·I_{FIN}	
756	Control Deviation Limitation	%	0.00 ... 100.00	
Current controller				
757	Current below P.700 is in effect	A	0.00· ... o·I_{FIN}	18.5.2
758	Current above P.759 is in effect	A	0.00· ... o·I_{FIN}	18.5.2
759	Amplification high Current	-	0.00 ... 8.00	18.5.2
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770	Frequency lower limit source	-	Selection	18.5.3.3
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778	Reduction Factor Flux	%	20 ... 100	18.5.6
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796	SET-UP Select	-	Selection	9.5
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1199	Reverse sense of rotation	-	Selection	11.2.8
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			RAM: 17 … 33	
1252	Mux inputs	-	Selection	16.5.4
1253	DeMux Input	-	Selection	16.5.4
User Warning				
1363	User Warnig 1	-	Selection	16.4.11
1364	User Warnig 2	-	Selection	16.4.11
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1371	In-F-PDP-word 2		Selection	19.9
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1373	In-F-intern long 2		Selection	19.9
1374	In-F-Convert Reference	Hz	0.01...599.00	19.9

In the KP500 control unit, parameter numbers > 999 are shown in hexadecimal form (999, A00 … B5 … C66).

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