Bonfiglioli
Vectron

Active Next Generation

Operating Instructions
0,25 kW…400kW
ANG210 / ANG410 / ANG510 / ANG610

Bonfiglioli

TABLE OF CONTENTS

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 describe all functions of the frequency inverter. The parameters required for adapting the frequency inverter to specific applications 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 subjects connected with the use of the frequency inverter is described specific to the 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 NEXT GENERATION* series:

Operating Instructions *ACTIVE NEXT GENERATION*	Functions of the frequency inverter.
Quick Start Guide *ACTIVE NEXT GENERATION*	Installation and commissioning. Delivered with the device.
Manuals Expansion Modules	EM-AUT-01: Automation Interface Module with EtherCAT® EM-AUT-02: Automation Interface Module with EtherCAT® and R-track evaluation EM-AUT-04: Automation Interface Module with EtherCAT® without digital encoder interface EM-AUT-11: Automation Interface Module with ProfiNet EM-AUT-21: Automation Interface Module with Ethernet/IP EM-AUT-31: Automation Interface Module with VARAN Bus
Safe Torque Off (STO) manual	Safety function STO
Operating Instructions Liquid Cooling Supplemental	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	Using at least 2 drives as electronic gear with Slave 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 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 encounter specific problems which are not dealt with in sufficient detail in the documentation, contact your local BONFIGLIOLI agent.
The present document was created in English. Other language versions are translations.

1.2 This document

This document describes the frequency inverters of the *ACTIVE NEXT GENERATION* series. The modular hardware and software structure enables customer-specific adaptation of the frequency inverter series. Applications with high functionality and dynamism can be realized easily.
With their standard settings, the devices are suited for a wide range of applications.
The present documentation refers to the frequency inverters ACTIVE Next Generation 210 and ACTIVE Next Generation 410 series.
This document contains important information on the installation and use of the product in its specified application range. Compliance with this document 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 ANG series, the following documentation must be complied with:

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

The ANG series can be identified 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 solar 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

This Operating Instructions document must be read before commissioning. 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

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. In case the frequency inverter is sold to other users, this Operating Instructions document 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

The chapter "General safety instructions and information on use" 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.

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 protection class 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 (in some configurations up to 25) minutes after shutdown. The valid waiting period is indicated on the device housing.

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 at 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

2.6.3 Personal safety equipment

Symbol	Meaning
	Wear body protection
	Wear hearing protection

2.6.4 Recycling

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

2.6.5 Grounding symbol

Symbol	Meaning
	Ground connection

2.6.6 ESD symbol

Symbol	Meaning
	ESD: Electrostatic Discharge (can damage components and assemblies)

2.6.7 Information signs

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

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 operating instructions for the frequency inverter. The Operating Instructions of the frequency inverter must be included in the user manual 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 in connection with 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 office 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 this 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 a 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:

1 Isolate
2 Secure to prevent restarting
3 Check isolation
4 Earth and short-circuit,
5 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, never open the machine/plant
- Do not connect/disconnect any components/equipment during operation.
- 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 brake 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 frequency inverters must not have access to the frequency inverter.
- Do not bypass nor decommission any protective facilities.
- 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 Auto Start 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. Repairs on the frequency inverters may only be carried out by the manufacturer or persons authorized by the manufacturer. 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 provision, 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 MDS 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.
- As a "rule of thumb", before installing the devices, the manufacturer recommends storing the devices for 24 hours at the site of installation to allow for acclimatization.

- 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.

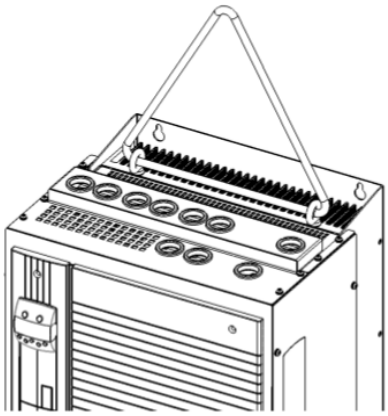
3.6 Bringing the device into installation position

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. Installation, see Chapter 6 "Mechanical Installation".

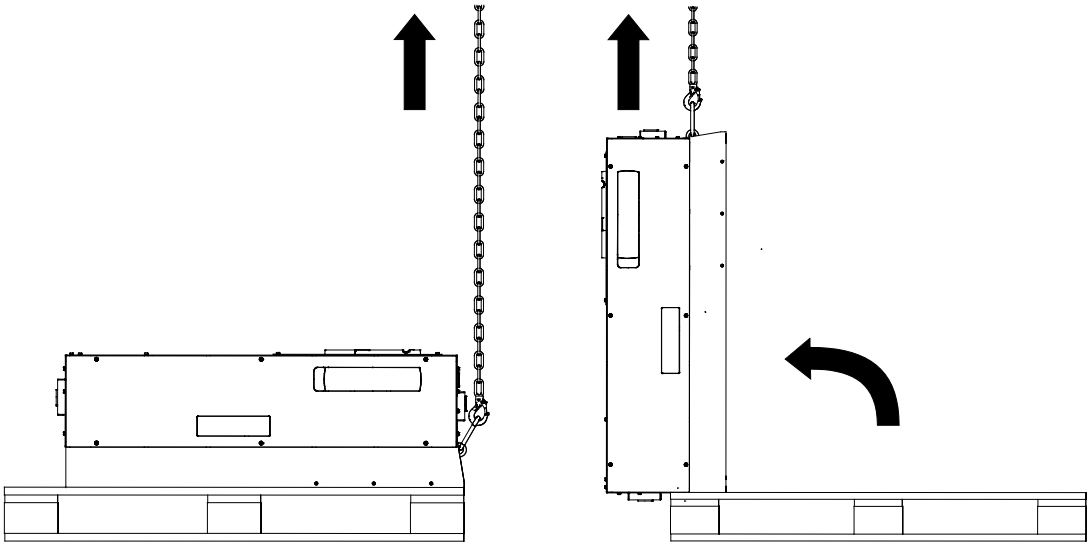
3.6.2 Sizes 7 and 8

- 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.

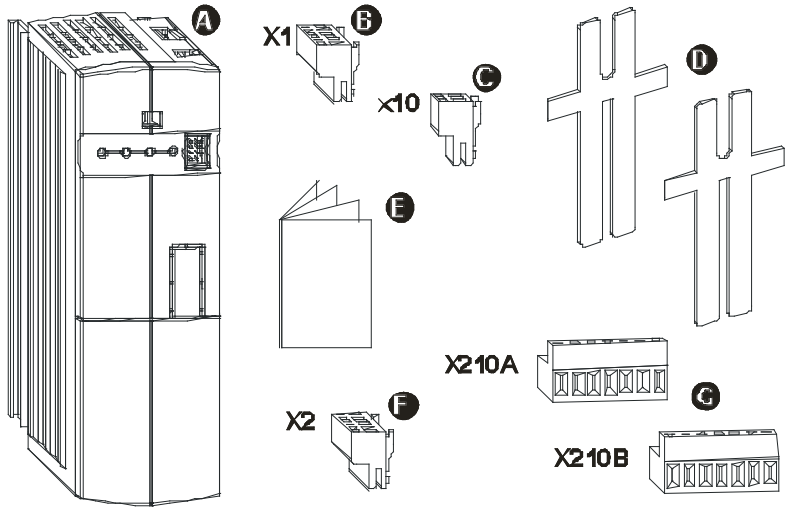
- Move the frequency inverter to its installation position in the electrical cabinet and fix it there, see Chapter 6 "Mechanical Installation".
- After mechanical installation, disconnect the device from the crane and remove the crane eyes.

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 ANG 210 (up to 3.0 kW) and 410 (up to 4.0 kW)

Scope of Supply



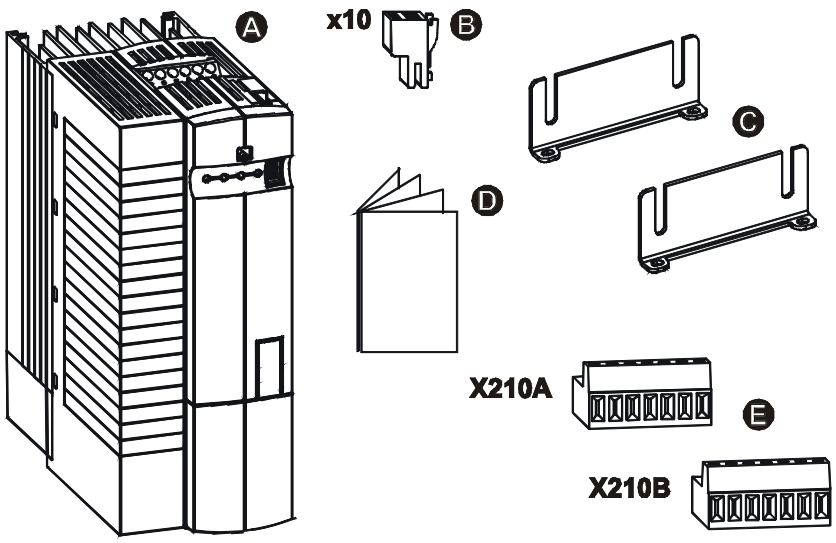
Scope of Supply

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 and Operating Instructions
F	Terminal strip X2 (Phoenix ZEC 1,5/ST7,5) Plug-in terminal for brake 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 nature 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 ANG 210 (4.0 to 9.2 kW) and 410 (5.5 to 15.0 kW)

Scope of Supply

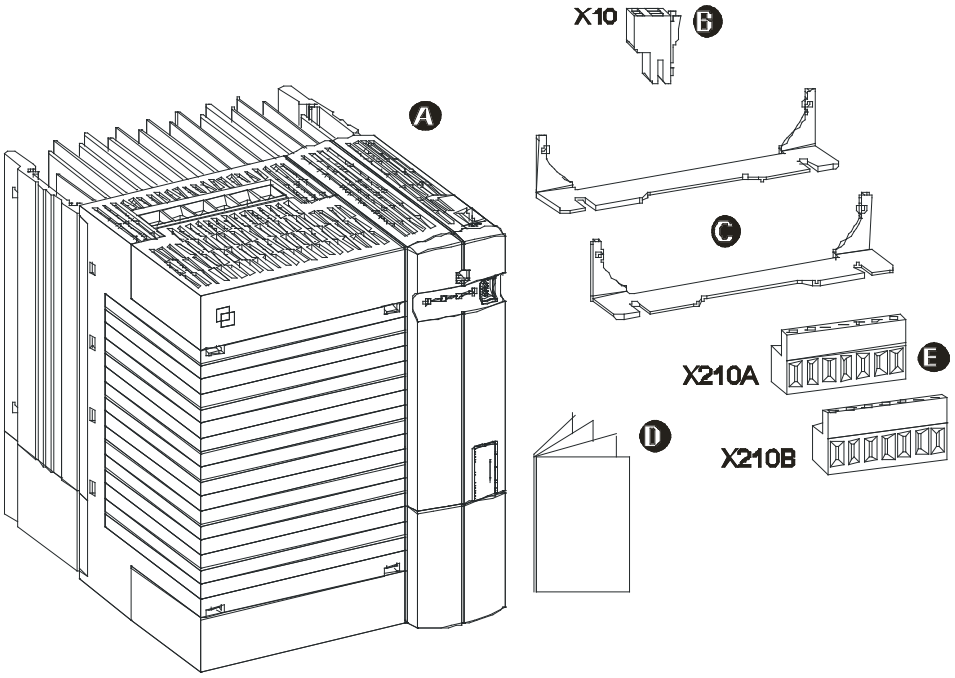


Scope of Supply	
A	Frequency inverter
B	Terminal strip X10 (Phoenix ZEC 1.5/3ST5.0) Plug-in terminals for the relay output
C	Standard fittings with fitting screws (M4x20, M4x60) for vertical assembly
D	Quick Start Guide and Operating Instructions
E	Control terminals X210A / X210B (Wieland DST85 / RM3.5)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

Please check incoming goods for quality, quantity and nature 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 ANG 410 (18.5 to 30.0 kW)

Scope of Supply

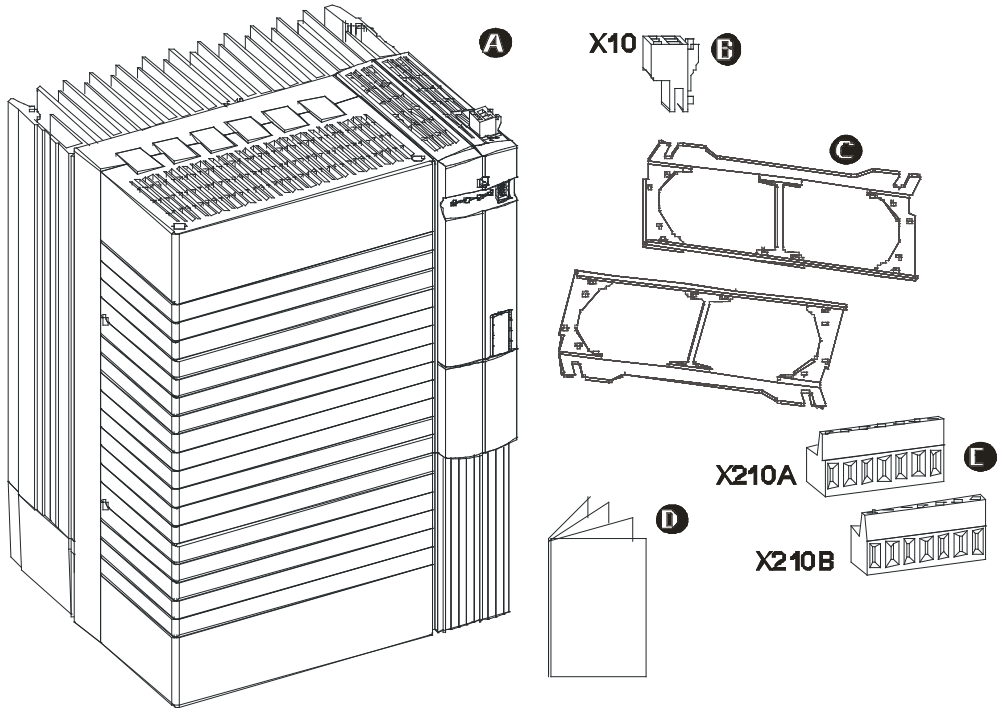


Scope of Supply	
A	Frequency inverter
B	Terminal strip X10 (Phoenix ZEC 1.5/3ST5.0) Plug-in terminals for the relay output
C	Standard fittings with fitting screws (M4x20, M4x70) for vertical assembly
D	Quick Start Guide and Operating Instructions
E	Control terminals X210A / X210B (Wieland DST85 / RM3.5)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

Please check incoming goods for quality, quantity and nature 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 ANG 410 (37.0 to 65.0 kW)

Scope of Supply



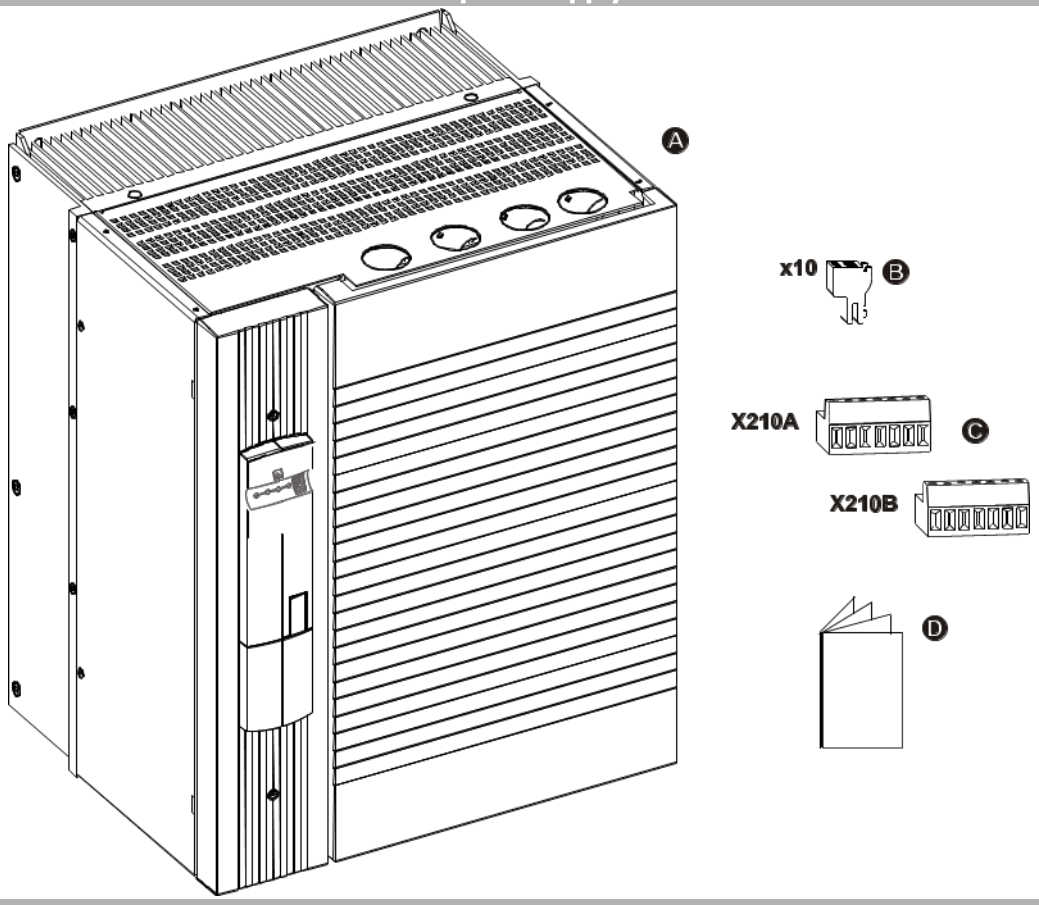
Scope of Supply

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 (M5x20) for vertical assembly
D	Quick Start Guide and Operating Instructions
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 nature 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 ANG 410 (75.0 to 132.0 kW)

Scope of Supply



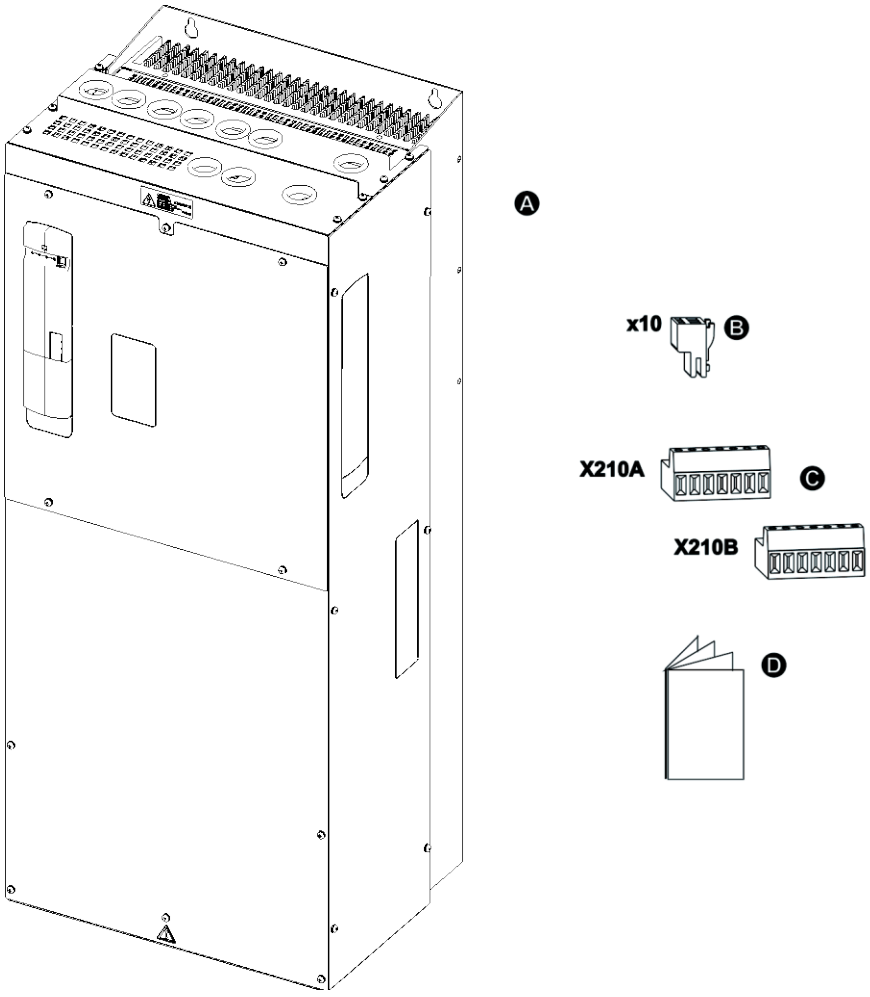
Scope of Supply

A	Frequency inverter
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 and Operating Instructions

Please check incoming goods for quality, quantity and nature 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 ANG 410 (160 through 400 kW)

Scope of supply



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 and Operating Instructions

Please check incoming goods for quality, quantity and nature 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

5.1 General technical data

CE conformity	The frequency inverters ANG meet the requirements of the low voltage directive 2014/35/EU and 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 frequency inverters ANG meet the requirements of EN 61800-3 for use in industrial environments.		
UL Approval	The frequency inverters marked with the UL label according to UL508c / UL61800-5-1 also meet the requirements of the CSA Standard C22.2-No. 274. UL approved are the device series ANG410 in sizes 1 to 7 and ANG210 devices in sizes 1 and 2.		
Safety function	The function is described in the application manual "Safe Torque Off".		
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.		
Overload capability	Continuous Operation: 100 % I_N Up to 150 % I_N for 60 s Up to 200 % I_N for 1 s	Devices -**01**, -**03** (0.25 & 0.37 kW): Devices -51 .. -61 (160 .. 400 kW):	Up to 200 % I_N for 60 s Up to 200 % I_N for 1 s Up to 150 % I_N for 60 s Up to 180 % I_N 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; From 160 kW to 250 kW device power (size 8): 18 kA As from 315 kW device power (size 8): ≥ 30 kA
Contamination level	The frequency inverters are designed for Pollution Degree 2.
Overvoltage category	The frequency inverters are designed for Overvoltage Category III.
Functions	Control methods adjusted to motors and application (configuration). Adjustable speed/torque control. Various control functions for motor and frequency inverter. Positioning absolute or relative to a reference point. Search Run. 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 parameter.

5.2 Technical Data – Control Electronic Equipment

Control terminal X210A		
X210A.1	DC 20 V output (I_{max}=130 mA) or DC 24 V ±10% input for external power supply	
X210A.2	GND 20 V/ GND 24 V (ext.)	
X210A.3	Digital input **STOA** (first shutdown path)	safety relevant
X210A.4	Digital inputs [1]	
X210A.5		
X210A.6		
X210A.7		

Control terminal X210B		
X210B.1	Digital input [1]	
X210B.2	Digital input **STOB** (second shutdown path)	safety relevant
X210B.3	Digital input/output [1]	
X210B.4	Multifunction I/O MF2[1] (voltage signal, proportional act. frequency, factory settings)	
X210B.5	Supply voltage DC 10 V for reference value potentiometer, (I_{max}= 4 mA)	
X210B.6	Multifunction input [1] (reference speed 0 … +10 V, factory settings)	
X210B.7	Ground 10 V	

Relay output X10	
S3OUT.1	Inverted Error Signal [1]

[1] Control terminals are freely configurable.

- Control "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. For an overview of the settings, see Page **Fehler! Textmarke nicht definiert.** of these Operating Instructions.

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, f_{max}=150 kHz
Digital input/output (X210B.3): Low Signal: DC 0…3 V, High Signal: DC 12…30 V, Max. Out.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 input/output (X210B.4): Digital input: Low Signal: DC 0 V… 3 V, High Signal: DC 12 V … 30 V, max. output current: 50 mA, PLC compatible Digital output: Low Signal: DC 0 V… 3 V, High Signal: DC 12 V … 30 V, PLC compatible Analog output: DC 19 … 28 V, maximum out. current: 50 mA, pulse-width modulated (fPWM= 116 Hz), Frequency signal: Output voltage: DC 0 V … 24 V, maximum output current: 40 mA, maximum output frequency: 150 kHz
Multifunction input (X210B.6): Analog signal: Input voltage: DC 0… 10V/ ±10V (R_i=73,5kΩ), input current: DC 0…20 mA (Ri=249 Ω) Digital signal: Low Signal: DC 0…3V, High Signal: DC 12V…30V, 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 ANG 210 (0.25 to 1.1 kW, 230 V)

Type							
ANG 210			-01	-03	-05	-07	-09
Construction 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
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 ... 1000, depending on switching frequency				
Switching frequency	f	kHz	2, 4, 8, 16				
Output, brake resistor							
Min. brake resistance	R	Ω	100	100	100	100	100
Recommended brake resistor (U_{dBC} = 385 V)	R	Ω	430	300	230	160	115
Input, mains side							
Mains current [3] 3ph/PE 1ph/N/PE; 2ph/PE	I	A	1.6 2.9	2.5 4.5	3 5.4	4 7.2	5.5 [1] 9.5 [2]
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
Mechanics							
Dimensions	HxWxD	mm	190 x 60 x 175				
Weight (approx.)	m	kg	1.2				
Degree of protection	-	-	IP20 (EN60529)				
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 for air cooling	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)				
Storage temperature	T_L	°C	-25 ... 55				
Transport temperature	T_T	°C	-25 ... 70				
Rel. air humidity	-	%	15 ... 85; not condensing				

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.

Output current [6]

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 [2]	5.4 A [2] [5]	5.4 A [2] [5]	3.7 A [5]

[1] Three-phase connection requires a commutating choke.
[2] One- and two-phase connection requires a commutating choke.
[3] Mains current with relative mains impedance ≥ 1% (see chapter "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
[6] Maximum current in continuous operation

5.4 ANG 210 (1.5 to 3.0 kW, 230 V)

Type					
ANG 210			-11	-13	-15
Construction Size			2		
Output, motor side					
Recommended motor shaft power	P	kW	1.5	2.2	3.0
Output current	I	A	7.0	9.5	12.5 [4]
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 ... 1000, depending on switching frequency		
Switching frequency	f	kHz	2, 4, 8, 16		
Output, brake resistor					
Min. brake resistance	R	Ω	37	37	37
Recommended brake resistor (U_{dBC} = 385 V)	R	Ω	75	55	37
Input, mains side					
Mains current [3] 3ph/PE 1ph/N/PE; 2ph/PE	I	A	7 13.2	9.5 16.5 [2]	10.5 [1] 16.5 [2] [4] [7]
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
Mechanics					
Dimensions	HxWxD	mm	250 x 60 x 175		
Weight (approx.)	m	kg	1.6		
Degree of protection	-	-	IP20 (EN60529)		
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 for air cooling	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)		
Storage temperature	T_L	°C	-25 ... 55		
Transport temperature	T_T	°C	-25 ... 70		
Rel. air humidity	-	%	15 ... 85; not condensing		

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.

Output current [6]

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 [2]	9.5 A [2]	9.5 A [2]	6.5 A
3.0 kW [2] [4]	12.5 A [1]	12.5 A [1] [5]	12.5 A [1] [5]	8.5 A [5]

[1] Three-phase connection requires a commutating choke.
[2] One- and two-phase connection requires a commutating choke.
[3] Mains current with relative mains impedance ≥ 1% (see chapter „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 [6] Maximum current in continuous operation
[7] The device for single phase connection is not listed in the product catalogue and only available on request.

5.5 ANG 210 (4.0 to 9.2 kW, 230 V)

Type						
ANG 210			-18	-19	-21	-22
Construction 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 ... 1000, depending on switching frequency			
Switching frequency	f	kHz	2, 4, 8, 16			
Output, brake resistor						
Min. brake resistance	R	Ω	24	24	12	12
Recommended brake resistor (U_{dBC} = 385 V)	R	Ω	30	24	16	12
Input, mains side						
Mains current **3)** 3ph/PE 1ph/N/PE; 2ph/PE	I	A	18 28 **2) 7)**	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)**
Mechanics						
Dimensions	HxWxD	mm	250 x 100 x 200		250 x 125 x 200	
Weight (approx.)	m	kg	3.0		3.7	
Degree of protection	-	-	IP20 (EN60529)			
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 for air cooling	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)			
Storage temperature	T_L	°C	-25 ... 55			
Transport temperature	T_T	°C	-25 ... 70			
Rel. air humidity	-	%	15 ... 85; not condensing			

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.

Output current **6)**				
Frequency inverter nominal power	**Switching frequency**			
	2 kHz	4 kHz	8 kHz	16 kHz
4.0 kW	18.0 A **2)**	18.0 A **2)**	18.0 A **2)**	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) Three-phase connection requires a commutating choke.
2) One- and two-phase connection requires a commutating choke.
3) Mains current with relative mains impedance ≥ 1% (see chapter „Electrical installation")
4) Three-phase connection permissible only.
5) Reduction of switching frequency in thermal limit range **6)** Maximum current in continuous operation
7) The device for single phase connection is not listed in the product catalogue and only available on request.

5.6 ANG 410 (0.25 to 1.5 kW, 400 V)

Type								
ANG 410			-01	-03	-05	-07	-09	-11
Construction 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 ... 1000, depending on switching frequency					
Switching frequency	f	kHz	2, 4, 8, 16					
Output, brake resistor								
Min. brake resistance	R	Ω	300	300	300	300	300	300
Recommended brake resistor (U_{dBC} = 770 V)	R	Ω	930	930	930	634	462	300
Input, mains side								
Mains current [2] 3ph/PE	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					
Mechanics								
Dimensions	HxWxD	mm	190 x 60 x 175					
Weight (approx.)	m	kg	1.2					
Degree of protection	-	-	IP20 (EN60529)					
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 for air cooling	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)					
Storage temperature	T_L	°C	-25 ... 55					
Transport temperature	T_T	°C	-25 ... 70					
Rel. air humidity	-	%	15 ... 85, not condensing					

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.

Output current [4]

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] Three-phase connection requires a commutating choke.
[2] Mains current with relative mains impedance ≥ 1% (see chapter „Electrical installation")
[3] Reduction of switching frequency in thermal limit range
[4] Maximum current in continuous operation

5.7 ANG 410 (1.85 to 4.0 kW, 400 V)

Type						
ANG 410			-12	-13	-15	-18
Construction 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 ... 1000, depending on switching frequency			
Switching frequency	f	kHz	2, 4, 8, 16			
Output, brake resistor						
Min. brake resistance	R	Ω	136	136	136	92
Recommended brake resistor (U_{dBC} = 770 V)	R	Ω	300	220	148	106
Input, mains side						
Mains current [2)] 3ph/PE	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		
Mechanics						
Dimensions	HxWxD	mm	250 x 60 x 175			
Weight (approx.)	m	kg	1.6			
Degree of protection	-	-	IP20 (EN60529)			
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 for air cooling	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)			
Storage temperature	T_L	°C	-25 ... 55			
Transport temperature	T_T	°C	-25 ... 70			
Rel. air humidity	-	%	15 ... 85, not condensing			

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.

Output current [4)]				
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)] Three-phase connection requires a commutating choke.
[2)] Mains current with relative mains impedance ≥ 1% (see chapter „Electrical installation")
[3)] Reduction of switching frequency in thermal limit range
[4)] Maximum current in continuous operation

5.8 ANG 410 (5.5 to 15.0 kW, 400 V)

Type							
ANG 410			-19	-21	-22	-23	-25
Construction 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 ... 1000, depending on switching frequency				
Switching frequency	f	kHz	2, 4, 8, 16				
Output, brake resistor							
Min. brake resistance	R	Ω	48	48	48	32	32
Recommended brake resistor (U_{dBC} = 770 V)	R	Ω	80	58	48	48	32
Input, mains side							
Mains current [2)] 3ph/PE	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
Mechanics							
Dimensions	HxWxD	mm	250 x 100 x 200			250 x 125 x 200	
Weight (approx.)	m	kg	3.0			3.7	
Degree of protection	-	-	IP20 (EN60529)				
Terminals	A	mm^2	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 for air cooling	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)				
Storage temperature	T_L	°C	-25 ... 55				
Transport temperature	T_T	°C	-25 ... 70				
Rel. air humidity	-	%	15 ... 85, not condensing				

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.

Output current [4)]

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)] Three-phased connection demands mains commutating choke
[2)] Mains current with relative mains impedance ≥ 1% (see chapter „Electrical installation")
[3)] Reduction of switching frequency in thermal limit range
[4)] Maximum current in continuous operation

5.9 ANG 410 (18.5 to 30.0 kW, 400 V)

Type					
ANG 410			-27	-29	-31
Construction 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 ... 1000, depending on switching frequency		
Switching frequency	f	kHz	2, 4, 8		
Output, brake resistor					
Min. brake resistance	R	Ω	16		
Recommended brake resistor (U_{dBC} = 770 V)	R	Ω	26	22	16
Input, mains side					
Mains current [2] 3ph/PE	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
Mechanics					
Dimensions	HxWxD	mm	250x200x260		
Weight (approx.)	m	kg	8		
Degree of protection	-	-	IP20 (EN60529)		
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 for air cooling	T_n	°C	0 ... 40 (3K3 DIN IEC 721-3-3)		
Storage temperature	T_L	°C	-25 ... 55		
Transport temperature	T_T	°C	-25 ... 70		
Rel. air humidity	-	%	15 ... 85, not condensing		

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.

Output current [3]			
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] Three-phase connection requires a commutating choke.
[2] Mains current with relative mains impedance ≥ 1% (see chapter „Electrical installation")
[3] Maximum current in continuous operation

5.10 ANG 410 (37.0 to 65.0 kW, 400 V)

Type						
ANG 410			-33	-35	-37	-39
Construction 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 ... 1000, depending on switching frequency			
Switching frequency	f	kHz	2, 4, 8			
Output, brake resistor [5]						
Min. brake resistance	R	Ω	7.5			
Recommended brake resistor (U_{dBC} = 770 V)	R	Ω	13	11	9	7.5
Input, mains side						
Mains current [2] 3ph/PE	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
Mechanics						
Dimensions	HxWxD	mm	400x275x260			
Weight (approx.)	m	kg	20			
Degree of protection	-	-	IP20 (EN60529)			
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	Tn	°C	0 ... 40 (3K3 DIN IEC 721-3-3)			
Storage temperature	T_L	°C	-25 ... 55			
Transport temperature	T_T	°C	-25 ... 70			
Rel. air humidity	-	%	15 ... 85, not condensing			

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.

Output current [4]

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] Three-phase connection requires a commutating choke.
[2] Mains current with relative mains impedance ≥ 1% (see chapter „Electrical installation")
[3] Reduction of switching frequency in thermal limit range
[4] Maximum current in continuous operation
[5] Optional the frequency inverter of this size is purchasable without brake transistor.

5.11 ANG 410 (75.0 to 200.0 kW, 400 V)

Type								
ANG 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 [4]

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
[4] Maximum current in continuous operation
[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** ANG 410-53 size 7 devices only

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

5.12 ANG 410 (160.0...400.0 kW, 400 V)

Type								
ANG 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 [3]					
Rotary field frequency	f	Hz	±500 Hz [3]					
Switching Frequency	f	kHz	2, 4, 8 [4]					
Output, braking resistor (external) [4]								
Min. Brake resistance	R	Ω	1.20	1.20	1.20	0.80	0.80	0.80
Recommended Brake resistance (U_{dBC} = 770 V)	R	Ω	1.50	1.50	1.50	1.00	1.00	1.00
Input, mains side								
Mains current [5]	I	A	305	350	440	550	620	690
Mains voltage	U	V	400					
Mains frequency	f	Hz	50 (60)					
Fuses	I	A	315	355	500	630	630	800
Mechanical								
Dimensions	HxWxD	mm	1036 x 439 x 375					
Weight approx.	m	kg	120	120	140	140	140	140
Ingress protection rating	-	-	IP20 (EN60529)					
Connection terminal	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	T_n	°C	-25 … 45 (3K3 DIN IEC 60721-3-3)					
Storage temperature	T_L	°C	-25 ... 55					
Transport temperature	T_T	°C	-25 ... 70					
Relative humidity	-	%	15 ... 85, not condensing					

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.

Output current [6]

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
[3] depending on switching frequency
[4] Reduction of switching frequency possible on certain conditions
[5] Rated value with recommended motor power, 400V mains voltage and mains inductance U_K=4%
[6] Maximum current in continuous operation

5.13 ANG 510 (160.0...400.0 kW, 525 V)

Type								
ANG 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[3]					
Rotary field frequency	f	Hz	±500 Hz [3]					
Switching Frequency	f	kHz	2, 4, 8 [4]					
Output, braking resistor (extern) [4]								
Min. Brake resistance	R	Ω	1.20	1.20	1.20	0.80	0.80	0.80
Recommended Brake resistance (U_{dBC} = 770 V)	R	Ω	2.70	2.70	2.70	1.50	1.50	1.50
Input, mains side								
Mains current [5]	I	A	215	270	335	420	470	525
Mains voltage	U	V	400					
Mains frequency	f	Hz	50 (60)					
Fuses	I	A						
Mechanical								
Dimensions	HxWxD	mm	1036 x 439 x 375					
Weight approx.	m	kg	120	120	140	140	140	140
Ingress protection rating	-	-	IP20 (EN60529)					
Connection terminal	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	T_n	°C	-25 … 45 (3K3 DIN IEC 60721-3-3)					
Storage temperature	T_L	°C	-25 ... 55					
Transport temperature	T_T	°C	-25 ... 70					
Relative humidity	-	%	15 ... 85, not condensing					

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.

Output current[6]

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
[3] depending on switching frequency
[4] Reduction of switching frequency possible on certain conditions
[5] Rated value with recommended motor power, 400V mains voltage and mains inductance U_K=4%
[6] Maximum current in continuous operation

5.14 ANG 610 (160.0...400.0 kW, 690 V)

Type								
ANG 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[3]					
Rotary field frequency	f	Hz	±500 Hz [3]					
Switching Frequency	f	kHz	2, 4, 8 4[4]					
Output, braking resistor (extern) [5]								
Min. Brake resistance	R	Ω	3.00	3.00	3.00	1.80	1.80	1.80
Recommended Brake resistance (U_{dBC} = 770 V)	R	Ω	5.00	5.00	5.00	3.00	3.00	3.00
Input, mains side								
Mains current[5]	I	A	160	200	250	320	360	410
Mains voltage	U	V	690 (for UL reduced: 600)					
Mains frequency	f	Hz	50 (60)					
Fuses	I	A	200	250	315	355	400	500
Fuses as per UL [6] in preparation	Type							
Mechanical								
Dimensions	HxWxD	mm	1036 x 439 x 375					
Weight approx.	m	kg	120	120	140	140	140	140
Ingress protection rating	-	-	IP20 (EN60529)					
Connection terminal	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	T_n	°C	-25 … 45 (3K3 DIN IEC 721-3-3)					
Storage temperature	T_L	°C	-25 ... 55					
Transport temperature	T_T	°C	-25 ... 70					
Relative humidity	-	%	15 ... 85, not condensing					

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.

Output current[7]

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

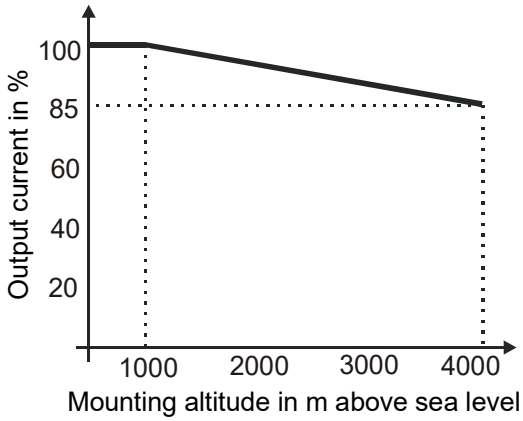
[1] Power reduction with torsional frequencies below 15 Hz
[2] Only with torsional frequencies above 15 Hz
[3] depending on switching frequency
[4] Reduction of switching frequency possible on certain conditions
[5] Rated value with recommended motor power, 400V mains voltage and mains inductance UK=4%
[6] For UL-compliant fusing, the specified fuses must be used.
[7] Maximum current in continuous operation

5.15 Operation diagrams

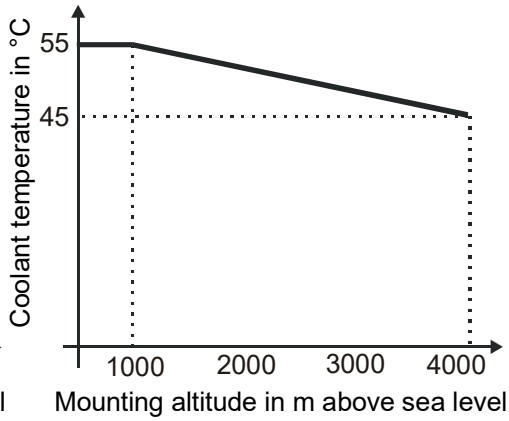
The technical data of the frequency inverters refer to the nominal point which was selected to enable a wide range of applications. A functionally and efficient dimensioning (derating) of the frequency inverters is possible based on the following diagrams.

Installation altitude

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

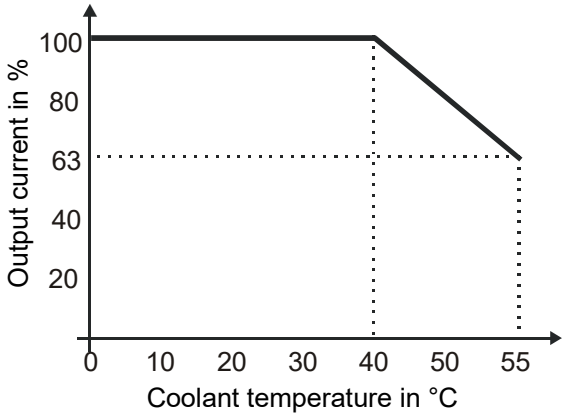


max. coolant temperature,
3.3 °C/1000 m above sea level,



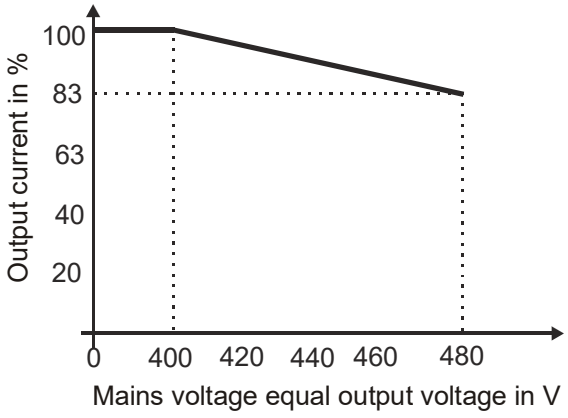
Coolant temperature

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, both the installation and the safety instructions as well as the device specifications must be complied with.

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

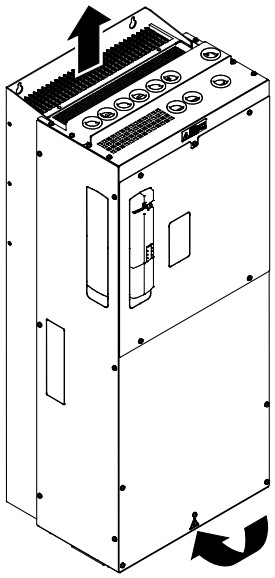
CAUTION

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:

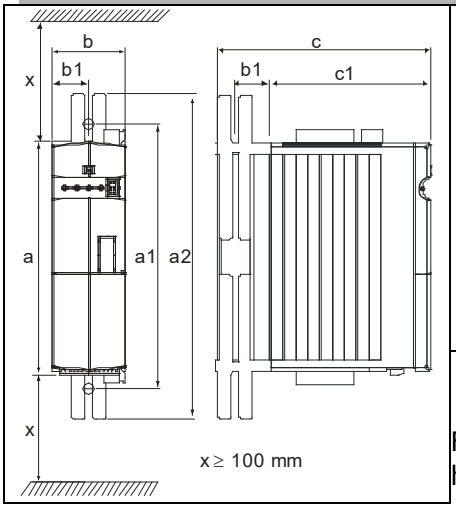


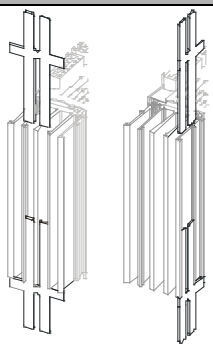
For cooling the air-cooled frequency inverters, air is taken in through openings in the bottom plate. The air coming from below heats up and escapes through openings in the top of the case. The illustration shows the air flow from below for size 8 frequency inverter.

6.2 ANG 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.

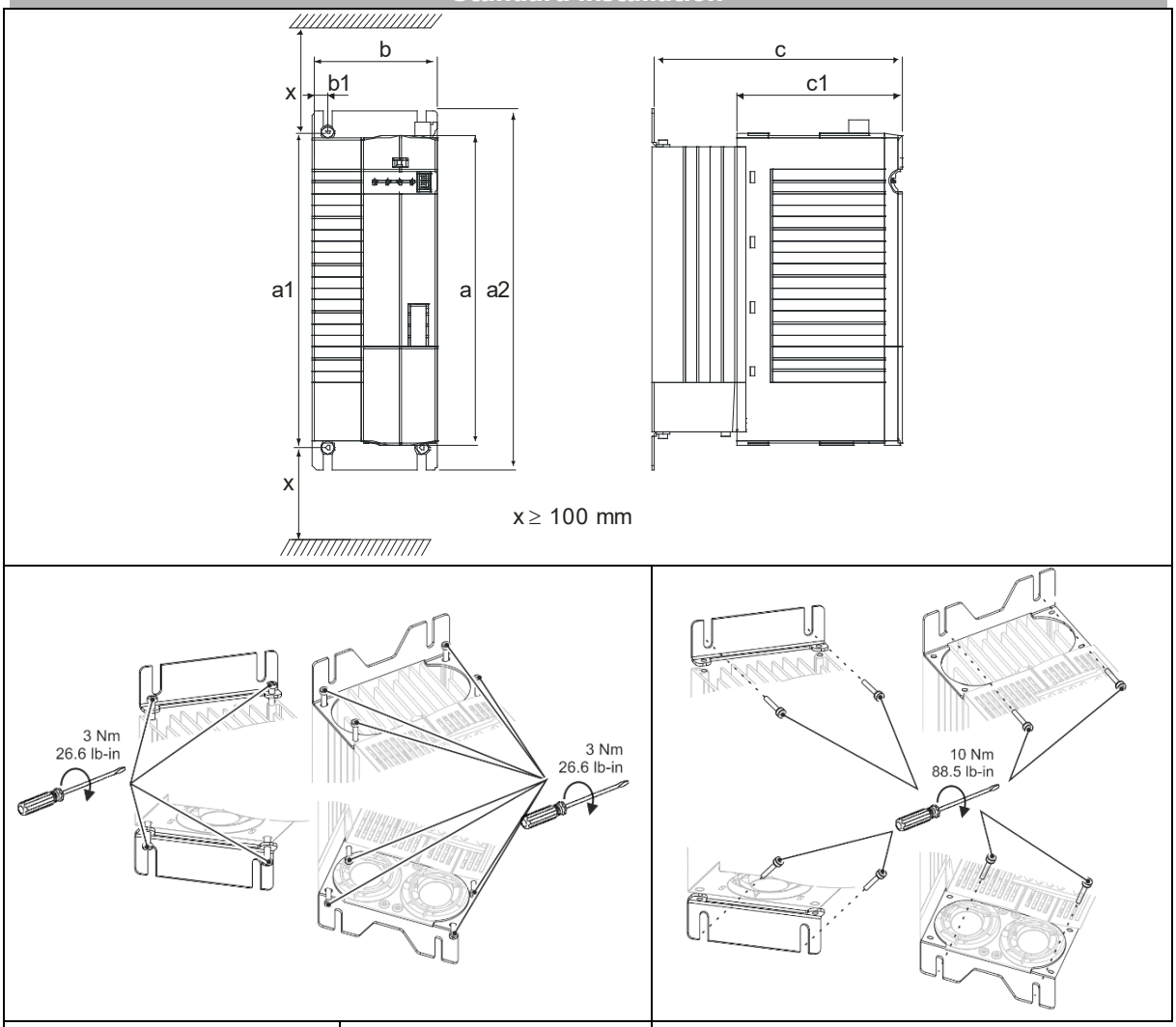
The dimensions of the device and the installation dimensions are those of the standard device without optional components and are given in millimeters.

Dimensions [mm]					Installation dimensions [mm]			
ANG		**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 ANG 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



Top fixing bracket (screws M4x20)	Bottom fixing bracket (screws M4x60)

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

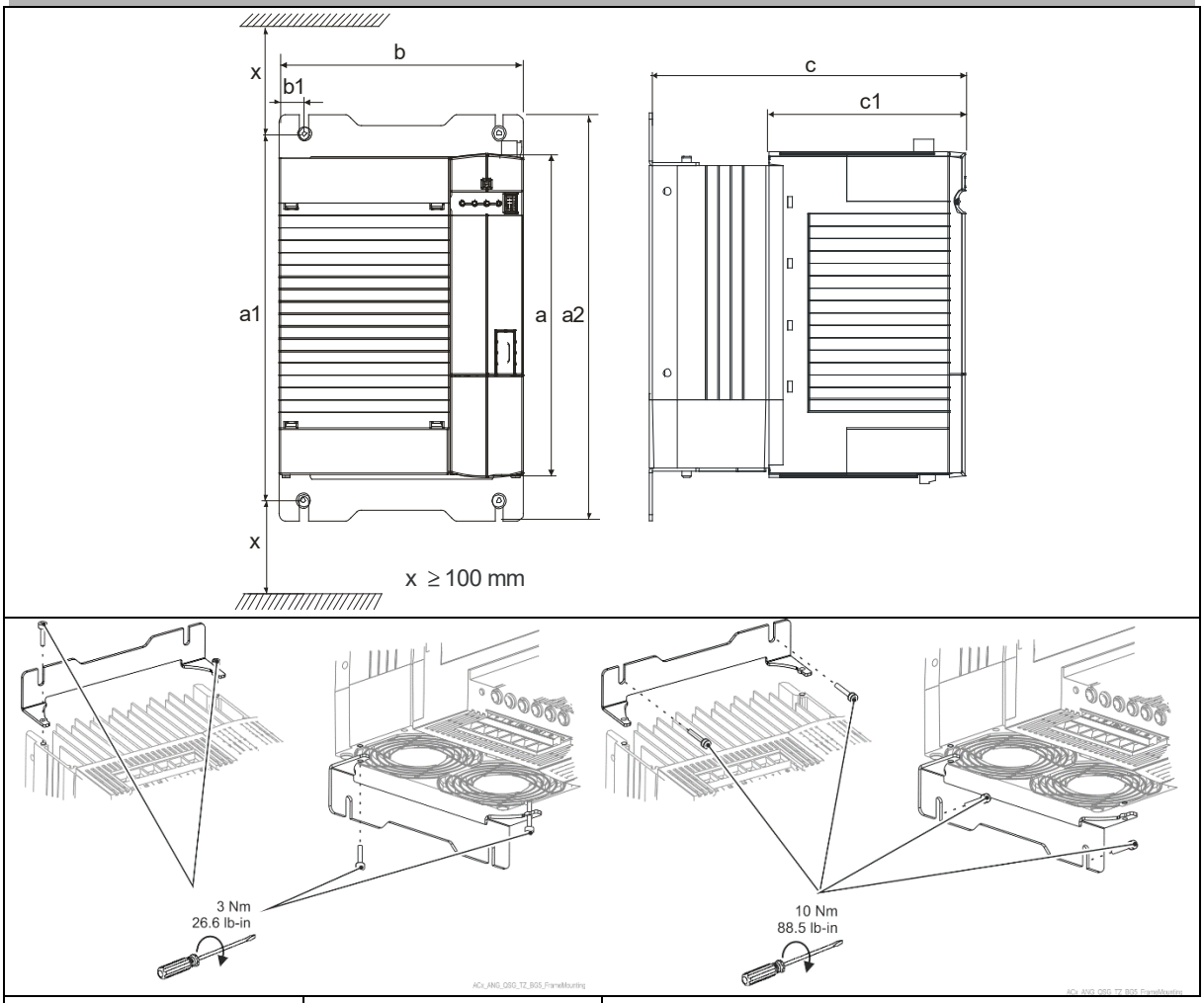
The frequency inverters are provided with fixing brackets, which are fitted using four thread-cutting screws. The dimensions of the device and the installation dimensions are those of the standard device without optional components and are given in millimeters.

Dimensions [mm]					Installation dimensions [mm]			
ANG		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 ANG 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



Top fixing bracket (screws M4x20)	Bottom fixing bracket (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.

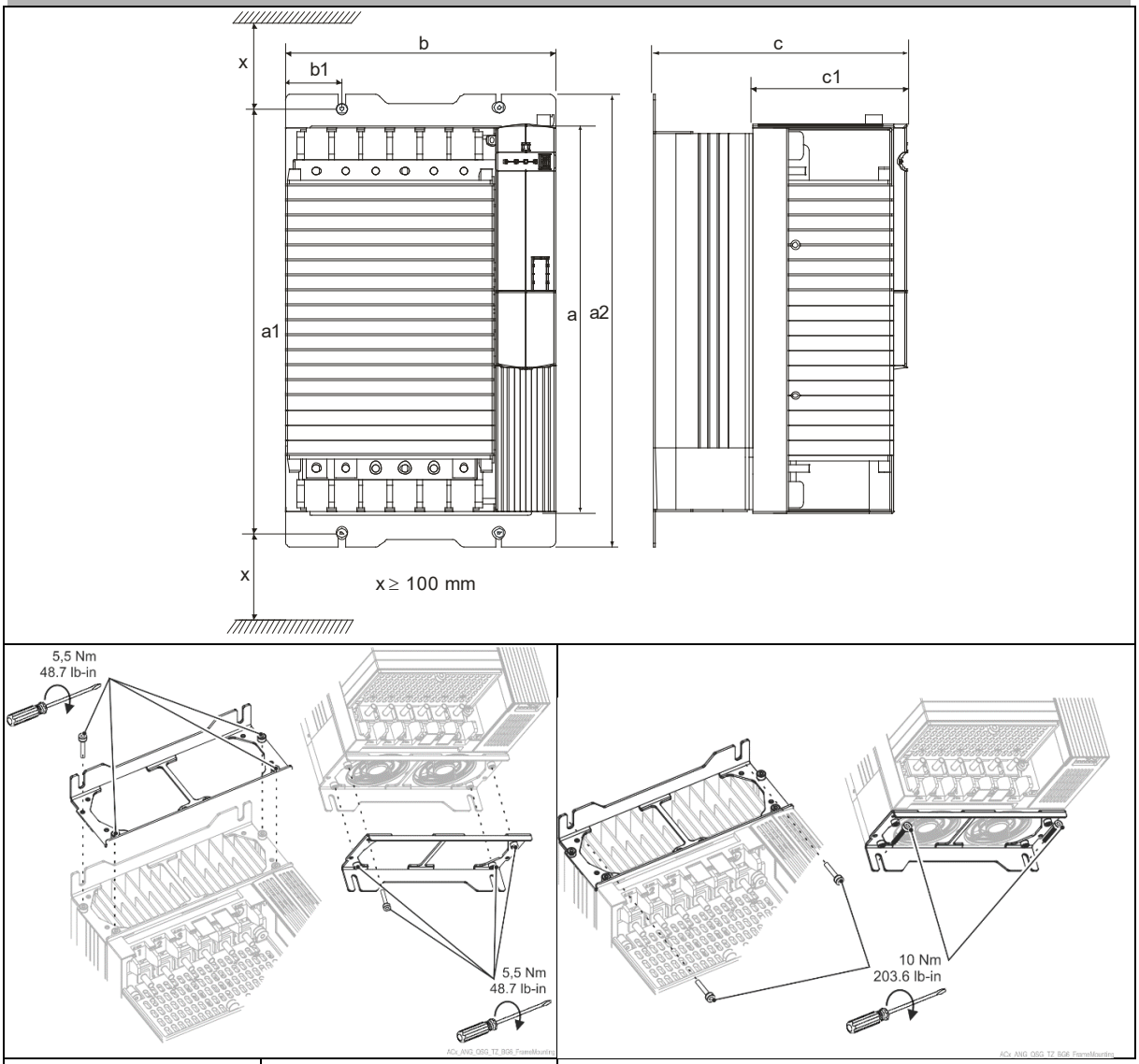
Dimensions [mm]					Installation dimensions [mm]			
ANG		a	b	c	a1	a2	b1	c1
410	**18.5...30.0 kW**	250	200	260	270 ... 290	315	20	160

6.5 ANG 410 (37.0 to 65.0 kW) (air cooled)

For mechanical installation of liquid-cooled 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



Top screw fixture M5x20	Bottom screw fixture 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.

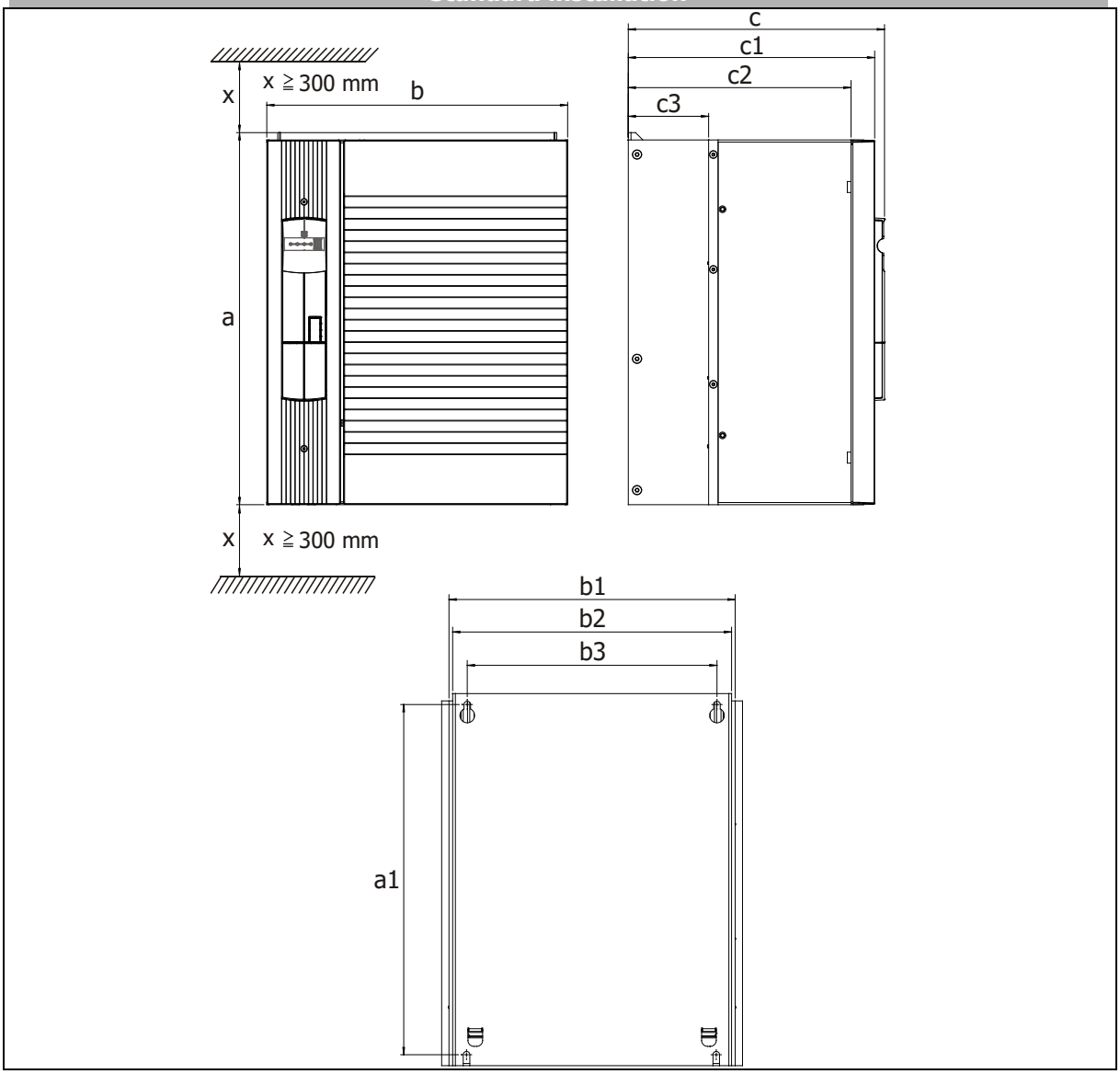
Dimensions [mm]					Installation dimensions [mm]			
ANG		a	b	c	a1	a2	b1	c1
410	**37...65 kW**	400	275	260	425 ... 445	470	20	160

6.6 ANG 410 (75.0 to 132.0 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 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.

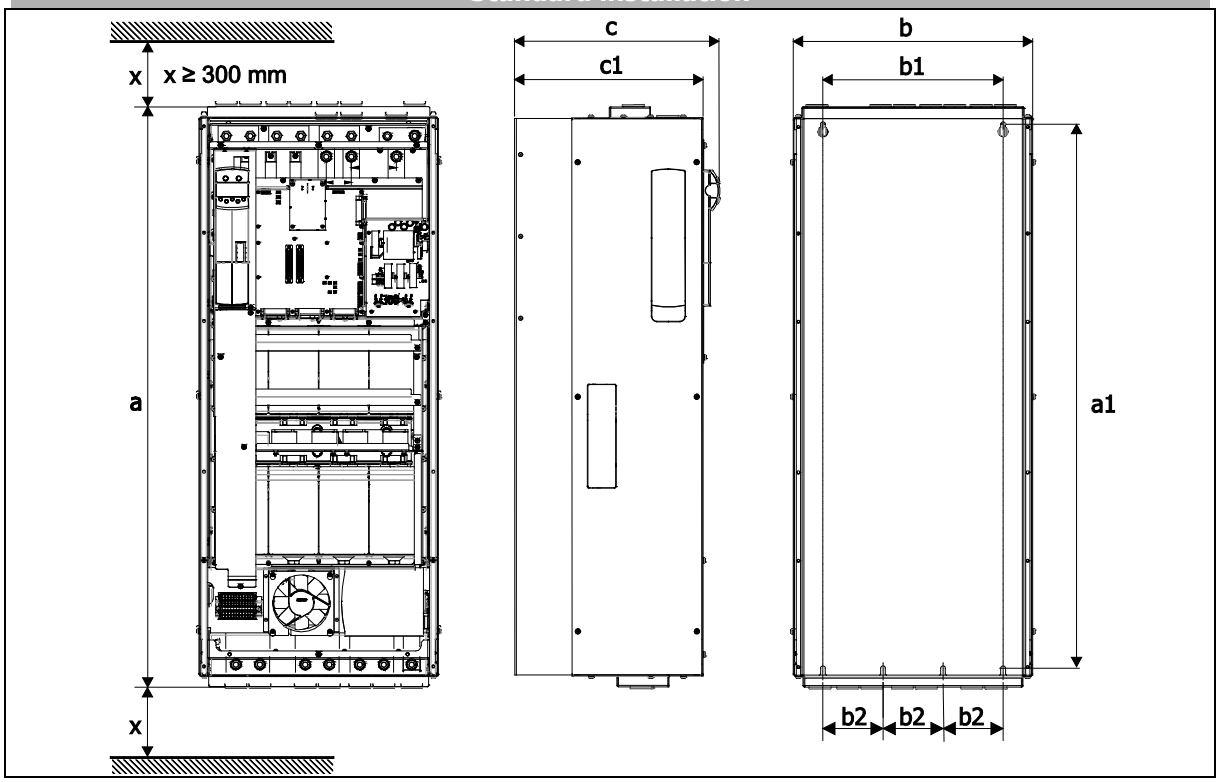
Dimensions [mm]					Installation dimensions in mm						
ANG		a	b	c	a1	b1	b2	b3	c1	c2	c3
410	**75…132 kW**	510	412	351	480	392	382	342	338	305	110

6.7 ANG 410/510/610 (160.0 to 400.0 kW)

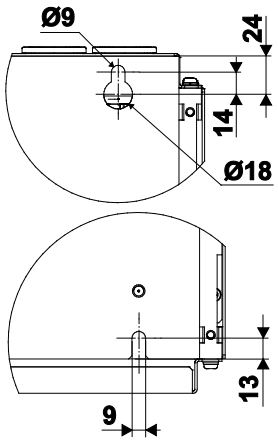
The illustration shows an example for mechanical installation of air-cooled frequency inverters. The dimensions and fitting elements correspond to those of liquid-cooled devices.

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

Standard installation



- Screw the rear wall of the frequency inverter heat sink to the assembly panel.



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]					Installation dimensions [mm]			
ANG		a	b	c	a1	a2	b1	c1
410	**160...400 kW**	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 60204-1 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 frequency inverters are to be grounded properly, i.e. large connection area and with good conductivity. The leakage current of the frequency inverters may be > 3.5 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.

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 unearthed mains (IT mains) is admissible after disconnection of the Y capacitors in the interior of the device.

- 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.

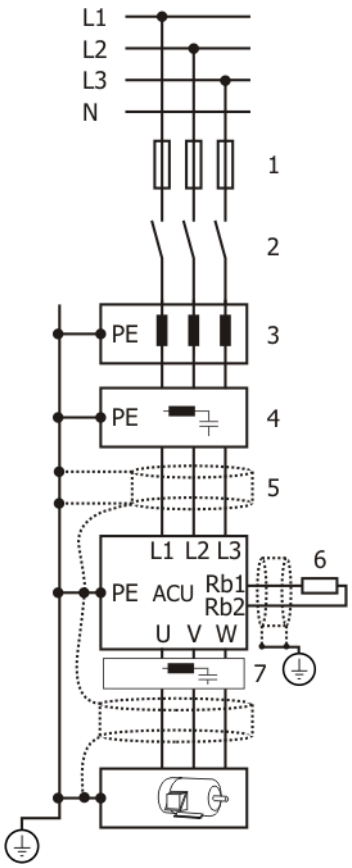
- The fuses to be used are to be selected depending on the specific application. The safety recommendations in the Technical Data are valid for continuous operation without overload.

7.1 EMC Information

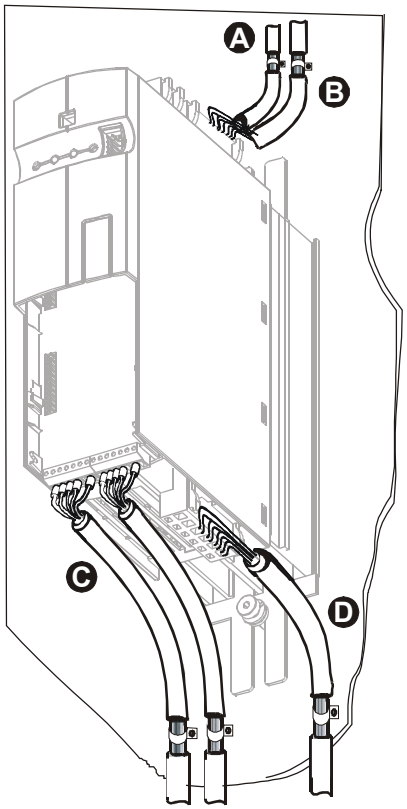
The frequency inverters are designed according to the requirements and limit values of product standard EN 61800-3 with an interference immunity factor (EMI) for operation in industrial applications. Electromagnetic interference is to be avoided by expert installation and observation of the specific 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 the plant. Plant components such as control cabinets, control panels, machine frames, etc. must be connected by means of PE cables.
- 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.
- Keep the cables as short as possible, make sure that cables are installed properly using appropriate cable clamps, etc.
- 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 brake resistor (optional)
7 output filter (optional)



Ⓐ	Mains Connection
The mains supply cable may be as long as required. However, it must be installed separate from the control, data and motor cables.	
Ⓑ	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.	
Ⓒ	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.	
Ⓓ	Motor and brake 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 brake resistor is used, the connection cable must also be shielded, and the shield is to be connected to earth potential on both sides.	

Line choke

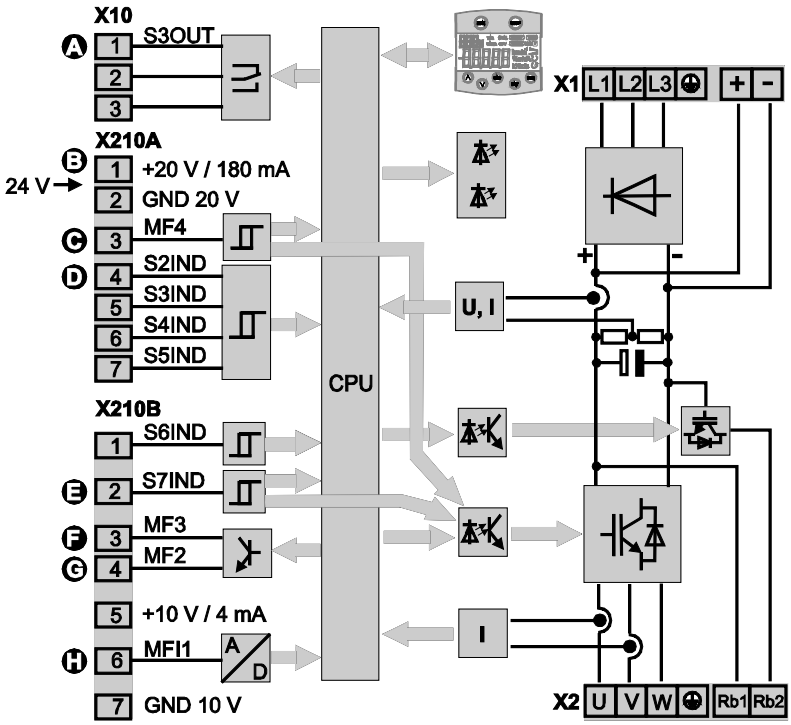
Line chokes reduce mains harmonics and reactive power. Additional the increase of product life is possible. Consider the reduction of the maximum output voltage if a line choke is installed.
The line choke must be installed between mains connection and input filter.

Input filter

Input filters reduce the conducted radio-frequency interference voltage. The input filter must be installed upstream on mains side 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



Ⓐ	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	
Ⓑ	Voltage output/input
Bidirectional, DC 20 V voltage output (I_{max}=130 mA) or input for external power supply DC 24 V ±10%	
Ⓒ	Digital input MF4/STOA
Digital signal, STOA (1st shutdown 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	
Ⓓ	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	
Ⓔ	Digital input S7IND/STOB
Digital signal, STOB (2nd shutdown path for safety function „Safe Torque Off"), response time: approx. 10 ms (On), 10 µs (Off), U_{max} = DC 30 V, 10 mA at DC 24 V,	
Ⓕ	MF3: Digital input / digital output
Low Signal: DC 0 V… 3 V, High Signal: DC 12 V … 30 V, Maximum output current: 50 mA, PLC compatible	
Ⓖ	MF2: Multifunction input/output
Digital input: Low Signal: DC 0 V… 3 V, High Signal: DC 12 V … 30 V, max. output current: 50 mA, PLC compatible Digital output: Low Signal: DC 0 V… 3 V, High Signal: DC 12 V … 30 V, PLC compatible Analog output: DC 19 … 28 V, maximum output current: 50 mA, pulse-width modulated (fPWM= 116 Hz), Frequency signal: Output voltage: DC 0 V … 24 V, maximum output current: 40 mA, maximum output frequency: 150 kHz	
Ⓗ	Multi-Function Input MF1
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, Umax = 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!

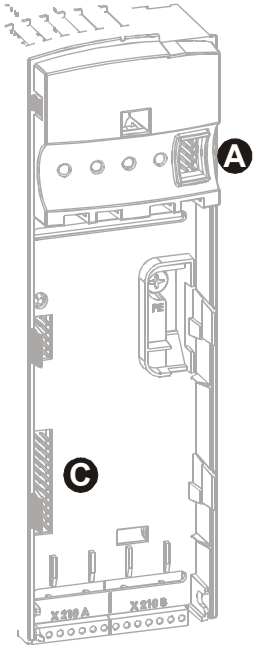
When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The discharge time is at least 3 minutes in the case of sizes 1 through 7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

- The unit may only be connected with the power supply switched off.
- Verify safe isolation from power supply.

NOTICE

The frequency inverter of the ANG series feature pre-installed extension modules. The EM-AUT-xx extension modules are part of the product. For this reason, mounting or dismounting of the modules is not required and not permitted.

Hardware modules



Ⓐ Control Unit KP500

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

Ⓒ Extension module EM

Slot for customer-specific adaptation:

- EM-AUT-01: Multifunction input, Resolver, Incremental encoder, Absolut encoder, CANopen and EtherCAT®.
- EM-AUT-04: Multifunction input, Resolver, Incremental encoder, CANopen and EtherCAT®.
- EM-AUT-11: Multifunction input, Resolver, Incremental encoder, Absolut encoder, CANopen and Profinet.
- EM-AUT-21: Multifunction input, Resolver, Incremental encoder, Absolut encoder, CANopen and Ethernet I/P.
- EM-AUT-31: Multifunction input, Resolver, Incremental encoder, Absolut encoder, CANopen and VARAN.

7.3.2 Shield sheets

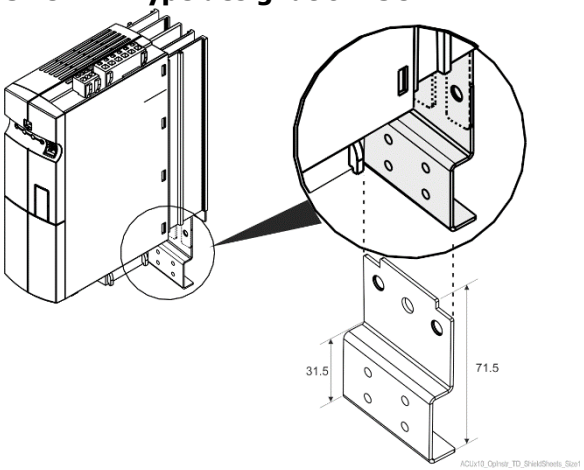
With an optional shield sheet, the shields of motor cables can be connected to PE potential in order to improve the EMC and EMI characteristics.

Shield sheet for motor cables

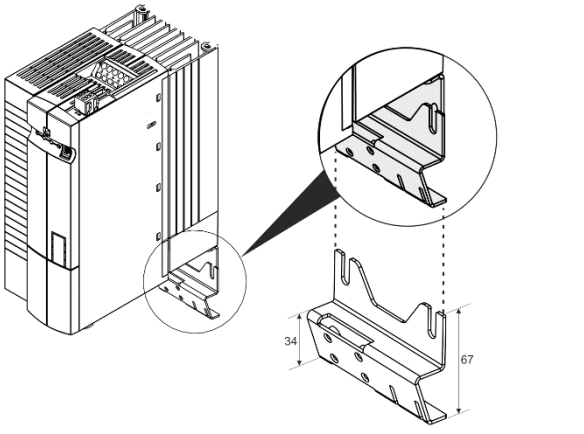
The applicable shield sheets depend on the device size.

The dimensions in the figures are given in mm.

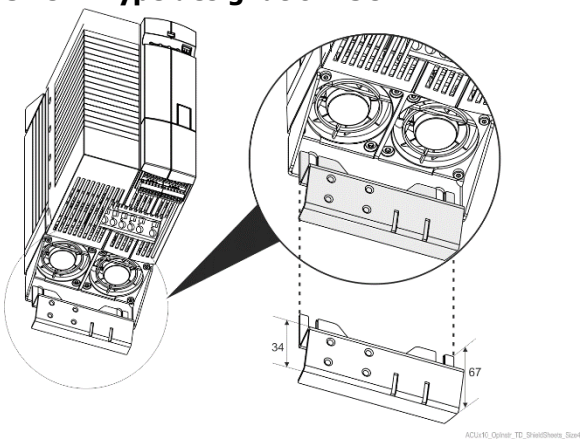
Size 1-2: Type designation: SCR 1-2



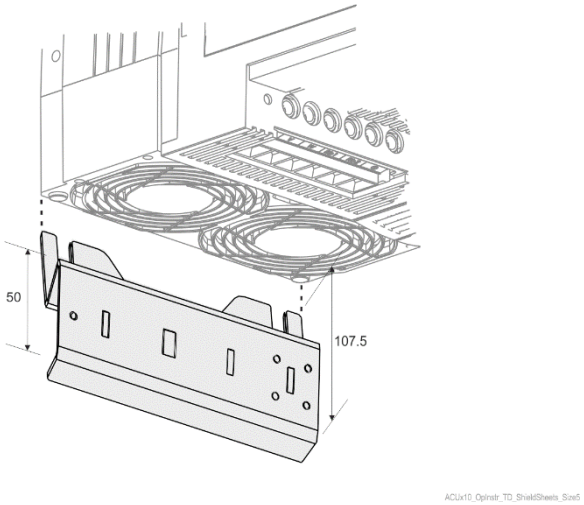
Size 3: Type designation: SCR 3



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 "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 cable.
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 cable.

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, and continuous mains current max. 100% rated input current). Actual mains cable cross-section requirements may deviate from these values due to 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* *1.85* *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

Note: liquid-cooled devices ANG 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
-51	*160 kW*	2x70 mm²	1x70 mm²	2x70 mm²
-53	*200 kW*	2x95 mm²	1x95 mm²	2x95 mm²
-55	*250 kW*	2x150 mm²	1x150 mm²	2x150 mm²
-57	*315 kW*	2x185 mm²	1x185 mm²	2x185 mm²
-59	*355 kW*	2x240 mm²	1x240 mm²	2x240 mm²
-61	*400 kW*	2x240 mm²	1x240 mm²	2x240 mm²

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

510		Mains cable	PE-conductor	Motor cable
-51	*160 kW*	2x70 mm²	1x50 mm²	2x70 mm²
-53	*200 kW*	2x70 mm²	1x70 mm²	2x70 mm²
-55	*250 kW*	2x95 mm²	1x95 mm²	2x95 mm²
-57	*315 kW*	2x120 mm²	1x120 mm²	2x120 mm²
-59	*355 kW*	2x150 mm²	1x150 mm²	2x150 mm²
-61	*400 kW*	2x185 mm²	1x185 mm²	2x185 mm²

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

610		Mains cable	PE-conductor	Motor cable
-51	*160 kW*	2x35 mm²	1x35 mm²	2x35 mm²
-53	*200 kW*	2x50 mm²	1x50 mm²	2x50 mm²
-55	*250 kW*	2x70 mm²	1x70 mm²	2x70 mm²
-57	*315 kW*	2x95 mm²	1x95 mm²	2x95 mm²
-59	*355 kW*	2x95 mm²	1x95 mm²	2x95 mm²
-61	*400 kW*	2x120 mm²	1x120 mm²	2x120 mm²

7.4.1.2 Typical 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 60204-1 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 MDS 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

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

The specified lengths of the motor cables must not be exceeded if no output filter is installed.

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. The frequency inverters ≤ 9.2 kW **size 3** with integrated EMC filter comply with the emission limits stipulated in EN 61800-3 if the motor cable is not longer than 20 m. Customer-specific requirements can be met by means of 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 with 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

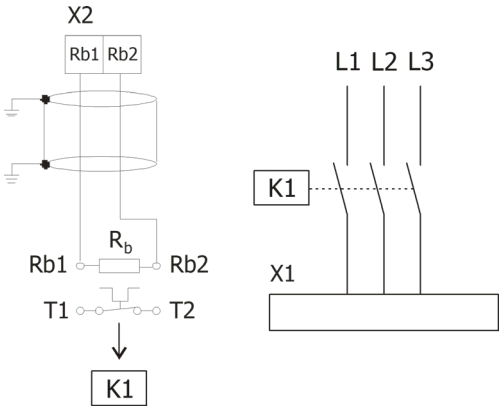
The surface of the braking resistor may reach a high temperature during operation and may remain hot for some time after operation.

- 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 MDS 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: ANG 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 (EN 60529) is only guaranteed with the terminals plugged.

WARNING

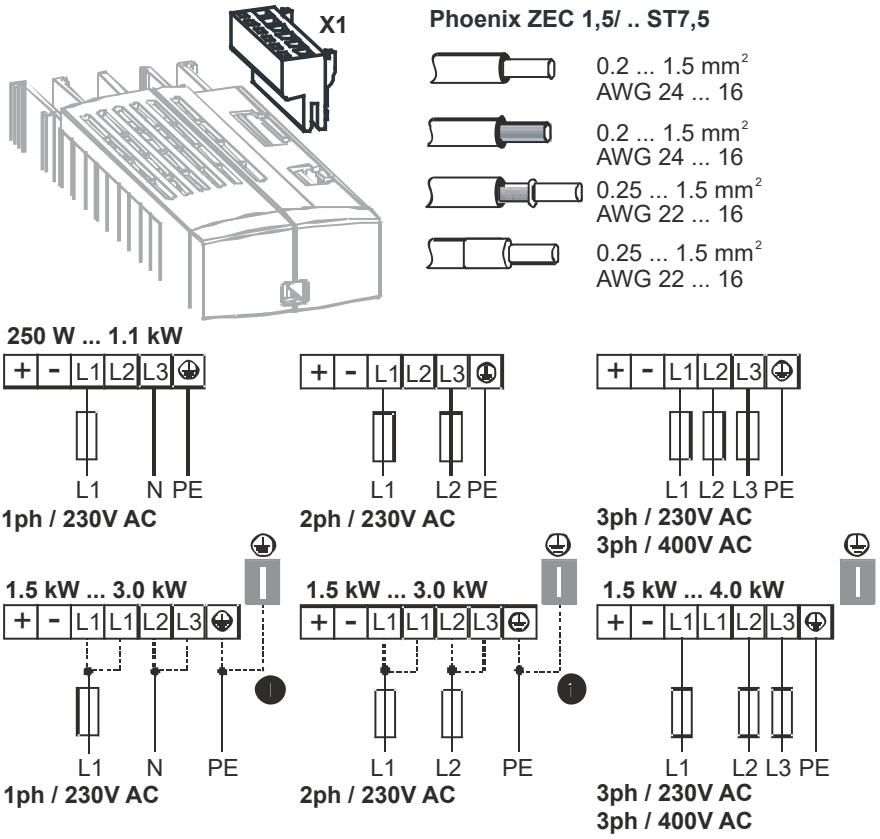
Dangerous voltage!

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 sizes 1 through 7 and
- at least 10 (in some configurations up to 25) minutes after shutdown in size 8. The valid waiting period is indicated on the device housing.

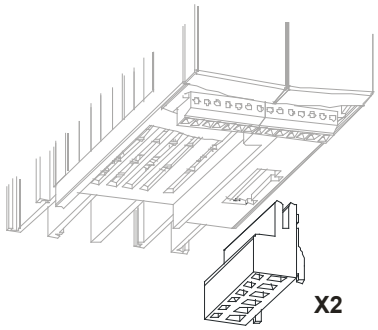
- The electrical installation must be carried out by qualified electricians according to the general and regional safety and installation directives.
- The documentation and device specification must be complied with during installation.
- Before any assembly or connection work, discharge the frequency inverter.
- Verify safe isolation from power supply.

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

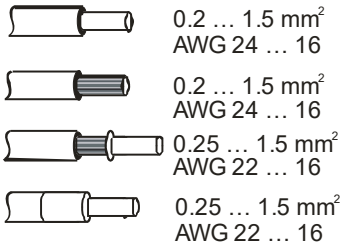


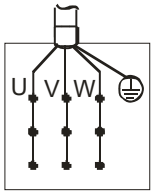
❶ With a mains current above 10 A, the mains power connection 230 V 1ph/N/PE and the mains power connection 230 V 2ph/N/PE are to be done on two terminals.

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

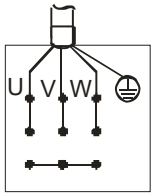


Phoenix ZEC 1,5/ .. ST7,5

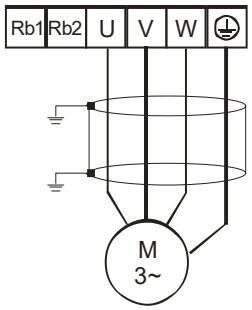




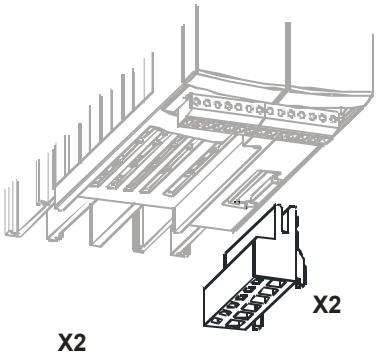
Delta connection



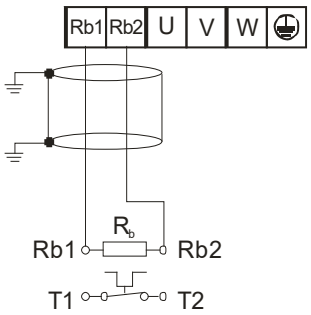
Star connection



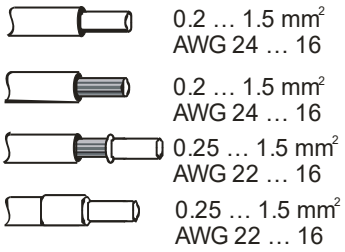
Connection of brake resistor with temperature switch



X2



Phoenix ZEC 1,5/ .. ST7,5



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

WARNING

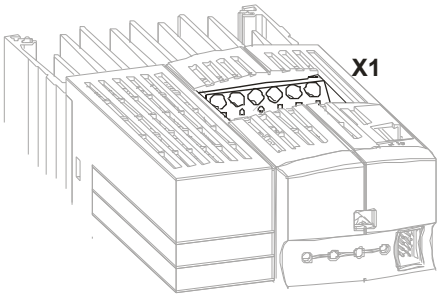
Dangerous voltage!

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

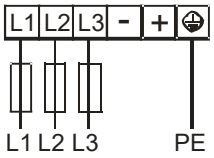
- at least 3 minutes in sizes 1 through 7 and
- at least 10 (in some configurations up to 25) minutes after shutdown in size 8. The valid waiting period is indicated on the device housing.

- 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.

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



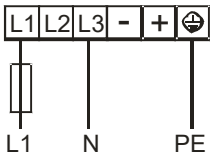
X1



3ph / 230V AC
3ph / 400V AC

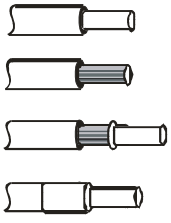
ACTIVE Cube 210-18 (4.0 kW):

X1



1ph / 230V AC

4.0 kW … 9.2 kW
6qmm / RM7,5



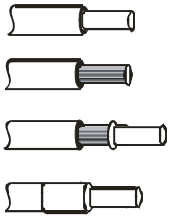
0.2 … 6 mm²
AWG 24 … 10

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

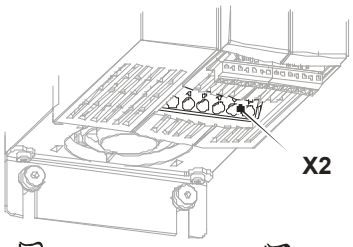
0.2 … 16 mm²
AWG 24 … 6

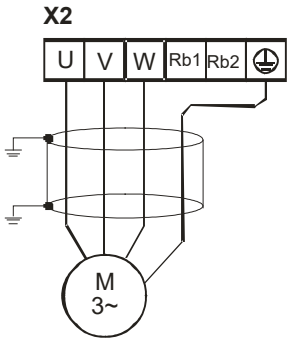
0.25 … 10 mm²
AWG 22 … 8

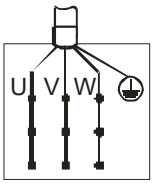
0.25 … 10 mm²
AWG 22 … 8

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

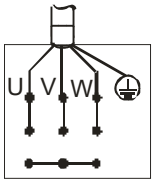
Motor connection ANG 210 (4.0 to 9.2 kW) and 410 (5.5 to 15.0 kW)







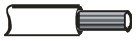
Delta connection



Star connection

4.0 kW … 9.2 kW
6qmm / RM7,5


0.2 … 6 mm²
AWG 24 … 10

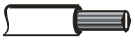

0.2 … 6 mm²
AWG 24 … 10


0.25 … 4 mm²
AWG 22 … 12


0.25 … 4 mm²
AWG 22 … 16

11.0 kW … 15.0 kW
16qmm / RM10+15

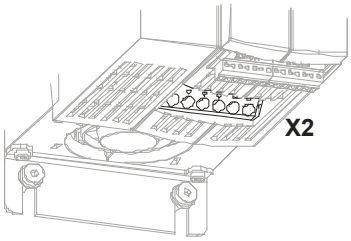

0.2 … 16 mm²
AWG 24 … 6

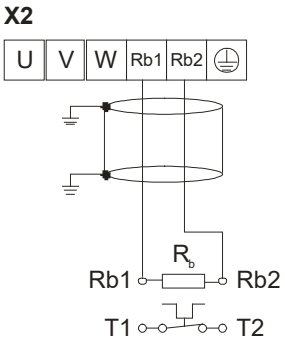

0.2 … 16 mm²
AWG 24 … 6


0.25 … 10 mm²
AWG 22 … 8


0.25 … 10 mm²
AWG 22 … 8

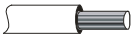
Connection of brake resistor with temperature switch

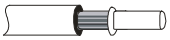


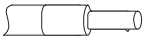


4.0 kW … 9.2 kW
6qmm / RM7,5


0.2 … 6 mm²
AWG 24 … 10

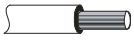

0.2 … 6 mm²
AWG 24 … 10

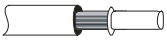

0.25 … 4 mm²
AWG 22 … 12

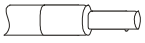

0.25 … 4 mm²
AWG 22 … 16

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

7.5.3 Size 5: ANG 410 (18.5 to 30.0 kW)

WARNING

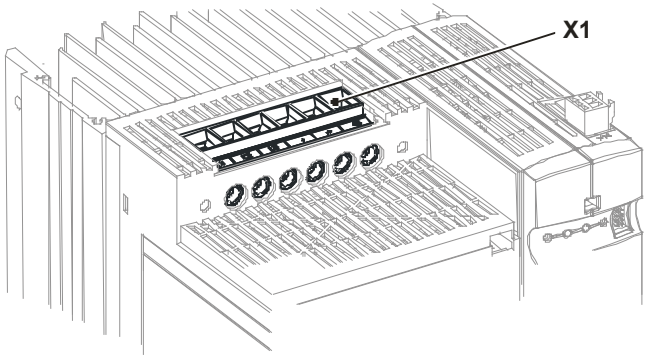
Dangerous voltage!

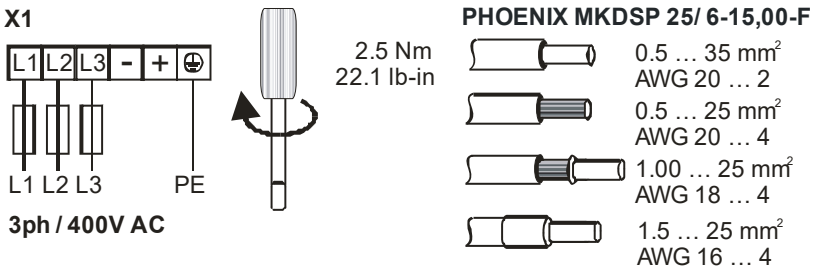
When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The time to wait is

- at least 3 minutes in sizes 1 through 7 and
- at least 10 (in some configurations up to 25) minutes after shutdown in size 8. The valid waiting period is indicated on the device housing.

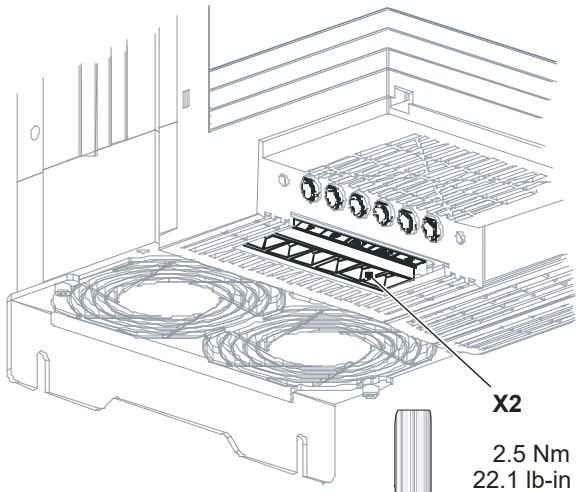
- The electrical installation must be carried out by qualified electricians according to the general and regional safety and installation directives.
- The documentation and device specification must be complied with during installation.
- Before any assembly or connection work, discharge the frequency inverter.
- Verify safe isolation from power supply.

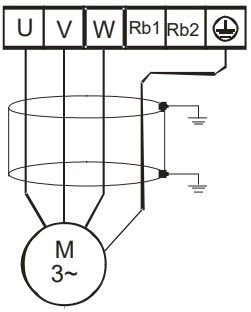
Mains connection ANG 410 (18.5 to 30.0 kW)



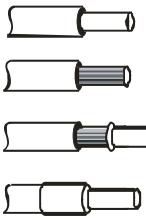


Motor connection ANG 410 (18.5 to 30.0 kW)

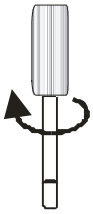




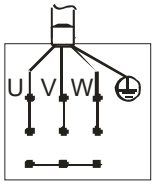
18.5 kW … 30 kW
25/ 6-15,00



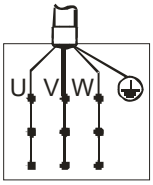
0.5 … 35 mm² AWG 20 … 2
0.5 … 25 mm² AWG 20 … 4
1.00 … 25 mm² AWG 18 … 4
1.5 … 25 mm² AWG 16 … 4



2.5 Nm
22.1 lb-in

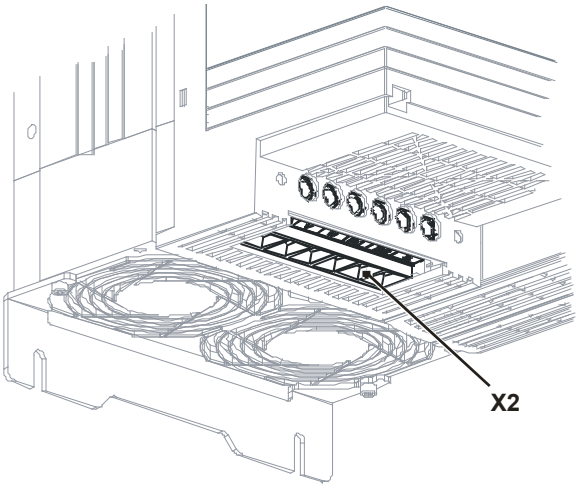


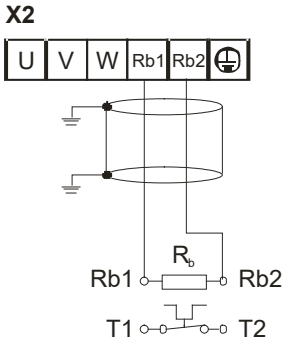
Star connection



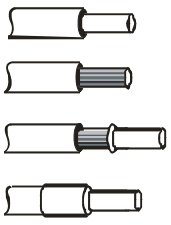
Delta connection

Connection of brake resistor with temperature switch

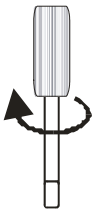




18.5 kW … 30 kW
25/ 6-15,00



0.5 … 35 mm² AWG 20 … 2
0.5 … 25 mm² AWG 20 … 4
1.00 … 25 mm² AWG 18 … 4
1.5 … 25 mm² AWG 16 … 4



2.5 Nm
22.1 lb-in

7.5.4 Size 6: ANG 410 (37.0 to 65.0 kW)

WARNING

Dangerous voltage!

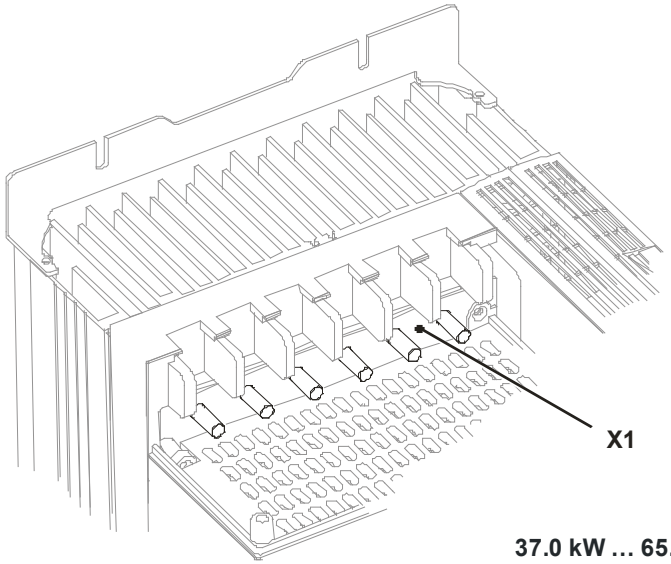
When the frequency inverter is disconnected from power supply, the mains, DC-link voltage and motor terminals may still be live for some time. Work at the device may only be started once the DC link capacitors have discharged. The time to wait is

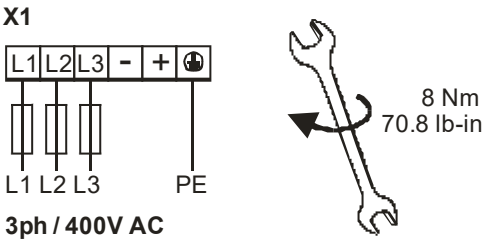
- at least 3 minutes in sizes 1 through 7 and
- at least 10 (in some configurations up to 25) minutes after shutdown in size 8. The valid waiting period is indicated on the device housing.

- 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.

The following illustrations show the air-cooled variant of an ANG 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.

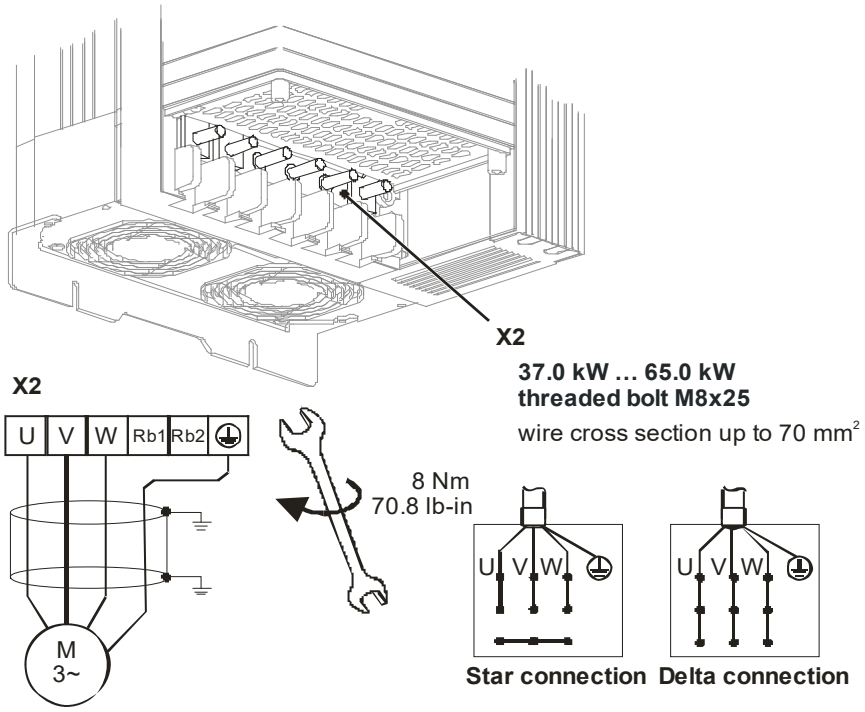
Mains connection ANG 410 (37.0 to 65.0 kW)



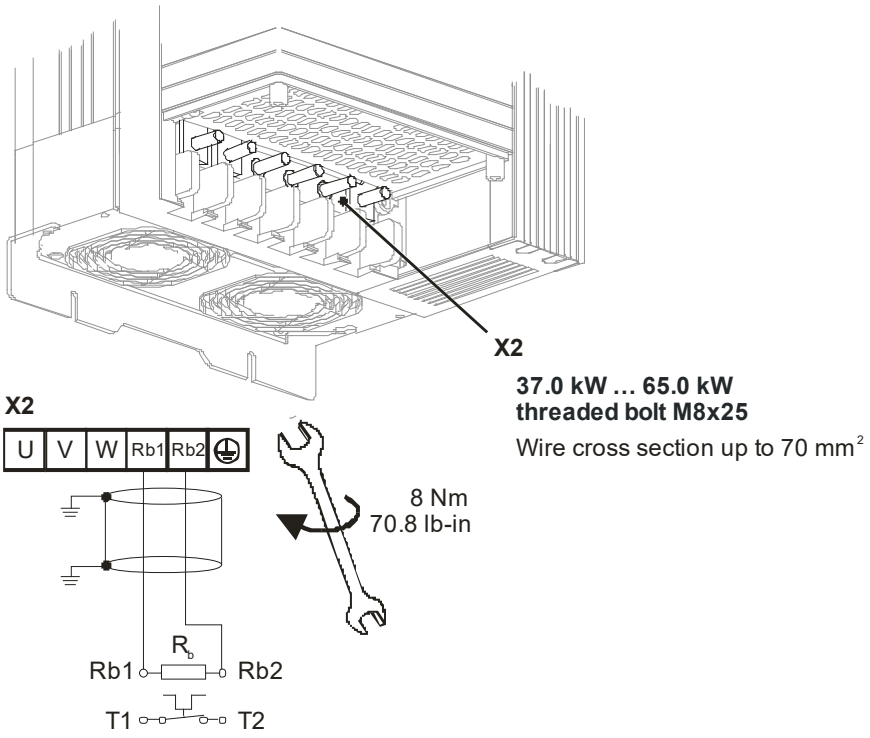


37.0 kW ... 65.0 kW
threaded bolt M8x25
wire cross section up to 70 mm^2

Motor connection ANG 410 (37.0 to 65.0 kW)



Connection of brake resistor with temperature switch



Optionally, the inverters in this size can be purchased without brake chopper and are then not provided with the terminal Rb2 for a brake resistor connection.

7.5.5 Size 7: ANG 410 (75.0 to 200.0 kW)

WARNING

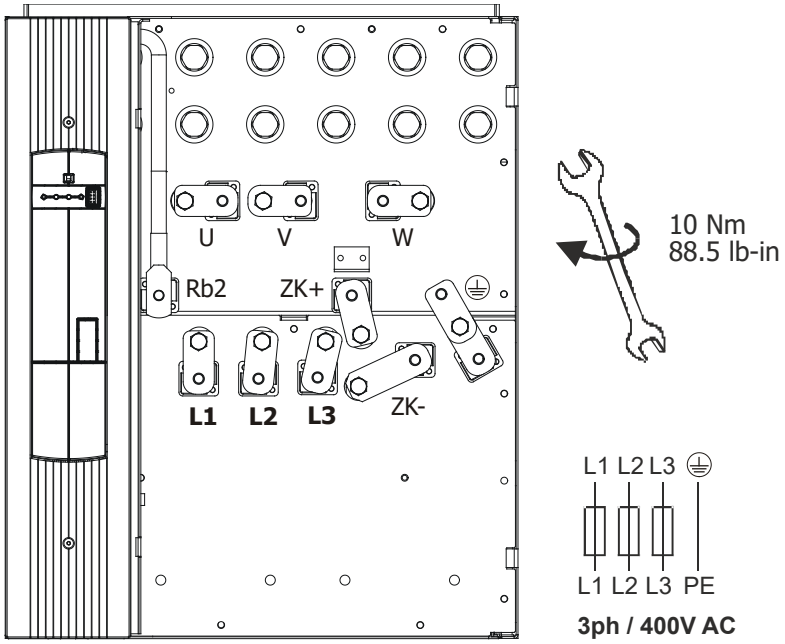
Dangerous voltage!

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 sizes 1 through 7 and
- at least 10 (in some configurations up to 25) minutes after shutdown in size 8. The valid waiting period is indicated on the device housing.

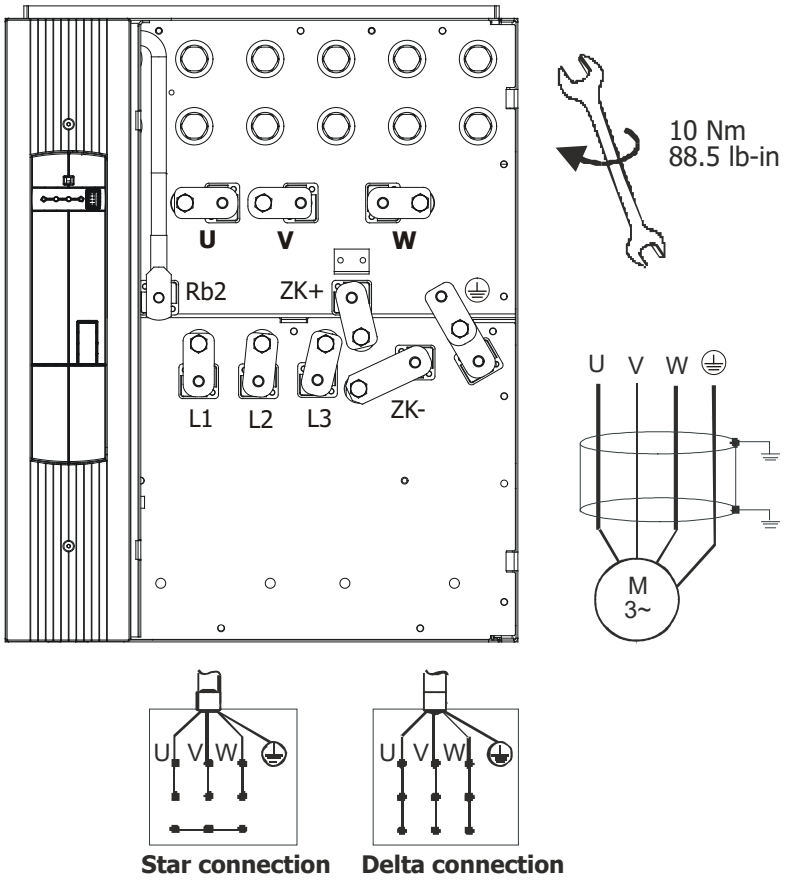
- The electrical installation must be carried out by qualified electricians according to the general and regional safety and installation directives.
- The documentation and device specification must be complied with during installation.
- Before any assembly or connection work, discharge the frequency inverter.
- Verify safe isolation from power supply.

Mains connection ANG 410 (75.0 to 132 kW)



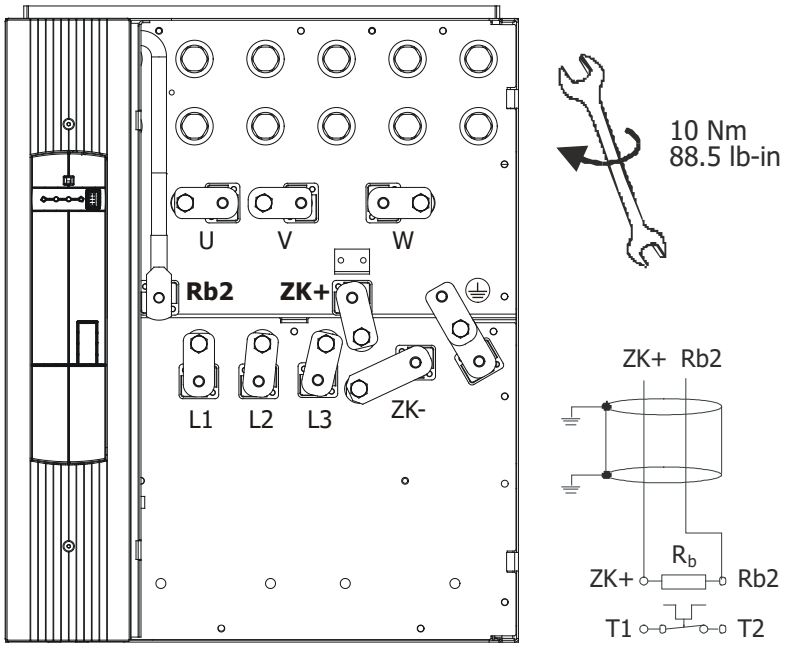
Threaded bolt M8x20

Motor connection ANG 410 (75.0 to 132 kW)



Threaded bolt M8x20

Connection of brake resistor with temperature switch



Threaded bolt M8x20

Optionally, the inverters in this size can be purchased without brake chopper and are then not provided with the terminal Rb2 for a brake resistor connection.

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

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 sizes 1 through 7 and
- at least 10 (in some configurations up to 25) minutes after shutdown in size 8. The valid waiting period is indicated on the device housing.

- 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.

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

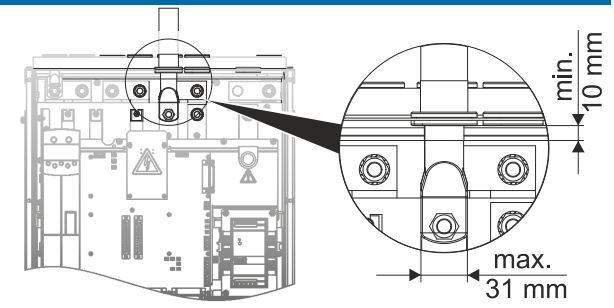
IP20 ingress protection rating is only achieved with terminals plugged and properly mounted covers. Improperly mounted covers lead to ingress of dirt or foreign objects into the housing of the device and might lead to malfunctions.

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

NOTICE

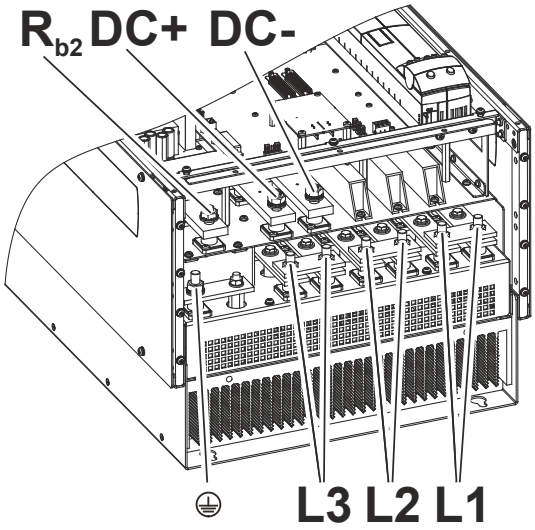
When connecting to mains, note:

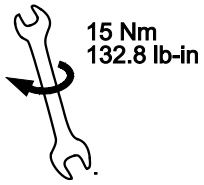
- Max. width of cable lugs: 31 mm
- Min. length of insulation under cable gland: 10 mm



Mains connection ANG 410/510/610 (160.0 to 400.0 kW)

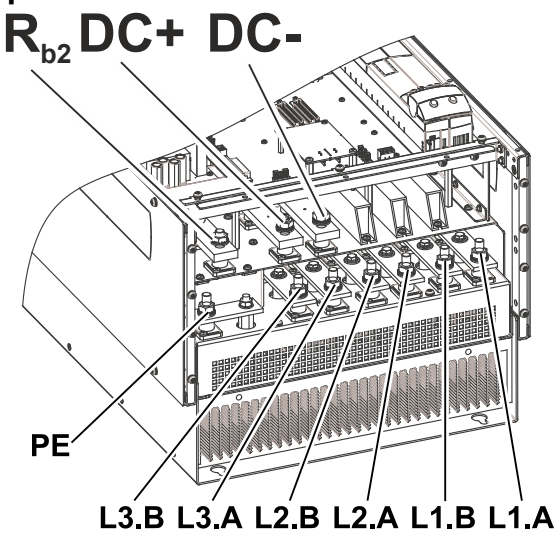
3 phases:

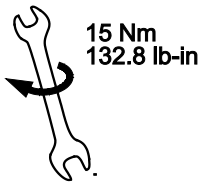




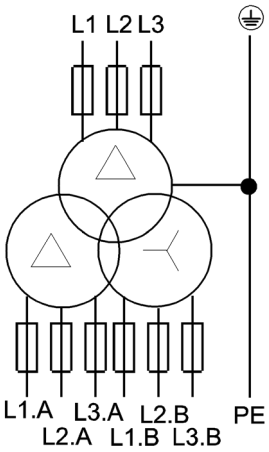
Threaded bolt M10x20

6 phases:



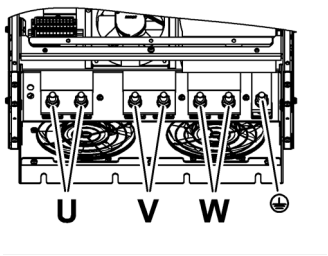


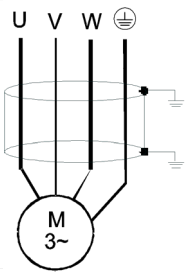
Threaded bolt M10x20

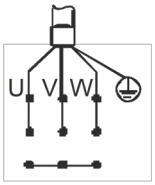


ANG 410: 6ph/400V AC
ANG 510: 6ph/525V AC
ANG 610: 6ph/690V AC

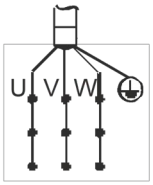
Motor connection ANG 410 (160.0 to 400.0 kW)



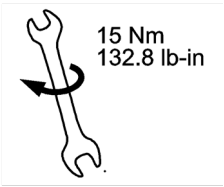




Star connection

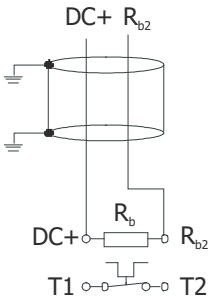


Delta connection



Threaded bolt M10x20

Connection of braking resistor with temperature switch



Optionally, the inverters in this size can be purchased without brake chopper and are then not provided with the terminal Rb2 for a brake resistor connection.

7.6 Control Terminals

The control and software functionality can be configured as required 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.

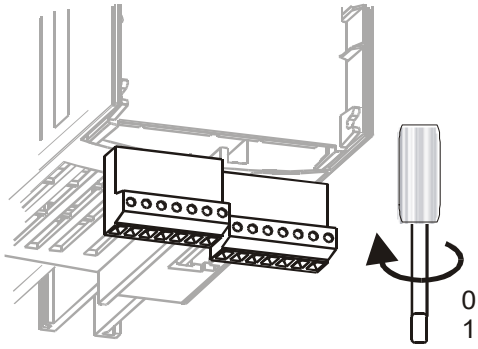
CAUTION

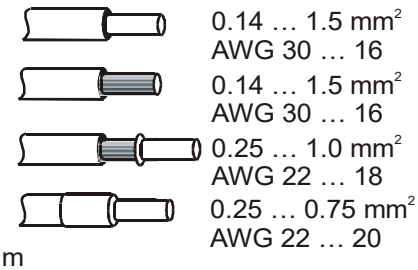
Live voltage

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.

Control Terminals





0.2 … 0.3 Nm
1.8 … 2.7 lb-in

Control terminal X210A

Ter.	Description
1	- Voltage output 20 V, I_{max}=130 mA [1] or - input for external power supply DC 24 V ±10%
2	GND 20 V and GND 24 V (ext.)
3	Digital signal, STOA (1st shutdown path for safety function STO – „Safe Torque Off "), U_{max}=DC 30 V, 10 mA at DC 24 V, input resistance: 2.5 kΩ, PLC compatible, response time approx. 10 ms
4	Digital input S2IND, U_{max}=30 V, 10 mA at DC 24 V, Input resistance: 2.5 kΩ, PLC compatible, response time approx. 2 ms
5	Digital input S3IND, U_{max}=30 V, 10 mA at DC 24 V, Input resistance: 2.5 kΩ, PLC compatible, response time approx. 2 ms
6	Digital input S4IND, U_{max}=30 V, 10 mA at DC 24 V, Input resistance: 2.5 kΩ, PLC compatible, frequency signal: 0...30 V, 10 mA at 24 V, f_{max} = 150 kHz
7	Digital input S5IND, U_{max}=30 V, 10 mA at DC 24 V, Input resistance: 2.5 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} = 130 mA. The maximum current available is reduced by the digital output MF3 and multifunctional output MFO1.

Control terminal X210B

Ter.	Description
1	Digital input S6IND, U_{max}=30 V, 10 mA at 24 V, input resistance: 2.5 kΩ, PLC compatible, response time approx. 2 ms
2	Digital input STOB (2nd shutdown path for function "Safe Torque Off"), U_{max}=30 V, 10 mA at 24 V, input resistance: 2.5 kΩ, PLC-compatible, response time approx. 10 ms
3	Digital output MF3, U=24 V, I_{max}=50 mA, overload and short-circuit proof Digital input S8IND, U_{max}=30 V, 10 mA at 24 V, input resistance: 2.5 kΩ, PLC compatible, response time approx. 2 ms

Control terminal X210B	
Ter.	**Description**
4	Multi-function output MFO1, Digital input MF2ID, U_{max}=30 V, 10 mA at 24 V, input resistance: 2.5 kΩ, PLC compatible, response time approx. 2 ms Digital output: U=24 V, I_{max}=50 mA, overload and short-circuit proof Analog output: U=24 V, I_{max}=50 mA, pulse-width modulated, f_{PWM}=116 Hz Frequency output: 0...24 V, I_{max}=50 mA, f_{max}=150 kHz
5	Reference output 10 V, I_{max}=4 mA
6	Multi-Function Input MFI1, Analog signal: resolution 12 Bit, 0...+10 V, ±10 V (Ri= 73,5 kΩ), 0...20 mA (Ri= 249 Ω), Digital signal: response time approx. 4 ms, U_{max} = 30 V, 4 mA at 24 V, PLC compatible, PTC, PT1000 and KTY
7	Ground / GND 10 V

	Level:
Digital inputs (X210A.3 ... X210B.4)	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.

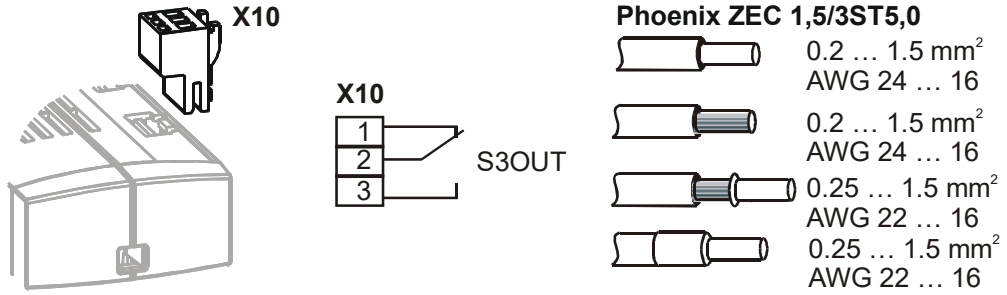
Requirements to be met by external power supply	
Input voltage range	DC 24 V ±10%
Rated input current	Max. 1.0 A (typical 0.45 A)
Peak inrush current	Typical: < 20 A
External fuse	Via standard fuse elements for rated current, characteristic: slow
Safety	Safety extra low voltage (SELV) according to EN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

Comply with the application manual "Safe Torque Off – STO", especially if you apply this safety-related function.

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.

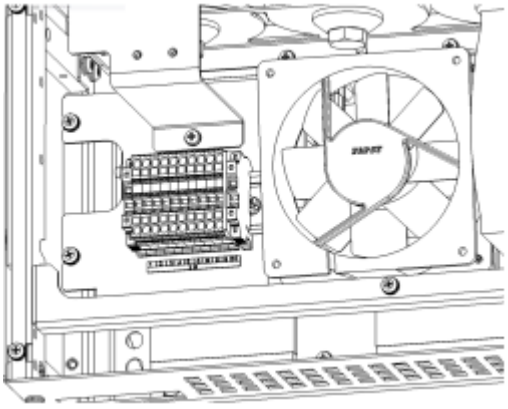
Relay Output



Control terminal X10	
Ter.	**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 ANG 510 and ANG 610

When an ANG 510 or ANG 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 ANG 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 configuration, refer to sections 14.6 "Motor Temperature" and 16.4.5 "Thermo contact".

7.9 Control terminals – Connection diagrams of configurations

WARNING

Safety functions failure

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 parameter *Configuration* **30.** The configurations are described in the following section.

The units of the ANG series feature the function STO ("Safe Torque Off"). If this function is not required, the "Controller release" signal must be connected to inputs MF4ID/STOA and S7IND/STOB.
Inputs MF4ID/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:

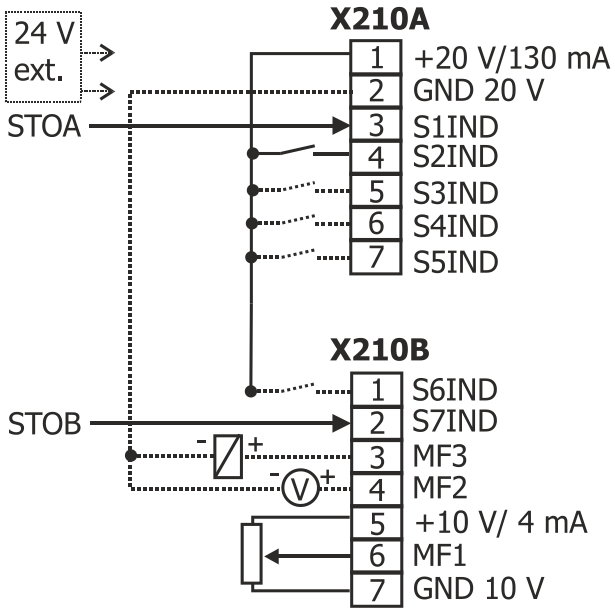
Function	V/f	Sensorless vec	Speed con-trolled	Servo	Sensorless Servo
Standard	110	410	210	510	610
Technology Controller	111	411	211	511	611
Electronic gear with posi-tion controller [1)]	115	415	215	515	
Electronic gear + index controller [1)]	116		216	516	
Torque control		430	230	530	630
Positioning [2)]		440	240	540	640
Brake control [3)]	160	460	260	560	

Please also comply with the following manuals:
1) Application Manual: Electronic Gear, Position Control and Index Control
2) Application Manual: Positioning
3) Application Manual: Lifting Gear Drives and Load Estimation

The control methods 2xx can be used with **HTL** sensors (with or without reference track) connected to the basic device.
The control methods 2xx with **TTL**, resolver signals (control method 5xx) or absolute encoders (Hiperface, EnDat2.1, SSI) require an expansion module type EM-AUT.

7.10.1 Configuration 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.

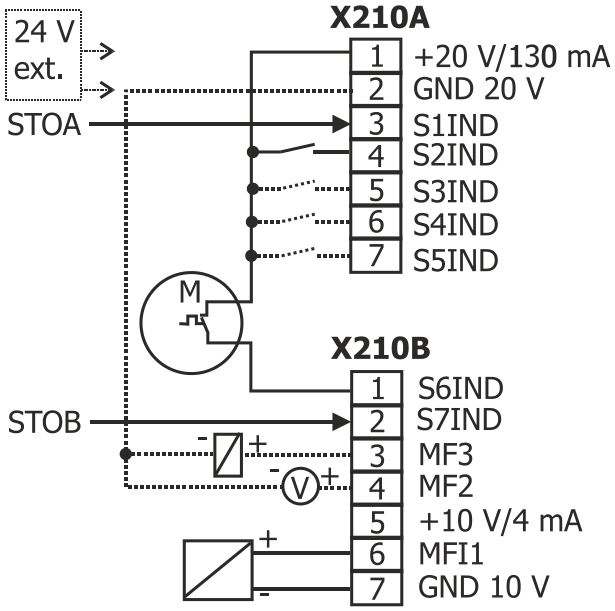


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Data set change-over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

Control terminal X210B	
X210B.1	Motor 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 +10V for reference value potentiometer
X210B.6	Reference speed 0 ...+10 V
X210B.7	Ground 10 V

7.10.2 Configuration 111 – Sensorless Control with 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.



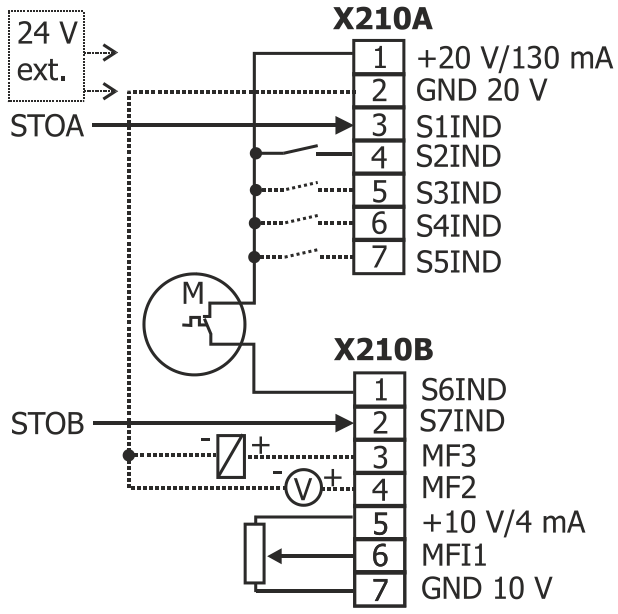
Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Fixed percentage value change-over 1
X210A.5	Fixed percentage value change-over 2
X210A.6	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 +10V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.3 Configuration 210 – Field-Oriented Control (FOC), Speed Controlled

The control methods 2xx can be used with **HTL** sensors (with or without reference track) connected to the basic device.
The control methods 2xx with **TTL** sensors and evaluation of Absolute encoders (Hiperface, EnDat2.1, SSI) require an expansion module.

Configuration 210 contains the functions for speed-controlled, field-oriented control of an asynchronous 3-phase machine with speed sensor feedback.

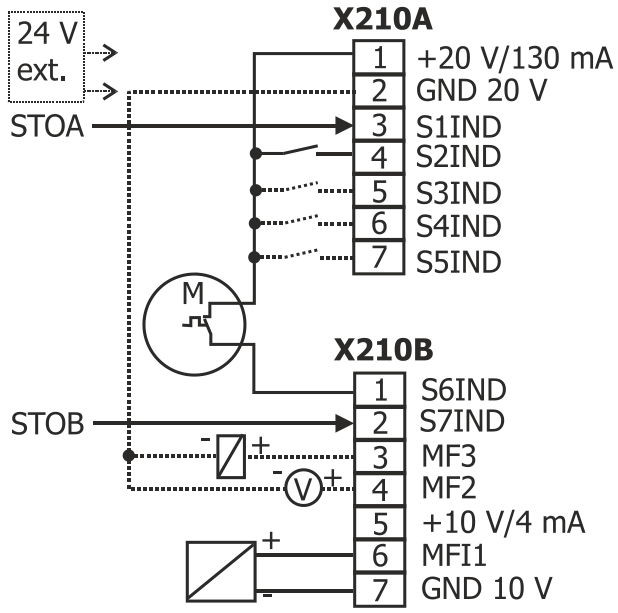


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input **STOA** (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Speed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

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 +10V for reference value potentiometer
X210B.6	Reference speed 0 ...+10 V
X210B.7	Ground 10 V

7.10.4 Configuration 211 – Field-Oriented Control (FOC) with Technology Controller

Configuration 211 extends the functionality of the speed-controlled, field-oriented control of Configuration 210 by a Technology Controller.

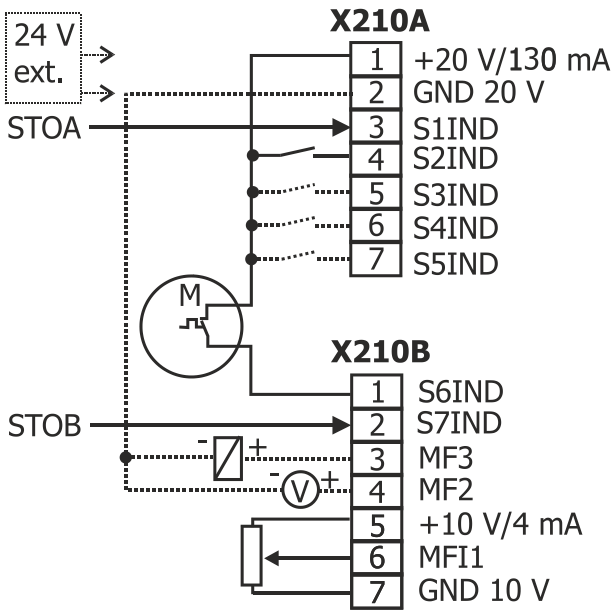


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Fixed percentage value change-over 1
X210A.5	no function assigned
X210A.6	Speed sensor track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

Control terminal X210B	
X210B.1	Motor 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 +10V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.5 Configuration 230 – Field-Oriented Control (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.

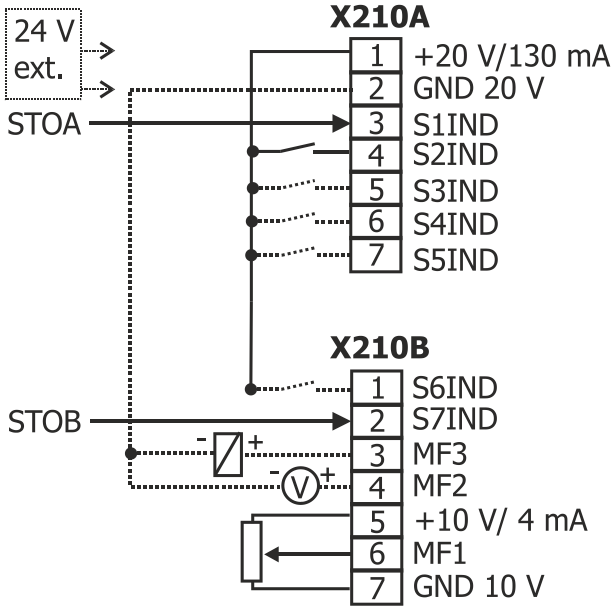


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	n-/M change-over control function
X210A.6	Speed sensor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

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 frequenc
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10
X210B.7	Ground 10 V

7.10.6 Configuration 410 – Sensorless Field-Oriented Control

Configuration 410 contains the 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.

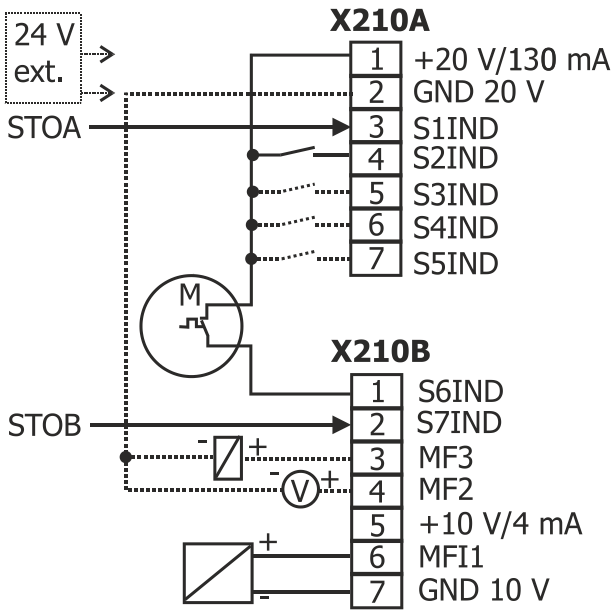


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Data set change-over 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
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10V for reference value potentiometer
X210B.6	Reference speed 0 ...+10 V[1)]
X210B.7	Ground 10 V

7.10.7 Configuration 411 – Sensorless FOC with Technology Controller

Configuration 411 extends the functionality of the sensorless field-oriented control of Configuration 410 by a Technology Controller.

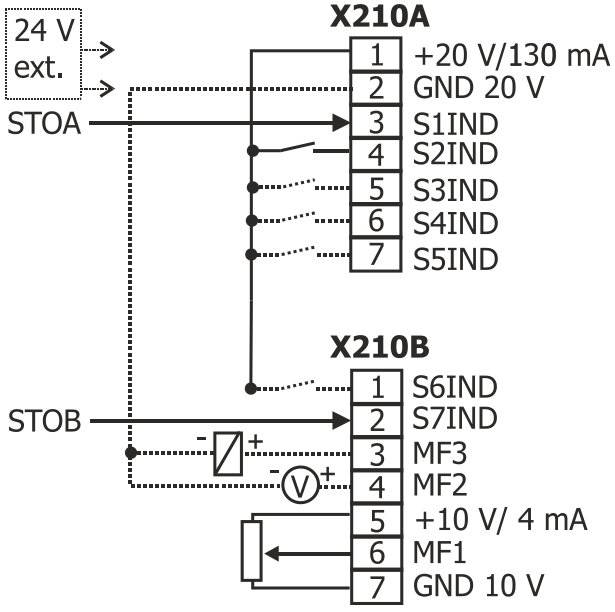


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Fixed percentage value change-over
X210A.5	No function assigned
X210A.6	Data set change-over 1
X210A.7	Data set change-over 2

Control terminal X210B	
X210B.1	Motor 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 +10V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.8 Configuration 430 – Sensorless FOC, Speed and Torque Controlled

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.



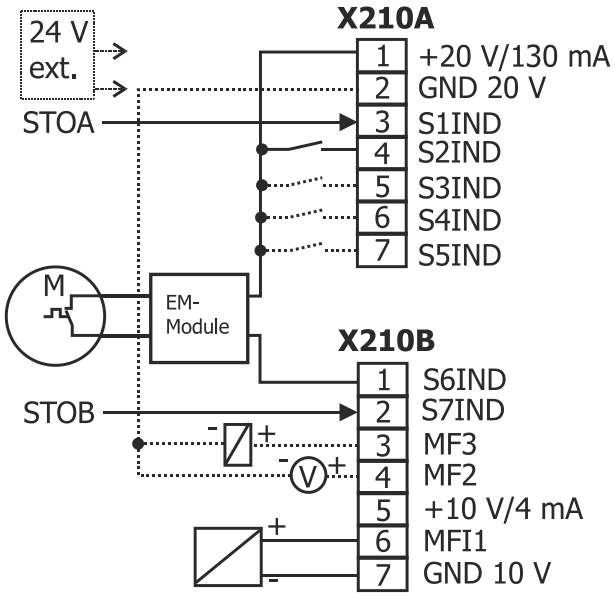
Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	n-/M change-over control function
X210A.6	Data set 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
X210B.7	Ground 10 V

7.10.9 Configuration 510 – FOC of Synchronous Machine, Speed Controlled

The expansion module EM-AUT-XX for evaluation of resolver signals is required for operation of a synchronous machine (control method 5xx).
An expansion module EM-AUT is required for evaluation of Absolute encoders (Hiperface, EnDat2.1, SSI).
Comply with the operating instructions for the expansion module for the connection of the resolver or absolute encoder.

Configuration `510` contains the functions for speed-controlled, field-oriented control of a synchronous machine with resolver feedback.



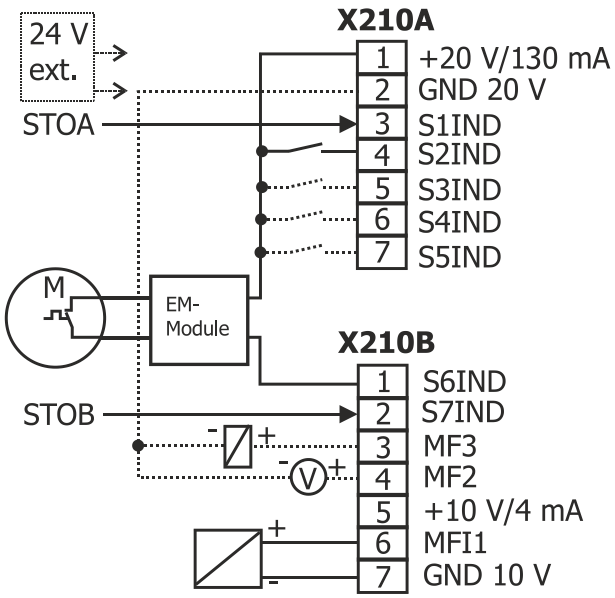
Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation
X210A.6	Data set change-over 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
X210B.4	Analog signal of actual frequency
X210B.5	Supply voltage +10V for reference value potentiometer
X210B.6	Reference speed 0 ...+10V
X210B.7	Ground 10 V

7.10.10 Configuration 511–FOC of Sync. Machine w. Tec Controller

The expansion module EM-AUT-XX for evaluation of resolver signals is required for operation of a synchronous machine (control method 5xx).
An expansion module EM-AUT is required for evaluation of Absolute encoders (Hiperface, EnDat2.1, SSI).
Comply with the operating instructions for the expansion module for the connection of the resolver or absolute encoder.

Configuration `511` extends the functionality of the field-oriented control of Configuration `510` by a Technology Controller.

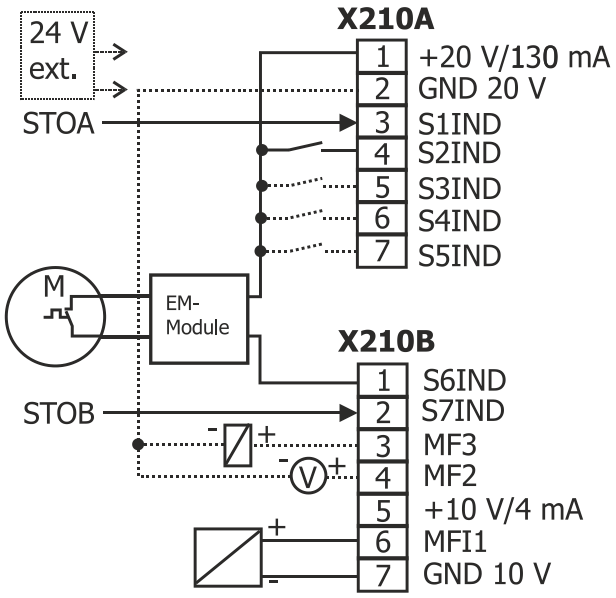


Control terminal X210A	
X210A.1	Voltage output +20 V or input for external power supply DC 24 V ±10%
X210A.2	GND 20 V/ GND 24 V (ext.)
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Fixed percentage value change-over 1
X210A.5	no function assigned
X210A.6	Data set change-over 1
X210A.7	Data set change-over 2

Control terminal X210B	
X210B.1	Motor 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 +10V
X210B.6	Actual percentage value 0 ...+10 V
X210B.7	Ground 10 V

7.10.11 Configuration 530 – FOC of Sync. Machine, Speed and Torque 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.



[1] Control terminals are freely configurable.

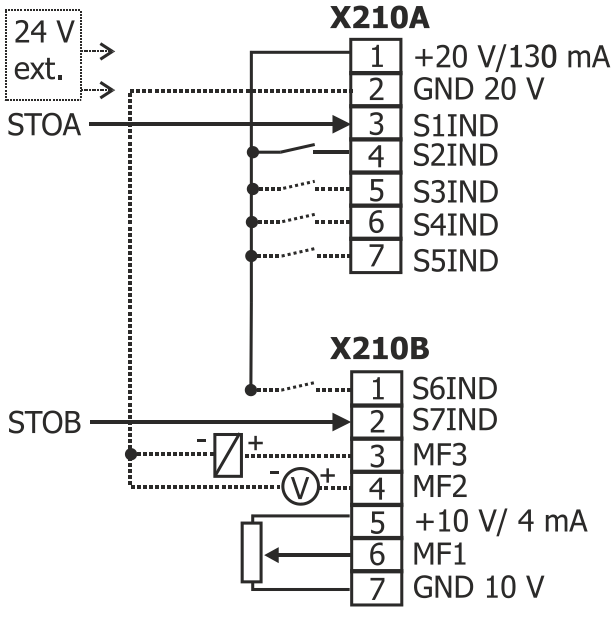
The overview shows default parameters only.

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.) [1]
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[1]
X210A.6	Data set change-over 1[1]
X210A.7	Data set change-over 2[1]

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[1]
X210B.5	Supply voltage +10 V for reference value potentiometer
X210B.6	Reference speed 0 ...+10V
X210B.7	Ground 10 V

7.10.12 Configuration 610 – Sensorless FOC of Sync. Machine, Speed Controlled

Configuration 610 contains the functions for speed-controlled, field-oriented control of a synchronous machine without resolver feedback. The separate control of torque and flux-forming current enables high drive dynamics with a high load moment. The missing resolver feedback compared to configuration 510 results in a small loss of dynamic and speed performance. Also refer to chapter 7.2 for details.



[1] Control terminals are freely configurable.

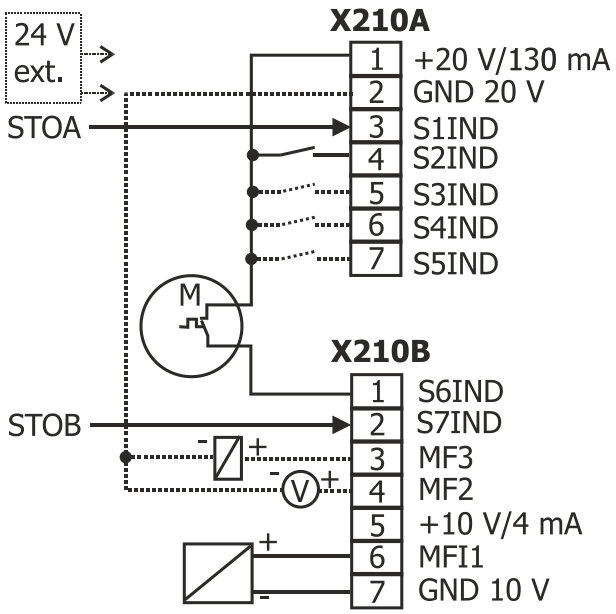
The overview shows default parameters only.

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.) [1]
X210A.3	Digital input STOA (1st shutdown path of safety function STO)
X210A.4	Start of clockwise operation
X210A.5	Start of anticlockwise operation[1]
X210A.6	Data set change-over 1[1]
X210A.7	Data set change-over 2[1]

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

7.10.13 Configuration 611 – Sensorless FOC of Sync. Machine w. Technology Controller

Configuration 611 extends the functionality of the sensorless field-oriented control 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. Also refer to chapter 7.2 for details.



[1] Control terminals are freely configurable.

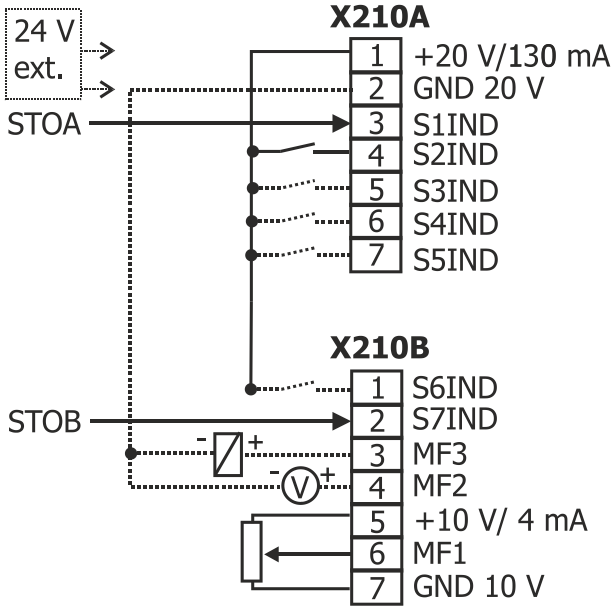
The overview shows default parameters only.

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	Fixed percentage value change-over
X210A.5	no function assigned[1]
X210A.6	Data set change-over 1[1]
X210A.7	Data set change-over 2[1]

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

7.10.14 Configuration 630 – Sensorless FOC of Sync. Machine, Speed and Torque 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. Also refer to chapter 7.2 for details.



[1] Control terminals are freely configurable.
The overview shows default parameters only.

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[1]
X210A.5	n-/M change-over control function[1]
X210A.6	Data set change-over 1[1]
X210A.7	Data set change-over 2[1]

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

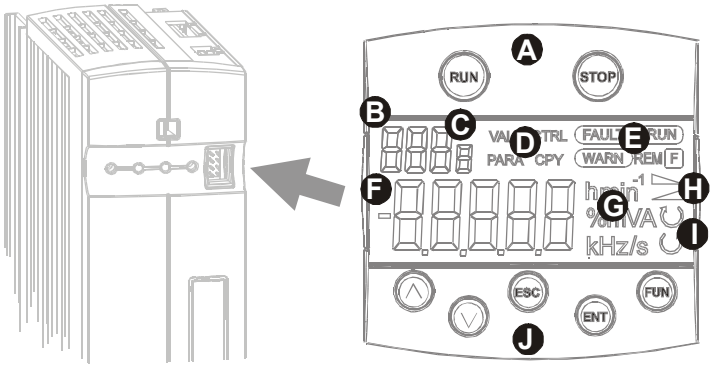
Suitable For Use On A Circuit Capable Of Delivering Not More Than 18 kA rms Symmetrical Amperes, 480 V AC Maximum when protected by Semiconductor fuses Types 170M5* made by Cooper Bussmann LLC.

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.

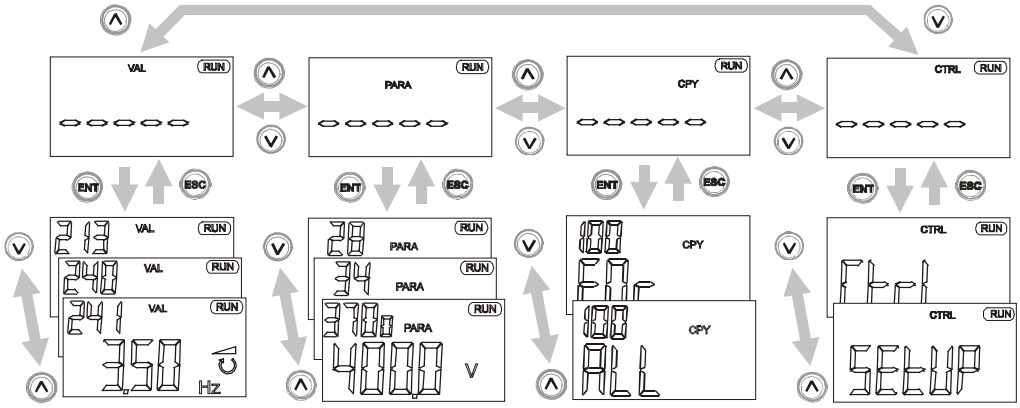


Keys		
A	RUN	Used for starting the drive and opening the CTRL menu. Press the RUN key to open the motor potentiometer function.
	STOP	Used for opening the CTRL menu, stopping the drive and acknowledging faults.
J	▲ ▼	Used for navigating in the menu structure and selecting parameters. Increasing/decreasing of parameter values.
	ENT	Used for opening parameters or switching to another menu within the menu structure. Confirmation of the selected function or the set parameter.
	ESC	Used for aborting parameters or switching back to the previous menu within the menu structure. Canceling the function or resetting the 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 of the selected menu branch:	
	VAL	Display 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 the 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: signals readiness for operation. Lights up: signals that the unit is operating and the output stage is enabled.
	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 the parameter value displayed.	
H	Active acceleration or deceleration ramp.	
I	Current direction of rotation of the drive.	

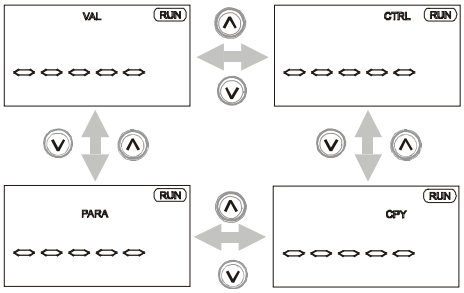
8.1 Menu Structure

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

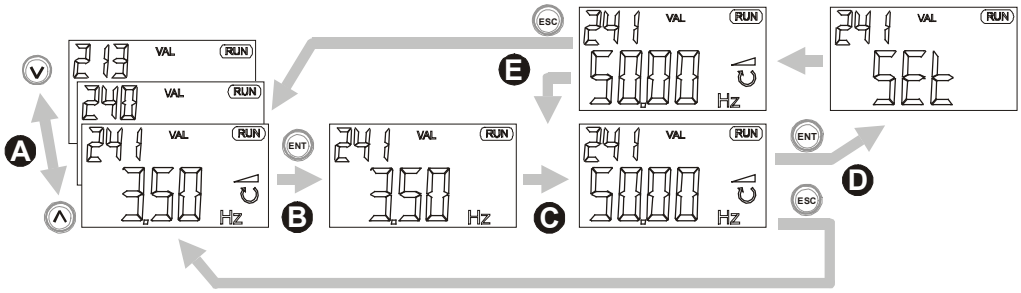
- Use the arrow keys to select the required menu branch. The selected menu branch is displayed (flashing).
- Select the menu branch by pressing the ENT key. The first parameter or the first function in the selected menu branch will be displayed.

If you press the ESC key you will return to the main menu of the control unit.

Keys	
▲ ▼	Navigate through the menu structure and select a menu branch.
ENT	Open the selected menu branch.
ESC	Cancel the current 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. If the highest parameter number is achieved, actuating the ▲-key displays the lowest parameter number. If the lowest parameter number is achieved, actuating the ▼-key displays the highest parameter number. 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.	
	Keys	
	▲ + ▼	Display the actual value parameter upon switch-on.
	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.

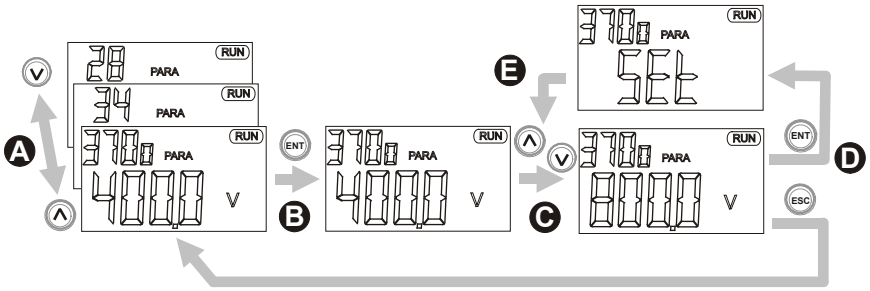
C	During commissioning, operation and error analysis, it is possible to monitor each actual value parameter specifically. Some of the actual value parameters are arranged in the four available data sets. If the parameter values in the four data records are identical, the actual value is displayed in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



Ⓐ	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). If the highest parameter number is achieved, actuating the ▲-key displays the lowest parameter number. If the lowest parameter number is achieved, actuating the ▼-key displays the highest parameter number. Parameter numbers > 999 are displayed hexadecimal at the leading digit (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.	
	Keys	
	▲ + ▼	Change to the last parameter edited.
	FUN , ▲	Display of last parameter (highest number).
	FUN , ▼	Display of first parameter (lowest number).

Ⓑ	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.	

Ⓒ	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.	
	Keys	
	▲ + ▼	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.

Ⓓ	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.

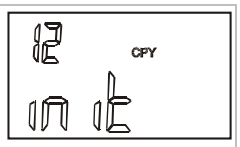
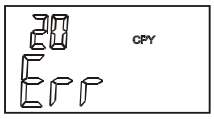
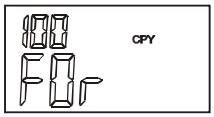
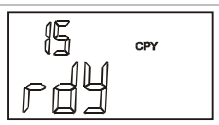
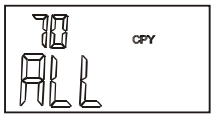
Ⓔ	After saving the parameter, you can edit the value again or return to the parameter selection menu by pressing the ESC key.

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.

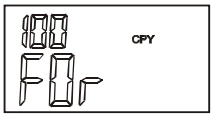
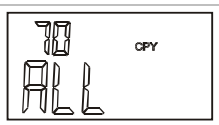
The Copy Menu (CPY) is accessible in control level 3. The control level can be adjusted, if necessary, via parameter *Control Level* **28**.

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 are 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

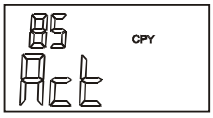
The copy menu CPY contains three main functions. Use the arrow keys to select the required function. Select the source and the destination for the process. The memory space available in the non-volatile memory of the control unit is displayed on the three-digit seven-segment display as a percentage value.

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.

- Confirm the selection Act by pressing the ENT key and continue by 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.

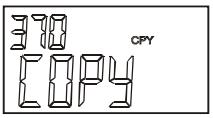
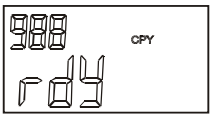
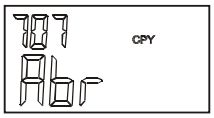
Display		Description
dSt.	0	The four data sets of the frequency inverter are overwritten.
dSt.	1	The data are copied to data set 1 of the frequency inverter.
dSt.	2	The data are copied to data set 2 of the frequency inverter.
dSt.	3	The data are copied to data set 3 of the frequency inverter.
dSt.	4	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)]

Display		Description
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]

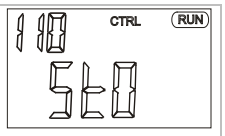
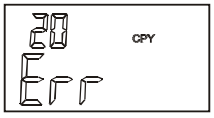
[1] Already existing files will not be offered as copy target.

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. If through the changing of parameters via copying a device fault is triggered, this device fault is displayed after the copying of the parameters is finished.

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 (MF4ID/STOA, S7IND/STOB) 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		
Code		**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.

Error Messages		
Code		**Meaning**
	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 disabled, 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(ming)* **34.** The control unit KP 500 must be connected to the frequency inverter.

Program(ming) 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(ming)* **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 the 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 Expansion module EM-AUT

- Establish connection to frequency inverter.
- Start communication and select *parameter Program(ming)* **34** via the communication interface.
- Via the communication interface enter value `111` in parameter *Program(ming)* **34** and confirm this value.
- Via the communication interface enter value `123` in parameter *Program(ming)* **34** 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 "Copy Menu") 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 processed 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 via 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(ming)* **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 expansion module EM-AUT and/or using control software VPlus

- Establish connection to frequency inverter.
- Start communication and select parameter *Program(ming)* **34** via the communication connection.
- Via the communication connection, enter value `110` in parameter *Program(ming)* **34** and confirm this value.
- Via the communication connection enter value `123` in parameter *Program(ming)* **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)

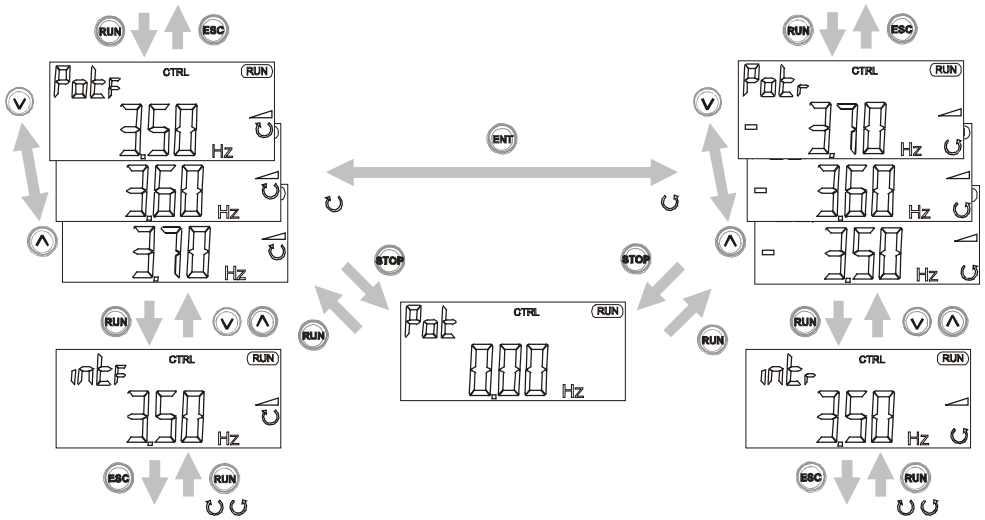
In order to be able to control the drive via the control unit, the digital inputs MF4ID/STOA and S7IND/STOB must be connected for enabling the output.

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 18.3 "Bus controller" for a detailed description of parameter *Local/Remote* **412**.

8.8 Controlling the Motor via the Control Unit

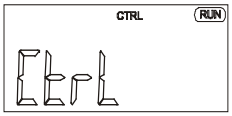
The control unit enables controlling the connected motor in accordance with the selected operation mode of parameter *Local/Remote* **412**.

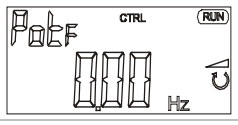
In order to be able to control the drive via the control unit, the digital inputs S1IND/STOA (STOA/terminal X210A.3) and S7IND/STOB (STOB/terminal X210B.2) must be connected for enabling the output. These are the inputs for the shut-down paths of the ST= safety function "Safe Torque Off".



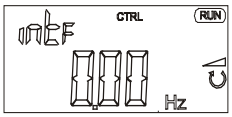
↻↻: When the RUN key was pressed, the drive was in operation already.

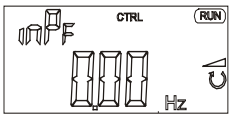
The CTRL menu branch can be accessed via the navigation within the menu structure. The **CtrL** function contains sub-functions which are displayed according to the operating point of the frequency inverter.
Pressing the RUN key leads to a direct change from anywhere within the menu structure to the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



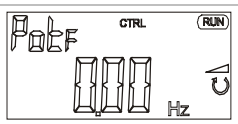


If the drive is already running, the display reads **intF** (forward, clockwise) / intr (reverse, anticlockwise) for the function internal reference value or inPF (forward, clockwise) / inPr (reverse, anticlockwise) for the function „Motorpoti (KP)".
The function „Motorpoti (KP)" enables linking to other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

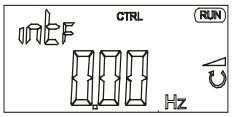




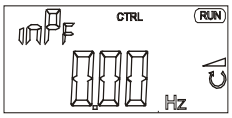
Motor potentiometer function **Pot**
Using the arrow keys, you can adjust the output frequency of the frequency inverter from the *minimum frequency* **418** to the *maximum frequency* **419**. The acceleration corresponds to the factory setting (2 Hz/s) for the parameter *Ramp Keypad-Motorpoti* **473**. The parameters *Acceleration (clockwise)* **420** and *Deceleration (clockwise)* **421** are taken into account with lower acceleration figures.



Internal reference value **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.

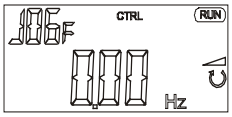


Function Motorpoti (KP) **inP**
Using the arrow keys, you can adjust the output frequency of the frequency inverter from *Minimum frequency* **418** to *Maximum frequency* **419**. The frequency value adjusted via the control unit can be linked to other reference values via the *Reference frequency source* **475** (Chapter „Reference frequency source" and „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 frequency value last adjusted is saved as the *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 set point int or motor potentiometer function Pot to JOG frequency; the 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.

9 Commissioning of the 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. If all electrical connections are correct, make sure that the frequency inverter is not enabled (check if inputs MF4ID/STOA and S7IND/STOB are low). 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. You must carry out the guided commissioning procedure with cool machine because part of the machine data depends on the operating temperature.

NOTICE

In For control of a synchronous machine and successful setting of parameter *Configuration* **30** to "510 - FOR syn. speed control", the guided commissioning must be stopped after the message "SEtUP" by pressing the ESC key in order to set parameter *Offset* **382** first.

- To do this, proceed according to the operating instructions for the expansion module EM-AUT installed.

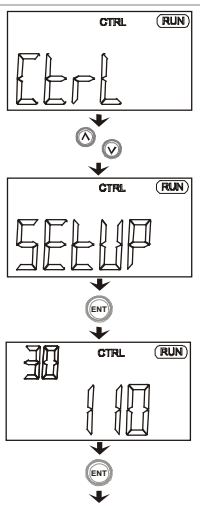
When the unit is in "as-delivered" condition, the guided commissioning procedure is started automatically. After successful commissioning, the guided commissioning can be carried out again later via the sub-menu CTRL, and the function can be called again.

- 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 key 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.

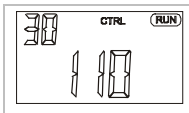


- Switch to the next parameter.
- After initialization, confirm the selected configuration by pressing the ENT key.
- Continue the guided commissioning procedure according to the following chapters.

9.2.1 Configuration

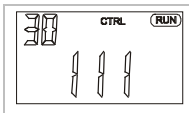
Parameter *Configuration* **30** determines the assignment and basic function of the control inputs and outputs as well as the software functions. The software of the frequency inverter offers several configuration options. These differ with respect to the way in which the drive is controlled. Analog and digital inputs can be combined and complemented by optional communication protocols as further reference value sources. The operating instructions describe the configurations and the relevant parameters in the third *Control level* **28** (adjustment of 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)**



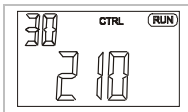
Configuration 110, sensorless control

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 V/f characteristic in accordance with the voltage/frequency ratio.



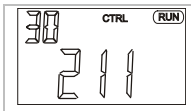
Configuration 111, sensorless control with technology controller

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.



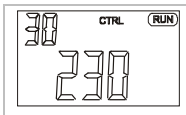
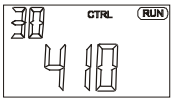
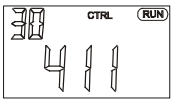
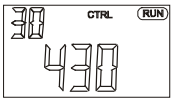
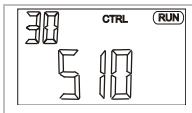
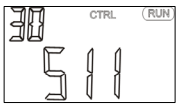
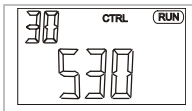
Configuration 210, field-oriented control

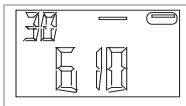
Configuration 210 contains the functions for speed-controlled, field-oriented control of a 3-phase machine with speed sensor feedback. The separate control of torque and flux-forming current enables high drive dynamics with a high load moment. The necessary speed sensor feedback results in a precise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



Configuration 211, field-oriented control with technology controller

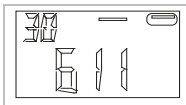
Configuration 211 extends the functionality of Configuration 210 by a Technology Controller. The Technology Controller enables a control based on parameters such as flow rate, pressure, filling level or speed.

	**Configuration 230, field-oriented control with speed/torque control** 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. The switch-over between variable-speed control and torque-dependent control is done without jerk in operation.
	**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, sensorless field-oriented control with 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, sensorless field-oriented control with speed/torque control** 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. The switch-over between variable-speed control is done without jerk in operation.
	**Configuration 510, field-oriented control of synchronous machine, 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 dynamics with a high load moment. The necessary speed sensor feedback results in a precise speed and torque performance.
	**Configuration 511, Field-Oriented Control of a Synchronous Machine with Technology Controller** Configuration 511 extends the functionality of the field-oriented control 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, field-oriented control of synchronous machine with speed/torque control** 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. The switch-over between variable-speed control and torque-dependent control is done without jerk in operation.



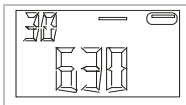
Configuration 610, Sensorless Field-Oriented Control of Synchronous Machine, Speed Controlled

Configuration 610 contains the functions for speed-controlled, field-oriented control of a synchronous machine without resolver feedback. The separate control of torque and flux-forming current enables high drive dynamics with a high load moment. The missing resolver feedback compared to configuration 510 results in a small loss of dynamic and speed performance.



Configuration 611, Sensorless Field-Oriented Control of a Synchronous Machine with Technology Controller

Configuration 611 extends the functionality of the sensorless field-oriented control 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, Sensorless Field-Oriented Control of a Synchronous Machine, Speed and Torque 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.

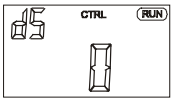
Function	Chapter	Configuration						
		V/f		Field-oriented control				
		Sensorless 1xx		SynRM 3xx		Sensor 2xx		
		110	111	310	330	210	211	230
Speed control	18.5.5			x	x	x	x	x
Torque control	18.5.2				x			x
Switch-over speed/torque control	16.4.6				x			x
Dynamic voltage pre-control	17.1	x	x					
Intelligent 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

Function	Chapter	Configuration						
		V/f		Field-oriented control				
		Sensorless 1xx		SynRM 3xx		Sensor 2xx		
		110	111	310	330	210	211	230
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
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

Function	Chapter	Configuration								
		Field-oriented control								
		Sensorless 4xx			Servo 5xx			Servo sensorless 6xx		
		410	411	430	510	511	530	610	611	630
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
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									

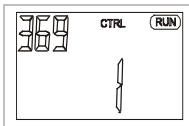
9.2.2 Data Set



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 "Data Set Change-Over").
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. In this case, the other data sets still contain the factory settings. 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. The 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.

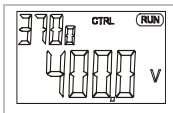
[1)] For setting of parameter *Motor type* **369** to operation mode „10 - Transformer", no parameter identification is performed.

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 are polled in accordance with the table below.

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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 cosine Phi	0.01	1.00	$\cos(\varphi)_N$
375	Rated frequency	10.00 Hz	599.00 Hz	50.00
376	Rated mechanical power	$0.01 \cdot P_{FIN}$	$10 \cdot P_{FIN}$	P_{FIN}

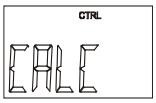
- Use the arrow keys to select the required parameter and edit the parameter value.
- Use the ENT key to confirm the selected parameter and the parameter values entered.

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 mechanical power	1.5 kW	1.5 kW

9.2.5 Plausibility check



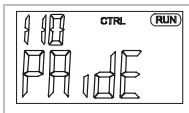
After the machine data (and the speed sensor data, if applicable) have been entered, the calculation or examination of the parameters is started automatically. The display changes over to "CALC" for a short time. If the verification of the machine data is successful, the guided commissioning procedure 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 repeated until the rated values have been entered correctly. Aborting the guided commissioning procedure by pressing ESC key should only be done by expert users because it may be possible that rated values have not been entered or determined correctly.

9.2.6 Parameter identification

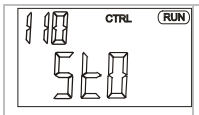


In addition to the parameterized rated data, the selected configuration demands knowledge of further machine data not stated on the rating plate of the three-phase machine. In addition to entering the rated motor parameters or as an alternative, the required machine data can also be measured during the 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.

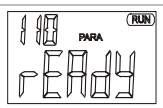
  During the parameter identification, the connected load is measured.

For the setting of parameter *Motor type* **369** to operation mode „10 - Transformer", no parameter identification is affected.



The safety functions of the frequency inverter avoid enabling of the power unit if no signal is present at digital input MF4ID/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 MF4ID/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.
Canceling the operation with the ESC key or withdrawing the enable signal MF4ID/STOA and S7IND/STOB results in an incomplete take-over of the values.

You must carry out the guided commissioning procedure with cool machine because 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 setup 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 demands enable 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 operator panel is being carried out.
SS030	No Release	No enable signal. The parameter identification demands enable on digital input STOA and STOB.
SS031	Error – see 259	Error during the auto set-up routine. Check the value of *Actual 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	The setup is not carried out until now.

9.2.8 Warnings during commissioning (SA...)

Warning Messages	
Code	**Measures / Remedy**
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 rating plate of the frequency inverter.
SA002	For a three-phase motor, the calculated efficiency is in the limit range. Check the values entered for the parameters *Rated voltage* **370**, *Rated current* **371** and *Rated power* **376**.
SA003	The value entered for parameter *Rated cos phi* **374** is outside of the 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 entered for parameters *Rated speed* **372** and *Rated frequency* **375**.
SA011	Current Controller non typical value; refer to 18.5.1.
SA012	Current Controller non typical value with 2 kHz; refer to chapter 18.5.1.
SA014	Current Controller non typical value with 4 kHz; refer to chapter 18.5.1.
SA018	Current Controller non typical value with 8 kHz; refer to chapter 18.5.1.
SA021	The stator resistance is 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	The rotor resistance is 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.
SA033	Shorten Motor Line for Switching frequency 8 kHz and higher.
SA041	The slip speed was not determined correctly. Check the values entered for parameters *Rated speed* **372** and *Rated frequency* **375**.
SA042	The slip speed was not determined correctly. Check the values entered for parameters *Rated speed* **372** and *Rated frequency* **375**.

Warning Messages	
Code	**Measures / Remedy**
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.
SA053	The Resolver angle was not estimated correctly.

9.2.9 Error messages during commissioning (SF...)

After completion or during the parameter identification, error messages may be displayed. Follow the instructions below and take the measures indicated.

Error Messages	
Code	**Measures / Remedy**
SF000	No error message exists.
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 Power* **376** and *Rated Voltage* **370**. Correct the values.
SF003	The value entered for parameter *Rated Cosine Phi* **374** is wrong (greater than 1 or smaller than 0.3). Correct the value.
SF004	The calculated slip frequency is negative. Check and, if necessary, correct the values entered for parameters *Rated Speed* **372** and *Rated Frequency* **375**.
SF005	The calculated slip frequency is too high. Check and, if necessary, correct the values entered for parameters *Rated Speed* **372** and *Rated Frequency* **375**.
SF006	The calculated total output of the drive is lower than the rated power. Correct and check, if necessary, the value entered for parameter *Rated Power* **376**.
SF007	The set configuration is not supported by the 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 the value 110 for parameter *Configuration* **30** (sensorless regulation according to U/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 the value 110 for parameter *Configuration* **30** (sensorless regulation according to U/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	The setup-routine is aborted.

9.2.10 Application data

Due to the wide range of drive applications with the resulting parameter settings it is necessary to check further parameters. The parameters polled during the guided commissioning procedure were selected from standard applications. After completion of commissioning, further parameters can be set in the PARA menu branch.

At the control unit KP500 parameter numbers > 999 are displayed hexadecimal at the leading digit (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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 setting *Voltage controller operation mode* **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.

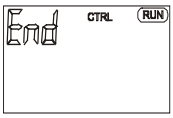
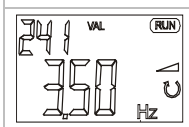
9.2.10.2 Set points at multi-functional input

The multi-functional 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 mA … 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, a digital input S2IND…S6IND or a digital input of an expansion module EM should be used.

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. The relay output X10 signalizes a fault, because of the factory 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** (factory setting 3.50 Hz in configurations 110, 111, 410, 411, 430 or to 0.00 Hz in configurations 210, 211, 230, 510) by: • signals at digital inputs MF4ID/STOA and S7IND/STOB and • Start clockwise by rising signal edge at S2IND or Start anticlockwise by rising signal edge at S3IND

Status signals

160 -	Ready Signal	1)	Indicates initialization and operating readiness of the inverter.
1 -	Ready or Standby Signal	2)	Indicates initialization and operating readiness of the inverter.
161 -	Run Signal	1)	Indicates enable and start command (output frequency available).
2 -		2)	Indicates enable and start command (output frequency available).
162 -	Error Signal	1)	Monitoring function signalizes a fault with display in parameter *Current Error* **259**.
3 -		2)	

1) For linking with inverter functions
2) For 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 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 MF4ID/STOA and S7IND/STOB as well as S2IND (Start clockwise) or connect MF4ID/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.

9.4 Speed sensor

For some configurations an incremental speed sensor must be connected. Depending on the speed sensor type it can be connected to the basic device or to an expansion module. Some applications require the connection to the basic device as well as to the expansion 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 or 3 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 expansion module.
10 -	Speed Sensor 3	The actual speed source is speed sensor 3 of an expansion module.

Depending on the application and applied speed sensors, the settings of parameters must be adapted according to the following table.

Parameter		Only speed sensor 1	Only speed sensor 2	Both speed sensors
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
766	Actual Speed Source	1	2	1 or 2

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

The above-mentioned parameters are selectable dependent on configuration setting and installed expansion module.

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".

For information on the speed sensor 2 and 3 see the operating instructions for the EM-AUT expansion module.

9.4.1 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 section 11.4.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact.**
490	Operation Mode speed sensor 1	Selection		
491	Division Marks speed sensor 1	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**.

9.4.2 Speed sensor 2

For information on the speed sensor 2 and 3 see the operating instructions for the EM-AUT-01 & EM-AUT-04 expansion module.

9.4.3 Speed sensor 3

For information on the speed sensor 2 and 3 see the operating instructions for the EM-AUT-01 & EM-AUT-04 expansion module.

9.5 Set-up 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.

The parameter *SETUP Selection* **796** defines the function which is carried out directly after the selection (if controller enabling signal is present at digital inputs MF4ID/STOA and S7IND/STOB). The operation modes include functions which are also carried out automatically one after the other during the guided commissioning procedure.

SETUP Selection 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 -	Auto set-up complete, DS1	The parameter values of the auto set-up are stored in data set 1.
12 -	Auto set-up complete, DS2	The parameter values of the auto set-up are stored in data set 2.
13 -	Auto set-up complete, DS3	The parameter values of the auto set-up are stored in data set 3.
14 -	Auto set-up complete, DS4	The parameter values of the auto set-up are stored in data set 4.
20 -	Check Machine Data, DS0	The auto set-up routine checks the rated motor parameters in the four data sets.
21 -	Plaus. contr. motor data, DS1	The rated motor parameters in data set 1 are checked for plausibility.
22 -	Plaus. contr. motor data, DS2	The rated motor parameters in data set 2 are checked for plausibility.
23 -	Plaus. contr. motor data, DS3	The rated motor parameters in data set 3 are checked for plausibility.
24 -	Plaus. contr. motor data, DS4	The rated motor parameters in data set 4 are checked for plausibility.
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	Additional motor data are measured, dependent parameters are calculated and the parameter values are saved in data set 1.
32 -	Calc. and para ident., DS2	Additional motor data are measured, dependent parameters are calculated and the parameter values are saved in data set 2.
33 -	Calc. and para ident., DS3	Additional motor data are measured, dependent parameters are calculated and the parameter values are saved in data set 3.
34 -	Calc. and para ident., DS4	Additional 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	Additional motor data are measured and saved in all of the four data sets.
41 -	Para-Ident. Machine Data only, DS1	Additional motor data are measured and saved in data set 1.
42 -	Para-Ident. Machine Data only, DS2	Additional motor data are measured and saved in data set 2.
43 -	Para-Ident. Machine Data only, DS3	Additional motor data are measured and saved in data set 3.

SETUP Selection 796		Function
44 -	Para-Ident. Machine Data only, DS4	Additional motor data are measured and saved in 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.

The "additional motor data" also contain values of the current controller settings.

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 the status message of the Auto set-up comply with

- 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…)"

10 Inverter Data

10.1 Serial Number

The *Serial Number* **0** is entered on the rating plate during the fabrication of the frequency inverter. Information on the device type and the fabrication data (8-digit number) are indicated. Additionally, the serial number is printed on the rating plate.

Serial number **0** :	603409000 ; 14053980 (part no.; serial no.)
Rating plate:	Type: ANG 410 – 09 ; Serial No.: 14053980

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 expansion module, refer to the corresponding operating instructions.

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 6-digit software key is printed on the rating plate of the frequency inverter.

Inverter software version **12**:	8.0.10.0
Rating plate:	Software Version: 8.0.10.0
Copyright **15**	(C) 2015 BONFIGLIOLI VECTRON

10.4 Set Password

As a protection against unauthorized access, the 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 the *Set password* **27** parameter is set to zero, no password is required for access to the parameters. The previous password is deleted.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
28	Control level	1	3	1

10.6 User Name

The *User name* **29** can be entered via the optional control software VPlus. The plant or machine designation cannot be displayed completely via the control unit.

32 alphanumeric characters

10.7 Configuration

The *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. The operating instructions describe the following configurations and the relevant parameters in the third *Control level* **28** (adjustment of parameter *Control level* **28** to value 3).

See also Chapter 9.2.1 “Configuration”

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 defined via VPlus.

10.9 Programming

The parameter *Program(ming)* **34** enables acknowledgment of a fault message 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(ming) 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
123 - Reset	The current error message can be acknowledged via digital input MF4ID/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**, *Language* **33** as well as *Configuration* **30** are not changed during resetting to factory settings (*Program(ming)* **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 inquired according to the selected *Configuration* **30**.

11.1 Rated Motor Parameters

Set the rated parameters of the three-phase asynchronous machine according to the rating plate or the data sheet of the motor. The default settings of the machine parameters are based on the rated data of the frequency inverter and the corresponding four-pole three-phase 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 rated values specified by default.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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	24	2
374	Rated cosine (φ)	0.01	1.00	$\cos(\varphi)_N$
375	Rated frequency	10.00 Hz	599.00 Hz	50.00 Hz
376	Rated mechanical power	$0.01 \cdot P_{FIN}$	$10 \cdot P_{FIN}$	P_{FIN}

U_{FIN} = Rated Voltage of Frequency inverter, typically 400 V or 230 V
I_{FIN} = Rated Output current of Frequency inverter
P_{FIN} = Rated Output of Frequency inverter
o: Overload capability of Frequency inverter

The Parameter *Rated cosine(φ)* **374** is not available in configurations 5xx and 6xx (Synchronous motor).

In the case of three-phase 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 is entered to match the reference output of the frequency inverter.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
377	Stator resistance [1]	0 mΩ	65535 mΩ	R_{sN}
1190	Stator resistance [2]	0.001 Ω	100.000 Ω	10.000 Ω

[1] Available in configurations 1xx, 2xx, 4xx (Parameter *Configuration* **30**).
[2] Available in configurations 5xx and 6xx (Parameter *Configuration* **30**).

Stator resistance asynchronous motor:

The value of the stator resistance 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 value of the stator resistance of the synchronous motor is entered during the guided commissioning. The value of the stator resistance is used for adjustments of the current controller and should be therefore entered as exact as possible. The *stator resistance* **1190** is the value between two motor phases and can be taken usually from the data sheet of the motor.

11.2.2 Leakage Coefficient

The leakage coefficient of the machine defines the ratio of the leakage inductivity to the main inductivity. 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 acceleration to various operating points of the drive. Unlike the torque-forming current *Isq* **216**, the flow-forming current *Isd* **215** should be largely independent of the load torque. The flow-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 magnetizing current* **716**, regardless of the load on the drive.
The sensorless control system uses the parameter *Leakage coefficient* **378** in order to optimize the synchronization to one drive.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
378	Leakage Coefficient	1.0 %	20.0 %	7.0 %

11.2.3 Magnetizing Current

The *Rated magnetizing current* **716** is a measure of the flux in the motor and thus of the voltage which is present in the machine in no-load condition depending on the speed. The guided commissioning determines this value at about 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 magnetizing current* **716**.
The field-oriented control with speed sensor feedback uses the parameterized *Rated magnetizing 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 *Magnetizing current 50%* **713**, *Magnetizing current 80%* **714** *and Magnetizing current 110%* **715**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 inductivity 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 maximum tolerance 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 value calculated by the rotor time constants can be read out via the actual value *Current rotor time constant* **227**. The adjustment should be done at a winding temperature which is also reached during normal operation of the motor.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
718	Rated slip correction factor	0.01 %	300.00 %	100.00 %

11.2.5 Voltage constant

In configuration 5xx and 6xx for the control of synchronous machines, the control behavior can be improved for high dynamic requirements by the settings of the 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 $\frac{V}{1000\ rpm}$. This value can be taken over for parameter *Voltage constant* **383**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
383	Voltage constant	0.0 mVmin	850.0 mVmin	0.0 mVmin

If the guided commissioning (Setup) is not carried out, the auto-setup should be carried out via parameter *SETUP selection* **796** in order to improve the drive behavior, particularly for small speeds. Select one of the settings 10 … 14 for *SETUP selection* **796**.
During the guided commissioning (via keypad and VPlus) for Bonfiglioli motors the voltage constant is pre-allocated.
For Non-Bonfiglioli motors the voltage constant should be entered if it is known. If the voltage constant is unknown, set *Voltage constant* **383** to `0 mV` before the commissioning to ensure the 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** displays the value 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 the control of synchronous machines, the control behavior can be improved for high dynamic requirements by setting the parameter *Stator inductance* **384**.
The *stator inductance* **384** is the value between two motor phases and can be taken usually from the data sheet of the motor.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
384	Stator inductance	0.1 mH	500.0 mH	1.0 mH

11.2.7 Peak current

The parameter *Peak Current* **1192** is used during the guided commissioning to set the limits for the Isq set value in the frequency inverter. This serves the protection of the connected synchronous motor. The value can be taken from the motor name plate or the motor data sheet. Exceeding the values given by the motor manufacturer can lead to damages in the motor.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
1192	Peak current	0.01 % $I_{FI,N}$	100 000 % o·$I_{FI,N}$	100 % $I_{FI,N}$

$I_{FI,N}$: Rated value of Frequency inverter
o: Overload capability of Frequency inverter

11.2.8 Reverse sense of rotation

The parameter *Change sense of rotation* **1199** reverses the rotating direction of the motor.

Operation mode 1199	Positive Set value	Negative Set value
0 - Off	Motor rotates forward (clockwise)	Motor rotates reverse (anti clockwise)
1 - On	Motor rotates reverse (anti clockwise)	Motor rotates forward (clockwise)

BONFIGLIOLI VECTRON defines with view on the motor A side and correct connection of the motor phases the sense of rotation clockwise (forward) with a positive set value. With a changed sense of rotation, the motor reverses with the same set value. Existing gear boxes and transmissions have to be considered.

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

With the parameter *Change sense of rotation* **1199** the sense of direction of the complete system (motor control and encoder evaluation) is reversed.
When the sense of direction is different between motor and encoder, this can be changed by two actions:

- Change the track A and track B at the encoder inputs at the terminals of ANG.
- Change the evaluation of the sense of rotation of the connected encoder with parameter **490** respectively **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		Parameter	
No.	**Description**	**No.**	**Description**
399	Internal value 01	706	Internal value 08
402	Internal value 02	707	Internal value 09
508	Internal value 03	708	Internal value 10
702	Internal value 04	709	Internal value 11
703	Internal value 05	745	Internal value 12
704	Internal value 06	798	Internal value 13
705	Internal value 07		

11.4 Speed Sensor 1

The frequency inverters are to be adapted to the application depending on the requirements. A part of the available *Configuration* **30** demand 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 expansion modules EM and sensor input modules, it is also possible to connect and evaluate sensors as speed sensor 2 and 3. Please refer to the corresponding operating instructions. Speed sensor 1 and speed sensors 2 and 3 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. Connect a unipolar speed sensor 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.
11 –	Single evaluation without sign	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 without sign	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	One-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, sense of rot. via contact	One-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	Same as in operation mode 1. The actual speed value is inverted. (Alternative to exchanging the track signals)
104 –	Quadruple evaluation inverted	Same as in operation mode 4. The actual speed value is inverted. (Alternative to exchanging the track signals)
111 –	Single evaluation negative	Same as operation mode 11. The actual speed value is negative.
112 –	Double evaluation negative	Same as operation mode 12. The actual speed value is negative.
131 –	Single evaluation, sense of rot. via contact inverted	One-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.

Operation mode 490		Function
132 –	Double evaluation, sense of rot. via contact inverted	One-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 with reference track	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 with reference track	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 with reference track	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 with sense of rot. without sign with ref. track	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 with sense of rot. without sign with ref. track	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 sense of rot. via contact with ref. track	One-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 sense of rot. via contact with ref. track	One-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.

Operation mode 490		Function
1101 –	Single evaluation inverted with reference track	Same as operation mode 1001. The actual speed value is negative.
1102 –	Double evaluation inverted with reference track	Same as operation mode 1002. The actual speed value is negative.
1104 –	Quadruple evaluation inverted with reference track	Same as operation mode 1004. The actual speed value is negative.
1111 –	Single evaluation inv. with sense of rot. without sign with ref. track	Same as operation mode 1011. The actual speed value is negative.
1112 –	Double evaluation inv. with sense of rot. without sign with ref. track	Same as operation mode 1012. The actual speed value is negative.
1131 –	Single evaluation inv. sense of rot. via contact with ref. track	One-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 inv. sense of rot. via contact with ref. track	One-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 *fmax*=**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:

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

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
A = evaluation (1, 2, 4)

for example:

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

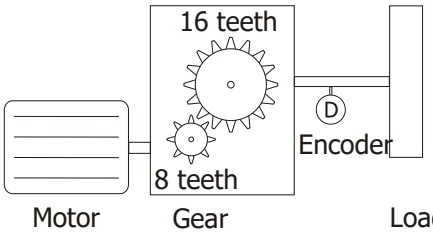
Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
491	Division marks, speed sensor 1	1	8192	1024

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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 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 to filter the speed of speed sensor 1. This can filter can be applied in cases, where the speed sensor fluctuates (in example due to mechanical reasons).
Bonfiglioli Vectron recommends to change the value in small steps and check the result and not to change the values in big steps.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
1193	EC1: Filter time constant	0 us	32000 us	0 us

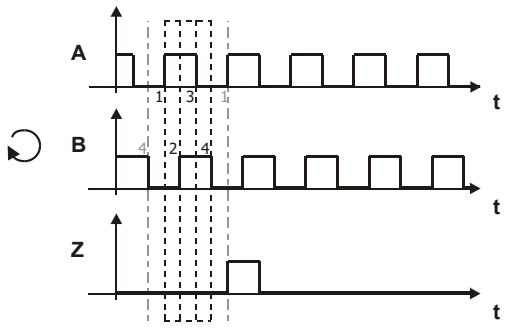
11.5 Sensor evaluation

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 machine 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 machine, different degrees of sensor evaluation accuracy 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.

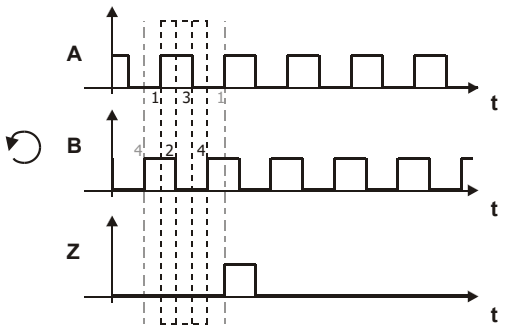
If an operation mode with reference track is selected for the speed sensor, the frequency inverter will make sure that the Z track occurs according to the parameterized *Division marks, speed sensor 1* **491**. If the evaluation is not consistent, a reaction as per parameter *Operation mode* **760** 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 sensors can be connected to the basic device. The connection of TTL sensors, SinCos encoders or Absolute encoders requires an expansion module type EM-AUT.

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 System Value

The parameter *Actual system value factor* **389** can be used if the drive is monitored via the actual value *Actual system value* **242**.
The *Actual frequency* **241** to be monitored is multiplied by the *Actual system value factor* **389** and can be read out via the parameter *Actual system value* **242**, i.e. *Actual frequency* **241** x *Actual system value factor* **389** = *Actual system value* **242**.

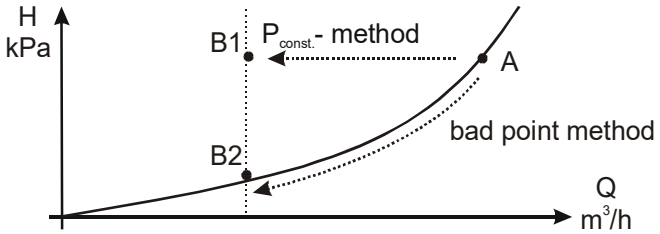
Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
389	Factor Actual Value System	-100.000	100.000	1.000

12.2 Volume Flow and Pressure

The parameterization of the factors *Nominal Volumetric Flow* **397** and *Nominal Pressure* **398** is necessary if the matching actual values *Volumetric Flow* **285** and *Pressure* **286** are used to monitor the drive. The conversion is done using the electrical control parameters.
Volume flow **285** and *Pressure* **286** are referred to the *Effective 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**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 affected at a constant pressure H (change of conveying flow Q, pressure H remains constant). The transition to partial load operation mode B2 can be affected 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 Operational 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 *Maximum 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

The 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	At the start the voltage with the value of parameter *Starting Voltage* **600** is set at an output frequency of 0 Hz. 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 are 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 zero Hz for the *Maximum flux-formation time* **780**. After this time has expired, the output frequency follows the adjusted V/f characteristic. (see operation mode 0- Off)
2 - Magnetization and current injection	Operation mode 2 includes operation mode 1. After the *Maximum flux-formation time* **780** 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.+ IxR-K.	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 zero Hz for the *Maximum flux-formation time* **780**. After the time 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 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.
12 - Magn. + current impr.+ w. ramp stop	Operation mode 12 contains an additional function to guarantee a starting behavior under difficult conditions. The magnetization and starting current injection 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 the intervention of the controller by displaying the message "RSTP".

Operation mode 620	Starting Behavior
14 - Magn. + current impr.+ w. R+ IxR-K.	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 checks the current injection by parameter *Starting current* **623**. The proportional and integrating parts of current controller can be adjusted via parameters *Amplification* **621** and *Integral time* **622**, respectively. The control functions can be deactivated by setting the parameters to `0`.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
621	Amplification	0.01	10.00	2.00
622	Integral time	1 ms	30000 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
623	Starting Current	0.0 A	$o \cdot I_{FIN}$	I_{FIN}

I_{FIN} = Rated Output current of Frequency inverter
o: Overload capability 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

13.1.1.2 Frequency Limit

The *Starting current* **623** is impressed in configurations 1xx, 4xx and 6xx for control in the selected configuration until the *Frequency limit* **624** is reached. Permanent operating points below the frequency limit are only admissible 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 up automatically during the guided motor commissioning in field oriented control configurations 4xx and 6xx. In V/f control configurations 1xx the parameter *Frequency limit* **624** is not changed by the guided motor commissioning.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 affected 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 the parameter *Current during flux formation* **781** the magnetization current I_{sd} is set, with the parameter *Maximum Flux-Formation Time* **780** the maximum time for the current injection is set.
The current injection is done until the reference value of the rated magnetizing current is reached or the *Maximum Flux-Formation Time* **780** is exceeded.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
780	Maximum Flux-Formation Time	1 ms	10000 ms	300 ms [1)]
				1000 ms [2)]
				50 ms [3)]
				200 ms [4)]
781	Current during flux formation	$0.1 \cdot I_{FIN}$	o · I_{FIN}	IF_{IN}

The factory setting of parameter *Maximum Flux Formation Time* **780** depends on the setting of parameter *Configuration* **30**:
[1)]- configurations 1xx/3xx
[2)]- configurations 2xx/4xx
[3)]- configurations 6xx
[4)]- configurations 3xx

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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
779	Min. Flux-Formation Time	1 ms	10000 ms	10 ms [1)]
				50 ms [2)]
				200 ms [3)]

The factory setting of parameter *Min. Flux-Formation Time* **779** depends on the setting of parameter *Configuration* **30**:
[1)]- configurations 2xx/3xx/4xx
[2)]- configurations 6xx
[3)]- configurations 3xx

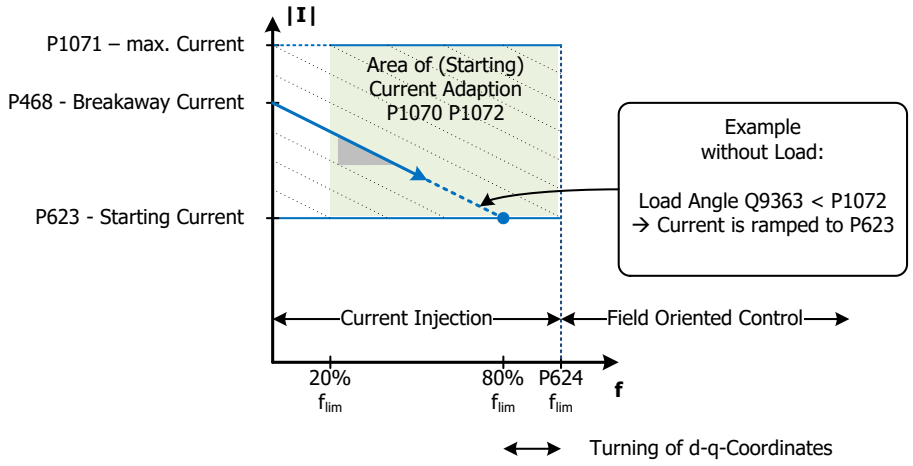
Min. Flux-Formation Time **779** = 0	Flux-forming ends when - reference flux value is reached or - after flux-formation time
Min. Flux-Formation Time **779** > 0	The current for flux-forming is impressed at least for this time, even if the reference flux value is reached.
Min. Flux-Formation Time **779** = *Max. Flux-Formation Time* **780**	Flux-forming ends after flux-formation time, even if the reference flux value is not reached.
Min. Flux-Formation Time **779** > *Max. Flux-Formation Time* **780**	Flux-forming ends after 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}

Parameter	
No.	**Description**
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 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, the 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 0 Free stopping	The inverter is disabled immediately. The drive deenergized immediately and coasts freely.
Stopping behavior 1 Stop + Switch 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 the parameter *Holding time* **638**. Depending on the setting of the parameter *Starting function* **620**, the *Starting current* **623** is impressed or the *Starting voltage* **600** is applied for the duration of the holding time.
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 the parameter *Starting function* **620**, the *Starting current* **623** is impressed as from standstill or the *Starting voltage* **600** is applied. In configurations 2xx the magnetizing current is used instead of the *Starting current* **623**. The magnetizing current results from *Rated magnetizing 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 "DC brake". Stopping behaviors 3, 6 and 7 are only available in the configurations for V/f sensorless control (1xx).
Stopping behavior 4 Emergency stop + switch 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 the parameter *Holding time* **638**. Depending on the setting of the parameter *Starting function* **620**, the *Starting current* **623** is impressed as from standstill or the *Starting voltage* **600** is applied.
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 the parameter *Starting function* **620**, the *Starting current* **623** is impressed as from standstill or the *Starting voltage* **600** is applied.
Stopping behavior 6 Emergency stop + Brake	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 "DC brake". Stopping behaviors 3, 6 and 7 are only available in the configurations for V/f sensorless control (1xx).
Stopping behavior 7 Direct current brake	Direct current braking is activated immediately. The direct current set with the parameter *Braking current* **631** is impressed for the die *Braking time* **632**. Comply with the notes in chapter "DC brake". Stopping behaviors 3, 6 and 7 are only available in the configurations for V/f sensorless control (1xx).

Please refer to the notes for controlling a mechanical brake in chapter 16.3.5 Brake release.
For connection of a synchronous motor BONFIGLIOLI VECTRON recommends the setting of *Operation Mode* **630** = `22`.

13.2.1 Switch-Off Threshold

NOTICE

If the motor builds up a stopping torque, it may be possible that the switch-off threshold stop function is not 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 stop function* **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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
637	Switch-off threshold	0.0 %	100.0 %	1.0 %

13.2.2 Holding Time

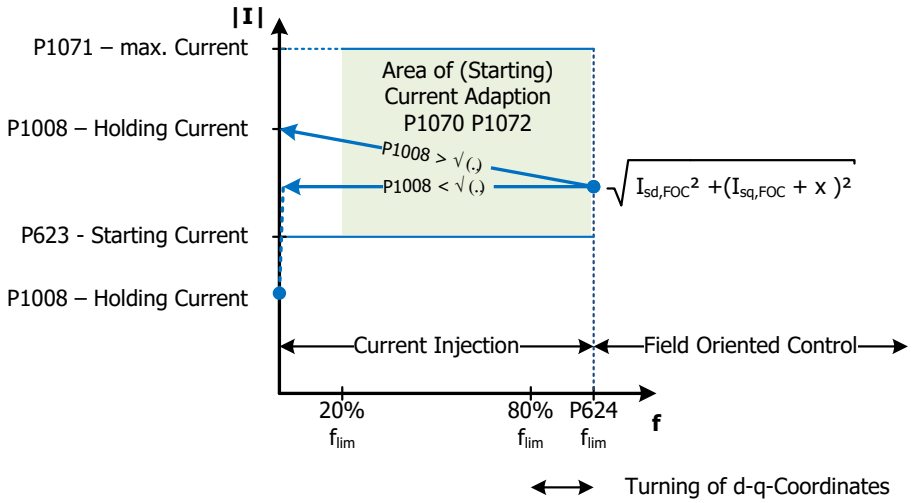
The *Holding time stop function* **638** is considered in stopping behavior 1, 3, 4 and stopping behavior 6. Controlling to speed zero leads to a heating of the motor and should only be done for a short period in internally ventilated motors.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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.

13.3 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
631	Braking current	0.00 A	$\sqrt{2}\cdot I_{FIN}$	$\sqrt{2}\cdot I_{FIN}$

I_{FIN} = Rated Output current 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 expired.
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 the 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 (MF4ID/STOA and S7IND/STOB) becomes logical 0 (low).

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
632	Braking time	0.0 s	200.0 s	10.0 s

To avoid current surges, which can possibly lead to a fault 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 PI controller checks the current injection of the set *Braking current* **631**. The proportional and integrating parts of current controller can be adjusted via parameters *Amplification* **634** and *Integral time* **635**, respectively. The control functions can be deactivated by setting the parameters to 0.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
634	Amplification	0.00	10.00	1.00
635	Integral time	0 ms	1000 ms	50 ms

13.4 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. The controller enabling signal and the start command are necessary according to 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	The drive is accelerated, after application of the mains voltage, as soon as the controller enabling signal and the start command are switched from stop to start (edge evaluation).
1 -	Switched on	The drive is accelerated by the frequency inverter as soon as the mains voltage is applied (level evaluation).

13.5 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 a fault switch-off. Via *Operation mode search run* **645**, the motor speed is synchronized to the current motor speed without an "Overcurrent" fault message. 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. Rotary frequencies of 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 a 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 was determined, the flux is formed (Parameter *Minimum flux-formation time* **779**, *Maximum 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 in front of the reference value. If a positive reference value (clockwise field of rotation) is entered, the search is in a positive direction (clockwise field of rotation), with a negative reference value, 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 (anticlock-wise field of rotation). If this attempt fails, it is tried to synchronize to the drive in positive direction (clockwise field of rotation).

Operation mode 645		Function
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 Synchroniza-tion	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 in front of the reference value. If a positive reference value (clockwise field of rotation) is entered, the search is in a positive direction (clockwise field of rotation), with a negative reference value, the search is in a negative direction (anticlockwise field of rotation).
14 -	Quick synch., clockw. only	Synchronization to the drive is only done in positive direction (clockwise field of rotation).
15 -	Quick synch., anticlockw. 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 the *Rated current* **371**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
647	Current / Rated Motor Current	1.00 %	100.00 %	70.00 %

The sensor-less control is extended for the search run by a PI-Controller, which regulates the parameterized *Current / Rated Motor Current* **647**. The proportional and integrating part of the current controller can be set via the parameters *Amplification* **648** and *Integral Time* **649**. The control functions can be deactivated by setting the parameters to 0.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
648	Amplification	0.00	10.00	1.00
649	Integral time	0 ms	1000 ms	20 ms

If the *Operation mode Synchronization* **645** parameter was set to operation mode 1 to 5 (search run), the search run is not started before the *Demagnetization 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 *Braking time after search run* **646**. The impress of the direct current set in the parameters of the direct current brake (DCB) leads to a heating of the motor and should only be done for a short period in internally ventilated motors.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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.

13.6 Positioning

Positioning is done in operation mode "Reference positioning" via the definition of the positioning distance or in operation mode "Axle 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.
Axle 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 "Axle 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 Configuration: 110, 210, 410, 510, 610.
2 - Axle positioning	Reference positioning via definition of the positioning angle, reference signal from speed sensor. Available in Configuration: 210, 510.

13.6.1 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**, the *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 the *Positioning distance* **460** causes an immediate stop of the drive according to the selected stopping behavior for *Operation mode* **630**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
460	Positioning distance	0.000 U	1000 000.000 U	0.000 U

The actual value parameter *Revolutions* **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 ⇒ rpm = 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	

3 -	S3IND, neg. edge	The positioning starts with the change of the logic signal from 1 (HIGH) to 0 (LOW) at the reference point.
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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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.

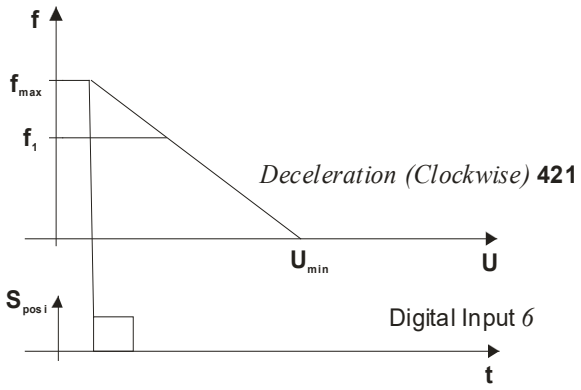
Activity after positioning 463		Function
0 -	End positioning	The drive is stopped with the stopping behavior of *Operation mode* **630**.
1 -	Wait for positioning signal	The drive is stopped until the next signal edge; with a new edge of the position signal, it is accelerated in the previous direction 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 *Waiting time* **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 *Waiting time* **464**; after the waiting time, it is accelerated in the opposite direction of rotation.

The position reached can be maintained for the *Waiting time* **464**, then the drive is accelerated according to operation mode 4 or 5.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
464	Waiting time	0 ms	3600,000 ms	0 ms

Positioning, Operation Mode 458 = 1

The diagram shows how the positioning to the set positioning distance is affected. 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 affected 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 the *Signal source* **459** parameter in operation mode 16–S6IND, pos. edge by a signal on digital input 6.
- The *Positioning distance* **460** with parameter value 0.000U (default) defines a direct stop of the drive with the deceleration behavior selected in parameter *Operation mode* **630** and the selected *Deceleration (clockwise)* **421**. If a *Positioning distance* **460** is set, the positioning is affected 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 of positioning.
- The *Waiting time* **464** is not considered because operation mode 0 is selected for the parameter *Activity after positioning* **463**.
- The actual value *Revolutions* **470** enables a direct comparison to the required *Positioning distance* **460**. In the case of deviations, a *Signal correction* **461** or *Load correction* **462** can be carried out.

13.6.2 Axle Positioning

For axle positioning a feedback system is mandatory. In most cases, an expansion module for the feedback evaluation is needed as well. The operation modes for parameter *Operation mode Speed sensor 2* **493** are to be set to `1004` or `1104`. For information on how to set the parameter, refer to the instructions on the optional expansion 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 axle positioning, the speed controller should be optimized after the guided commissioning. This is described in the chapter "Speed controller".
Via the 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 „Stopping Behavior").

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 the parameter *Start Positioning of Axle* **37**. The signal source can be selected from the operation modes for digital inputs described in chapter "Digital inputs".
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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
471	Positioning frequency	1.00 Hz	50.00 Hz	50.00 Hz

Via the parameter *Max. positional error* **472**, the maximum permissible deviation from the *Reference orientation* **469** can be set.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
472	Max. positional error	0.1°	90.0°	3.0°

Via parameter *Time constant positioning controller* **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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 MF4ID/STOA and S7IND/STOB is switched on.
- *Start Positioning of Axle* **37** is activated.
- The speed sensor monitoring is activated, i.e. operation mode 2 (error message) for parameter *Operation mode* **760** of the speed sensor monitoring is selected.
- Operation mode `1004` or `1104` (quadruple evaluation with reference impulse) is selected for the speed sensor input.
- The *actual frequency* **241** is smaller than 1 Hz.
- The deviation of the current position from the reference orientation is smaller than the *max. orientation 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 using a Resolver, the search mode during commissioning is skipped.
- If the motor was already rotating before axle 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 behaviour 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, a fault 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
405	Warning Limit Short Term Ixt	6 %	100 %	80 %
406	Warning Limit Long Term Ixt	6 %	100 %	80 %

Exceeding of warning limit is signaled by 165 - Warning Ixt".

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** is reached.

1) For linking with inverter functions
2) For 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 Heat Sink Temp.***407** for the heat sink temperature limit and the *Warning Limit Inside 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 (heat sink temperature).

Output signals

Reaching of warning limits is reported via digital signals.

166 -	Warning Heat Sink Temperature	1)	The value "80 °C minus *Warning Limit Heat Sink Temp.* **407**" is reached.
8 -		2)	
167 -	Warning Inside Temperature	1)	The value "65 °C minus *Warning Limit Inside Temp.* **408**" is reached.
9 -		2)	
170 -	Warning Overtemperature	1)	The value "80 °C minus *Warning Limit Heat Sink Temp.* **407**" or "65 °C minus *Warning Limit Inside Temp.* **408**" is reached.
12 -		2)	

1) For linking with inverter functions
2) For 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 the parameter *Controller status message* **409**.

Operation mode 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 Warning Mask and 22.3 Controller Status for a list of controllers and further possibilities to evaluate the controller states.

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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
415	IDC Compensation Limit	0.0 V	1.5 V	1.5 [1)]
				0.0 [2)]

[1)] Configurations 1xx
[2)] Configurations 2xx / 4xx / 5xx / 6xx

The factory setting of parameter Limit *IDC compensation* **415** depends on the setting of parameter *Configuration* **30**.

14.5 Frequency Switch-Off Limit

The maximum allowed output frequency of the frequency inverter can be set with the parameter *Frequency switch-off limit* **417**. If this frequency limit is exceeded by the *Stator frequency* **210** or *Actual frequency* **241**, the frequency inverter switches off with fault message "F1100".

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 parameterized specific to the application via the parameter *Motor Temp. Operation Mode* **570**. The integration into the application is improved by an operating mode with a delayed switch-off.

Operation mode 570		Function
0 -	Off	Motor temperature monitoring switched off.
1 -	Therm.-Cont.: 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 -	Motor temperature warning	1)	Monitor – selected via *Motor Temp. Operation Mode* **570** – reports critical operating point.
10 -		2)	

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

If the temperature value *max.Temp. Windings* **617** is exceeded a warning or an error switch-off is initiated according to *Motor Temp. Operation Mode* **570**.

Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
617	max.Temp. Windings	50 °C	200 °C	150 °C

Via parameter *Therm. Contact* **204**, a digital input signal can be linked to the *Motor Temp. Operation Mode* **570**.

14.7 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.

14.7.1 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.

14.7.2 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

14.8 Automatic Error Acknowledgment

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 the parameter *Restart delay* **579**. If the error must be acknowledged, the speed of the machine is determined with the quick Search Run 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 "Search run" must be observed.

With parameter *Allowed no. of auto-acknowl.* **578**, you can define the number of automatic error acknowledgements which are permitted within 10 minutes.

An acknowledgement 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 acknowledgement counters.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
578	Allowed no. of auto-acknowl.	0	20	5
579	Restart delay	0 ms	1000 ms	20 ms

15 Reference Values

The ANG 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, 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
719	Slip Frequency	0 %	10000 %	330 %

15.3 Percentage Value Limits

The setting range of the percentages is defined by the parameters *Minimum reference percentage* **518** and *Maximum reference percentage* **519**. The relevant control methods use the two limit values for scaling and calculating the frequency.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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	Reference value source is the multifunction input 1 in analog *Operation mode* **452**.
2 -	Abs. Analog Value EM- MF4IA	Reference value source is the analog input of the expansion module.
4 -	Abs. Value MFI1A + MF4IA	Combination of the operation modes 2 and 1.
10 -	Abs. value fixed frequency (FF)	The fixed frequency according to the *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 the operation modes 10 and 1.
12 -	Abs. Value MF4IA + FF	Combination of the operation modes 10 and 2.
14 -	Abs. Value MFI1A + MF4IA + FF	Combination of the operation modes 10, 1 and 2.
20 -	Abs. value Motorpoti (MP)	Reference value source is the function *Frequency Motorpoti Up* **62** and *Frequency Motorpoti Down* **63**.

Reference frequency source 475	Function
21 - Abs. value MFI1A + MP	Combination of the operation modes 20 and 1.
22 - Abs. Value MF4IA + MP	Combination of the operation modes 20 and 2.
24 - Abs. Value MFI1A + MF4IA + MP	Combination of the 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 the operation modes 30 and 1.
32 - Abs. value repetition freq.-/PWM input (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)	The frequency signals in *Operation mode* **490** are evaluated as a reference value.
35 - Abs. Value MFI1A + F2	Combination of operation modes 1 and 34.
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 MF4IA + KP	Combination of operation modes 40 and 2.
44 - Abs. Value MFI1A + MF4IA + KP	Combination of operation modes 40, 1 and 2.
80 - Abs. value MFI1A + FF + KP + F3 + (MF4IA)1)	Combination of the operation modes 1, 10, 40, 32 and 2. [1)]
81 - Abs. value MFI1A + FF + KP + F1 + F3 + (MF4IA)[1)]	Combination of the operation modes 1, 10, 40, 30, 32 and 2. [1)]
82 - Abs. value MFI1A + FF + KP + F3 + (F2)[2)] + (MF4IA)[1)]	Combination of the operation modes 1, 10, 40, 32, 34 [2)] and 2. [1)]
89 - Abs. value MFI1A + FF + KP + F1 + F3 + (F2)[2)] + (MF4IA)[1)]	Combination of the operation modes 1, 10, 40, 30, 32 , 34 [2)] and 2.[1)]
90 - Abs. value MFI1A + FF + MP + F3 + (MF4IA)[1)]	Combination of the operation modes 1, 10, 20, 32 and 2.[1)]
91 - Abs. value MFI1A + FF + MP + F1 + F3 + (MF4IA)[1)]	Combination of the operation modes 1, 10, 20, 30, 32 and 2.[1)]
92 - Abs. value MFI1A + FF + MP + F3 + (F2)2) + (MF4IA)[1)]	Combination of the operation modes 1, 10, 20, 32, 34 [2)] and 2.[1)]
99 - Abs. value MFI1A + FF + MP + F1 + F3 + (F2)2) + (MF4IA)[1)]	Combination of the operation modes 1, 10, 20, 30, 32, 34 [2)] and 2.[1)]
101 to 199	Operation modes with signs (+/-)

[1)] The reference value source is only available if an expansion module with analog input is connected. For information, refer to the expansion module operating instructions.
[2)] The reference value source is only available if an expansion module with speed sensor input is connected. For information, refer to the expansion module operating instructions.

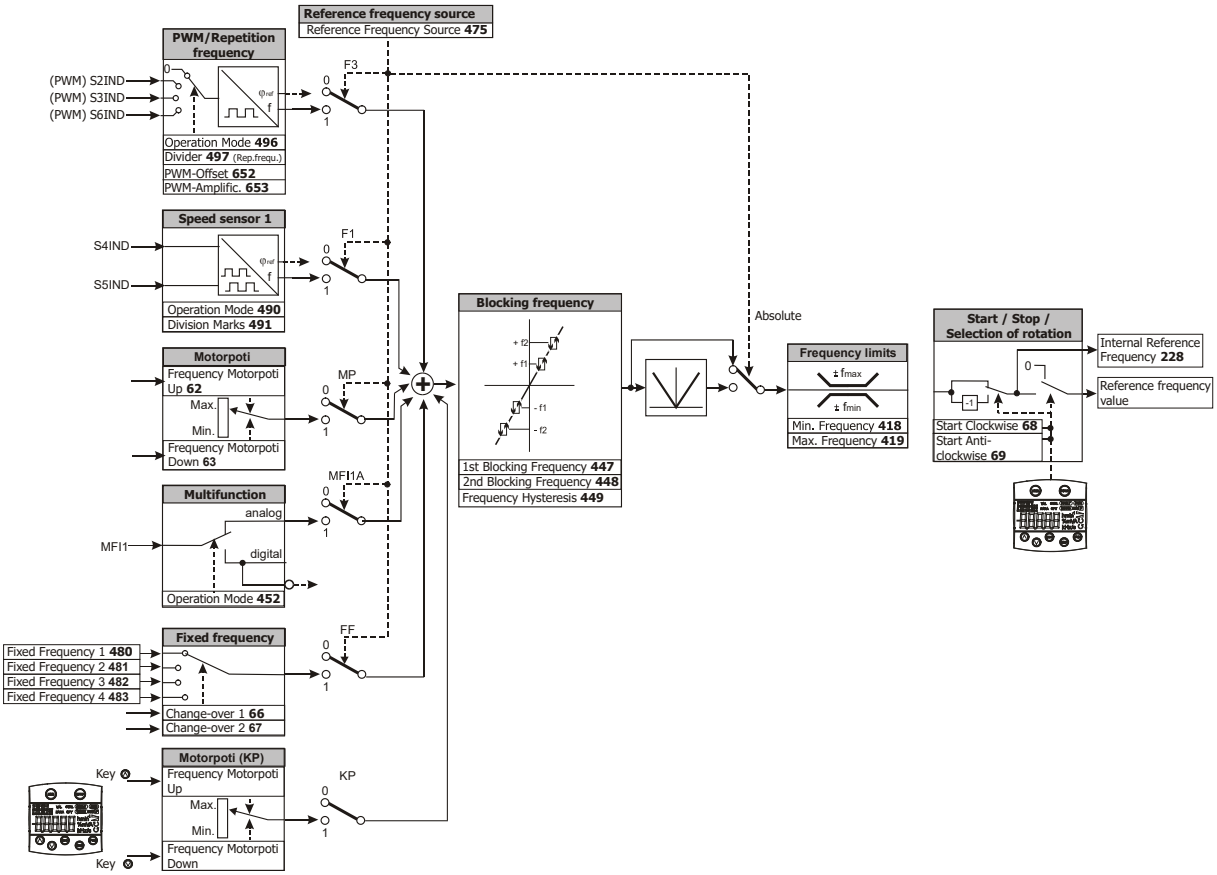
Block diagram

The following table describes the software switches shown in the circuit diagram as a function of the selected *Frequency reference value source* **475**.

	Switch position on circuit diagram								
Operation mode	**MFI1A**	**FF**	**MP**	**F1**	**F3**	**KP**	**MF4IA**	**F2**	**Signal**
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 signs (+/-).								+/-

Circuit diagram of frequency reference value channel



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	Reference value source is the multifunctional input 1 in analog *Operation mode* **452**.
2 -	Abs. Analog Value MF4IA[1)]	Reference value source is the Analog value of MF4IA.
4 -	Abs. Value MFI1A + MF4IA[1)]	Combination of the 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 the operation modes 1 and 10.
12 -	Abs. Value MF4IA + FP[1)]	Combination of the operation modes 2 and 10.
14 -	Abs. Value MFI1A + MF4IA + FP[1)]	Combination of the operation modes 1, 2 and 10.
20 -	Abs. value Motorpoti (MP)	Reference value source is the function *Percent Motorpoti Up* **72** and *Percent Motorpoti Down* **73**.
21 -	Abs. value MFI1A + MP	Combination of the operation modes 1 and 20.
22 -	Abs. Value MF4IA + MP[1)]	Combination of the operation modes 2 and 20.
24 -	Abs. Value MFI1A + MF4IA + MP[1)]	Combination of the operation modes 1,2 and 20.
32 -	Abs. Val. Rep. Freq./PWM Input (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 the operation modes 1 and 32.
90 -	Abs. value MFI1A + FP + MP + F3 (+ MF4IA) [1)]	Combination of the operation modes 1, 10, 20, 32(+ analog input of an expansion module).[1)]
95 -	Abs. Value Obj 0x6071 Target Torque	Reference value source is CANopen Object 0x6071.
99 -	Abs. Val. FT-Output Percentage 1	Reference value source is the output of the function table FT-Output percentage 1.
101 to 199		Operation modes with signs (+/-).

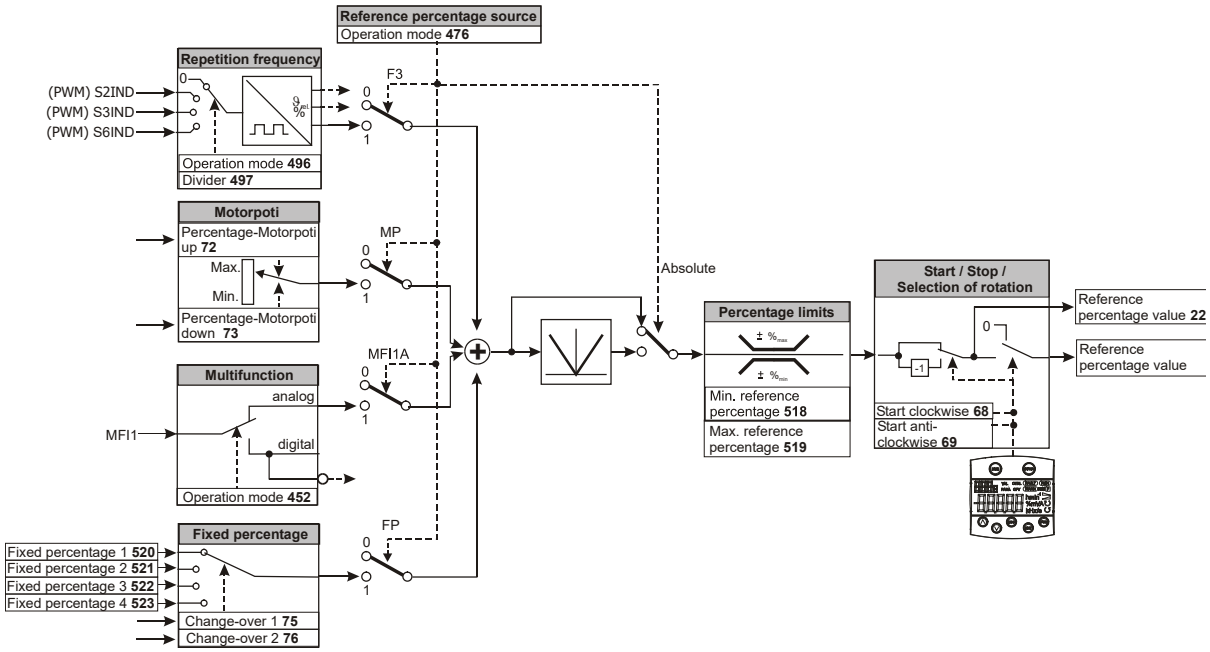
[1)] The reference value source is only available if an optional expansion module with analog input is connected. For information, refer to the expansion module operating instructions.

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**	**MF4IA**	**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
99	Output of FT output Percentage 1					Abs. value
101…199	Operation modes 1…99 with signs (+/-)					+/-

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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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-o-ver 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

If an optional expansion module with digital inputs is installed additional fixed frequencies can be selected. In this case refer to the instruction manual of the expansion 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
489	JOG frequency	-599.00 Hz	599.00 Hz	5.00 Hz

15.6.3 Fixed Percentages

The four percentage values 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 percentage channel.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 frequencies 1 through 4 can be selected:

Fixed Percentage Control		
***Fixed percentage change-over 1* 75**	***Fixed percentage 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 taken over for *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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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

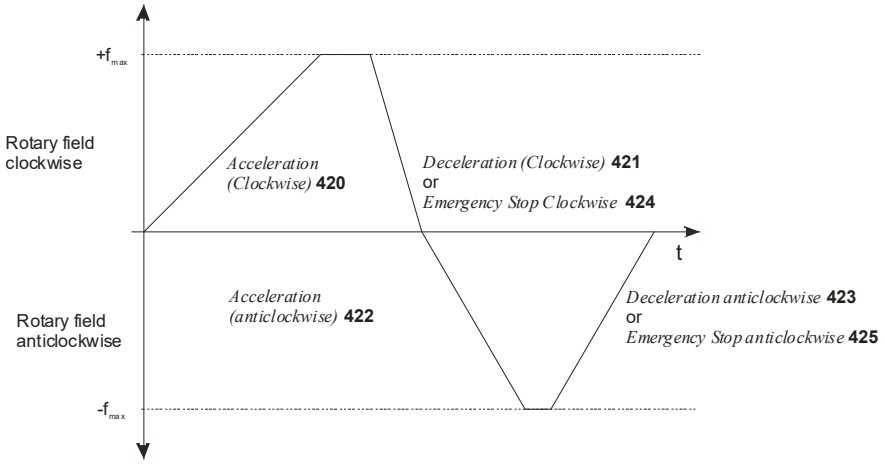
[1)] Value -0.01 Hz/s means: *Acceleration (Clockwise)* **420** is applied.

[2)] Value -0.01 Hz/s means: *Deceleration (Clockwise)* **421** is applied.

The setting 0.00 Hz/s won't accelerate or decelerate the drive due to the limitation of the ramp.

The ramps for the *Emergency stop clockwise* **424** and *Emergency stop anticlockwise* **425** of the drive mechanism 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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



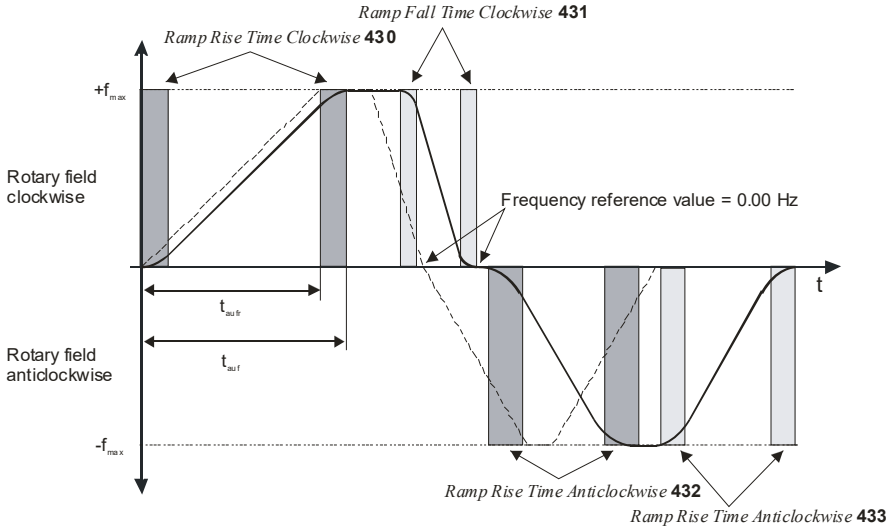
The parameter *Maximum leading* **426** limits the difference between the output of the ramp and the current actual value of the drive. The set maximum deviation is a dead time for the control system which should be kept as low as possible.
In case the drive is loaded heavily and high acceleration and 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 at 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.

$$t_{aufr} = \frac{\Delta f}{a_r}$$

$$t_{aufr} = \frac{50\,\text{Hz} - 20\,\text{Hz}}{2\,\text{Hz/s}} = 15\,\text{s}$$

$$t_{auf} = t_{aufr} + t_{Vr}$$

$$t_{auf} = 15\,\text{s} + 100\,\text{ms} = 15{,}1\,\text{s}$$

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 the *Configuration* **30**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
477	Gradient percentage ramp	0 %/s	60000 %/s	x %/s

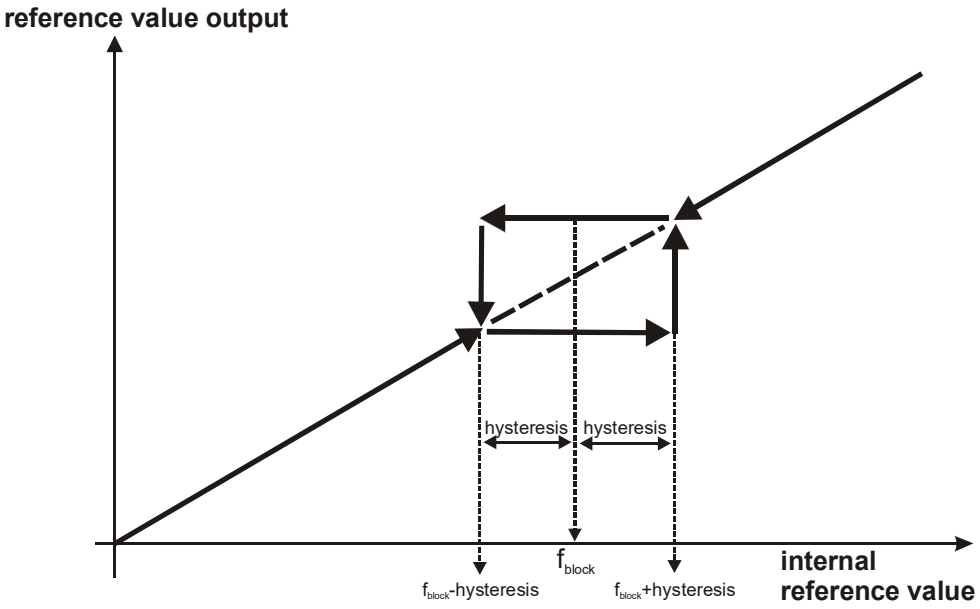
15.9 Block Frequencies

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. The parameters *1st block frequency* **447** and *2nd block frequency* **448** with the parameter *Frequency hysteresis* **449** define two resonance points.

A block frequency is active if the parameter values of the block 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
447	1. blocking frequency	0.00 Hz	599.00 Hz	0.00 Hz
448	2. blocking 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

With 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:

Activation				
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", "Frequency reference channel" and "Reference percentage channel".
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 motorpoti 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 - non-storing	In the operation mode motor potentiometer non-storing (not Latching), the drive goes to the set minimum reference value at each start.
1 - latching	In the operation mode storing (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 storing	This operation mode combines the behavior in operation mode 1 and 2.

15.10.1 Motorpoti (MP)

The Function "Motorpoti (MP)" is to be parameterized via the parameter *Reference frequency source* **475** or *Reference percentage source* **476**.

Frequency reference channel

Via the digital control inputs, the required functions *Frequency motorpoti up* **62** and *Frequency motorpoti down* **63** are triggered.
Limitation of the reference values is affected via parameters *Minimum frequency* **418** and *Maximum frequency* **419**.

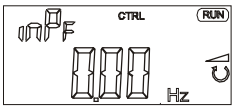
Reference percentage channel

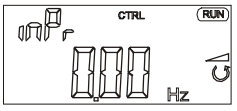
Via the digital control inputs, the required functions *Percentage motorpoti up* **72** and *Percentage motorpoti down* **73** are triggered. Limitation of the reference values is affected via parameters *Minimum percentage* **518** and *Maximum percentage* **519**.

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 motorpoti down* **63** are triggered.
Limitation of the reference values is affected via parameters *Minimum frequency* **418** and *Maximum frequency* **419**.

Control is performed as described in chapter „Control unit KP500, Controlling the Motor via the control unit".
If the function Motorpoti (KP) is activated, „`inPF`" will be displayed for clockwise (forward) direction of rotation and „`inPr`" for anticlockwise (reverse) 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; 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.

15.10.3 Controlling the Motor via the Control Unit

The function *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 function is activated as described in chapter „Control Unit KP500, Controlling the Motor via the Control Unit".
The speed of the modification of the reference value is limited by the parameter *ramp Keypad-Motorpoti* **473**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
473	Ramp Keypad Motorpoti	0.00 Hz/s	999.99 Hz/s	2.00 Hz/s

15.11 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 in the range between 50 Hz and 150 kHz can be evaluated.

Operation mode 496		Function
0 -	Off	The PWM signal or repetition frequency is 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 on terminal X210A.4. One edge of the frequency signal is evaluated with a positive sign.
22 -	S2IND Double evaluation pos.	Repetition frequency input on terminal X210A.4. Both edges of the frequency signal are evaluated with a positive sign.
31 -	S3IND Single evaluation pos.	Repetition frequency input on terminal X210A.5. One edge of the frequency signal is evaluated with a positive sign.
32 -	S3IND Double evaluation pos.	Repetition frequency input on terminal X210A.5. Both edges of the frequency signal are evaluated with a positive sign.
61 -	S6IND Single evaluation pos.	Repetition frequency input on terminal X210B.1. One edge of the frequency signal is evaluated with a positive sign.
62 -	S6IND Double evaluation pos.	Repetition frequency input on 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.

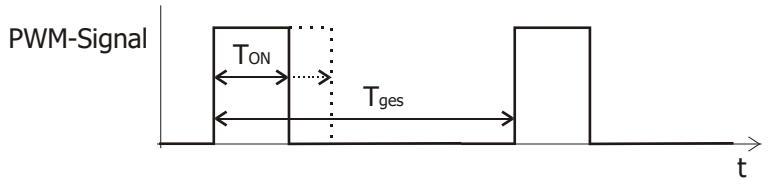
The signal frequency at the selected repetition frequency input can be scaled via the parameter *Divider* **497**. The parameter figure is comparable with the division marks of a speed sensor per rotation of the drive mechanism. The frequency limit of the parameterized digital input is to be taken into account for the frequency of the input signal.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
652	Offset	-100.00%	100.00%	0.00%
653	Amplification	5.0%	1000.0%	100.0%



$$\text{PWM} - \text{Value} = \textit{Offset}\ \mathbf{652} + \left(\frac{T_{on}}{T_{ges}}[\%] \times \textit{Amplification}\ \mathbf{653} \right)$$

Set the reference value via one the following modes.

- For reference frequency values:
  Reference Frequency Source **475** = "32 - Rep. Frequency Input (F3)". The PWM-value is related to *Maximum Frequency* **419**.
- For reference percentage values:
  Reference Percentage Source **476** = "32 - Rep. Frequency Input (F3)". The PWM-value is related to *Maximum Reference Percentage* **519**.

Parameter *PWM-Input* **258** shows the actual value of the PWM input.

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 Multi-Function Input MFI1

Multifunction input MFI1 (X210B.6) can be configured as a voltage, a 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 0 .. 10V	Voltage signal (MFI1A), 0 V ... 10 V
2 – Current Input 0 .. 20mA	Current signal (MFI1A), 0 mA ... 20 mA
3 – Digital Input	Digital signal (MFI1D), 0 V ... 24 V
4 – Voltage Input Bipolar -10 .. 10V	Voltage signal (MFI1A), ±10 V
11 – Motor PTC	PTC thermistor connection
12 – Motor KTY	KTY thermistor connection
13 – Motor PT1000	PT1000 thermistor connection

The sampling rate of multi-function input MFI1D is slower than that of digital signals MF4ID/STOA, S2IND, etc. For this reason, this input should only be used for signals which are not time-critical.

16.1.1 Analog input MFI1A

Multifunction input MFI1 is configured by default for an analog reference value source with a voltage signal of 0 V to 10 V or -10 V to 10 V.
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 fault message "F1407" displayed if the maximum figure is exceeded.

16.1.1.1 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.

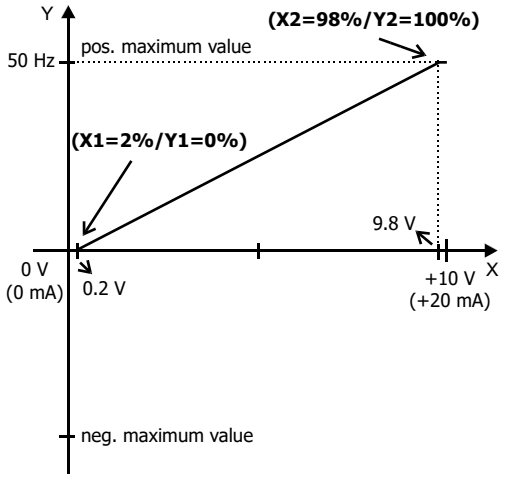
Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
454	Point X1	0.00 %	100.00 %	2.00 %
455	Point Y1	-100.00 %	100.00 %	0.00 %
456	Point X2	0.00 %	100.00 %	98.00 %
457	Point Y2	-100.00 %	100.00 %	100.00 %

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 percentage reference* **519**. The direction of rotation can be changed via the digital inputs and/or by selection of the points.

WARNING

The monitoring of the analog input signal via the parameter *Error/Warning behavior* **453** requires the examination of the parameter *Characteristic point X1* **454**.

The following characteristic is set by default and can be adapted to the application via the parameters mentioned.



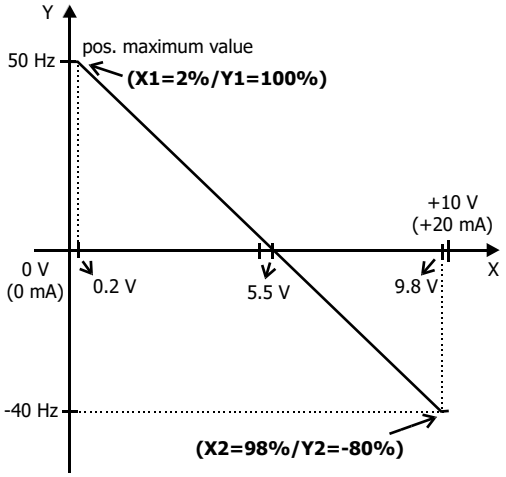
Point 1:

$$X1 = 2.00\% \cdot 10\ V = 0.20\ V$$
$$Y1 = 0.00\% \cdot 50.00\ Hz = 0.00\ Hz$$

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:

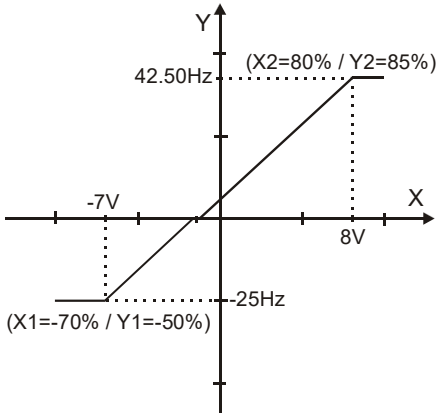
$$X2 = 98.00\% \cdot 10\ V = 9.80\ V$$
$$Y2 = -80.00\% \cdot 50.00\ Hz = -40.00\ Hz$$

The reversal of the direction of rotation is affected in this example at an analog input signal of 5.5V.

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.

$$Y = \frac{Y2 - Y1}{X2 - X1} \cdot (X - X1) + Y1$$

The following characteristic shows an example of a bipolar analog signal:



Point 1:

$$X1 = -70.00\% \cdot 10\ V = -7.00\ V$$
$$Y1 = -50.00\% \cdot 50.00\ Hz = -25.00\ Hz$$

Point 2:

$$X2 = 80.00\% \cdot 10\ V = 8.00\ V$$
$$Y2 = 85.00\% \cdot 50.00\ Hz = 42.50\ Hz$$

The reversal of the direction of rotation is affected in this example at an analog input signal of -1.44V.

16.1.1.2 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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

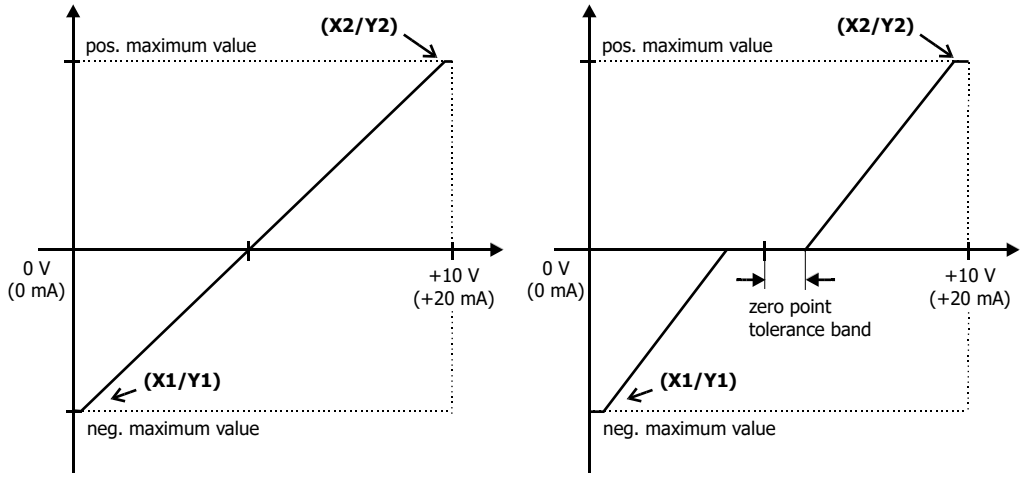
The control system uses the maximum value of the output frequency, which is calculated from the *Maximum Frequency* **419** and the compensated slip of the drive. The frequency limits define the speed range of the drive, and the percentage values supplement the scaling of the analog input characteristic in accordance with the functions configured.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
518	Minimum Reference Percentage	0.00 %	300.00 %	0.00 %
519	Maximum Reference Percentage	0.00 %	300.00 %	100.00 %

16.1.1.3 Tolerance Band and Hysteresis

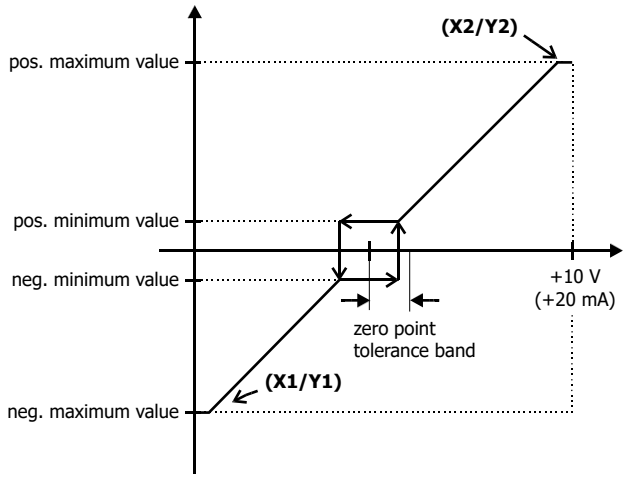
The analog input characteristic with change of sign of the reference value can be adapted by the parameter *Tolerance band* **450** of the application. The adjustable tolerance band extends the zero passage of the speed relative to the analog control signal. The parameter value (percent) is relative to the maximum current or voltage signal.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
450	Tolerance band	0.00 %	25.00 %	2.00 %



Without tolerance band **With tolerance band**

The default *Minimum Frequency* **418** or *Minimum Percentage* **518** extends the parameterized tolerance band to the hysteresis.



Tolerance band with set minimum 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.

16.1.1.4 Filter Time Constant

The time constant of the filter for the analog reference value can be set via the 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	

16.1.1.5 Error and warning behavior

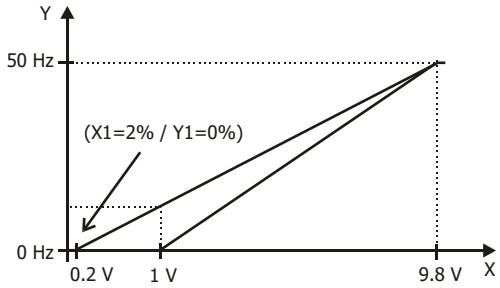
For monitoring the analog input signal, an operation mode can be selected via parameter *Error/warning behavior* **453**.

Error/Warning Behavior 453		Function
0 -	Off	The input signal is not monitored.
1 -	Warning < 1V/2mA	If the input signal is lower than 1 V or 2 mA, a warning message is issued.
2 -	Shut Down < 1V/2mA	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/2mA	If the input signal is lower than 1 V or 2 mA, a warning and fault message 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 (like described for stopping behavior 0), 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 - Stop < 1V/2mA" or "3 – fault switch-off < 1V/2mA". In the factory settings of the parameter *Point X1* **454** shutting down or fault switch-off are affected at an output frequency ≠ 0 Hz. If shutting down or fault switch-off are to be affected at an output frequency of 0 Hz, the Point X1 must be adjusted (e.g. X1=10% /1 V).



16.2 Multi-Function I/O MF2

Multifunction In-/Output X210B:4 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 -	Digital Input MF2ID	Digital input, 0...24 V.
1 -	Digital Output	Digital output, 0...24 V.
2 -	Analog Output	Analog output, 0...24 V.

16.2.1 Analog output MF2OA

By default, the multifunction output MFO1 is configured for the output of a pulse width modulated output signal with a maximum voltage of DC 24 V.
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**.
4 -	Abs. Speed Sensor 2	Abs. value of speed sensor signal 2, 0.00 Hz ... *Maximum frequency* **419**.
5 -	Abs. Speed Sensor 3	Abs. value of speed sensor signal 3, 0.00 Hz ... *Maximum frequency* **419**.
7 -	Abs. Actual Frequency	Abs. value of act. frequency, 0.00 Hz ... *Maximum frequency* **419**.
10 -	Abs. Ref. Percentage	Abs. value of ref. percentage, 0.00 % ... *Maximum Reference Percentage* **519**.

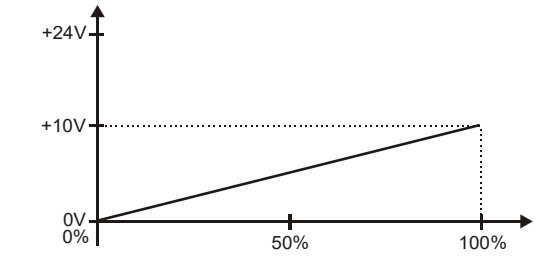
Analog operation 553		Function
11 -	Abs. Ref. Percent. betw. %min / %max	Abs. value of ref. percentage betw. %min / %max *Minimu Reference Percentage* **518**... *Maximum Reference Percentage* **519**.
20 -	Abs. Iactive	Abs. value of current effective current I_{Active}, 0.0 A ... FU rated current.
21 -	Abs. Isd	Abs. value of flux-forming current component, 0.0 A ... FU rated current.
22 -	Abs. Isq	Abs. value of torque-forming current component, 0.0 A ... FU rated current.
30 -	Abs. Pactive	Abs. value of current active power P_{Active}, 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. Analog Input MFI1A	Abs. signal value on analog input 1, 0.0 V ... 10.0 V or -10 V .. 10 V.
41 -	Abs. Analog Input EM-MFI1A	Abs. signal value on analog input 1 of EM, 0.0 V ... 10.0 V or -10 V .. 10 V.
50 -	Abs. I	Abs. current value of measured output currents, 0.0 A ... FU rated current.
51 -	DC –Link Voltage	DC link voltage du, 0.0 V ... 1000.0 V.
52 -	V	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 ... *Reference pressure* **398**.
61 -	Abs. Val. FT-Output percentage 1	Abs. value of FT-Output percentage 1, 0.00 % ... 327.67%.
62 -	Abs. Val. FT-Output percentage 2	Abs. value of FT-Output percentage 2, 0.00 % ... 327.67%.
101 to 162		Operation modes in analog operation with signs.

16.2.1.1 Output Characteristic

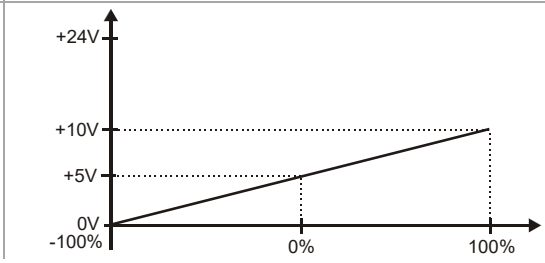
The voltage range of the output signal at multifunction output 1 can be adjusted. The value range of the actual value selected via parameter *Analog operation* **553** is assigned to the value range of the output signal which is adjusted via the parameters *Voltage 100%* **551** and *Voltage 0%* **552**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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. act. value:**



Analog operation 553 **with signs:**



With the 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 24V.

16.3 Digital Outputs

The Op. *Mode Multi-function-I/O MF3 X210B.3* **530** and the relay output with the parameter Op. *Mode Digital output 3* **532** link the digital outputs to various functions. The selection of the functions depends on the parameterized configuration. The use of the multifunctional input/output 1 as a digital output demands selection of an *Operation mode* **550** and linking via parameter *Digital operation* **554**.

Operation mode 530,532,554	Function
0 - Off	No digital operation. With the parameter Op. Mode *Digital output 3* **532** the function is 0 – Digital Input S8IND.
1 - Ready or Standby Signal	Frequency inverter is initialized and on stand-by or in operation.
2 - Run Signal	Signal enable STO (MF4ID/STOA and S7IND/STOB) and a start command are present, output frequency available.
3 - Error Signal	Message is displayed via the parameter *Current error* **259** or *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* **230** has reached the *Reference percentage* **229**.
7 - Ixt warning	The *Warning Limit Short-Term Ixt* **405** or *Warning Limit Long-Term Ixt* **406** has been reached.
8 - Warning Heat sink temperature	Max. heat sink temperature T_K of 80 °C minus the *Warning Limt Heat Sink Temp.* **407** reached.
9 - Warning Inside temperature	Max. inside temperature T_i of 65 °C minus the *Warning Limit Inside Temp.* **408** reached.
10 - Warning Motor Temperature	Warning behavior according to parameterized *Operation mode Motor temperature* **570** at max. motor temperature T_{PTC}.
11 - Warning General	The message is displayed via parameter *Warnings* **269**.
12 - Warning overtemperature	The selected limit values *Warning Limit Heat Sink Temp.* **407**, *Warning limit Inside Temp.* **408** or the maximum motor temperature has been 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 Protect. Switch	Parameterized *Operation Mode* **571** for the motor protection switch has triggered.
15 - Warning Current Limitation	A controller or the *Operation Mode* **573** of the intelligent current limits limits 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 *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 *Operation mode Comparator 1* **540** is true.
21 - Comparator 2	The comparison according to the selected *Operation mode Comparator 2* **543** is true.
22 - Warning V-belt	Warning of *Operation Mode* **581** of V-belt monitoring.

Operation mode 530,532,554	Function
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	Warning application is signaled. Display of the actual value is affected via parameter *Warnings Application* **273**.
27 - Warning Mask, Application	Message of the configurable parameter *Create Warning Mask Application* **626.**
28 - Warning, gen + Warning, Application	Warning or warning application is signaled.
29 - Warn. Mask, gen + Warn. Mask, Appl.	Message of configurable parameters *Create Warning Mask* **536** and *Create Warning Mask Application* **626**.
30 - Flux-Forming finished	Magnetic field has been impressed.
41 - Brake release	Activation of a brake unit depending on the *Operation Mode* **620** for the starting behavior, *Operation Mode* **630** for the stopping behavior or the configured brake control system.
43 - External Fan	The *Switch-On Temperature* **39** has been reached.
50 - Synchronization Fault [1)]	The phase error of the index control exceeded the *Warning limit* **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 *Switch-on position* **1243** and *Switch-off position* **1244** of the position comparator. The adjusted value of the parameter *Hysteresis* **1245** is considered.
59 - Homing Done [2)]	A reference travel operation was started and the reference position for positioning was set.
60 - Target Position Reached	*Reference orientation* **469** of axle positioning was reached or *Target position / Distance* **1202** of a positioning [2)] 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**).
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 conditions set for *parameter Digital Signal 1* **1218** were fulfilled. "Start", "Reference value reached" and "End" of a travel order were evaluated.
63 - Motion-Block Digital Signal 2 [2)]	Message on status of a travel order during a positioning operation. The conditions set for *parameter Digital Signal 2* **1219** were fulfilled. "Start", "Reference value reached" and "End" of a travel order were evaluated.
64 - Motion-Block Digital Signal 3 [2)]	Message on status of a travel order during a positioning operation. The conditions set for *parameter Digital Signal 3* **1247** were fulfilled. "Start", "Reference value reached" and "End" of a travel order were evaluated.
65 - Motion-Block Digital Signal 4 [2)]	Message on status of a travel order during a positioning operation. The conditions set for *parameter Digital Signal 4* **1248** were fulfilled. "Start", "Reference value reached" and "End" of a travel order were evaluated.

Operation mode 530,532,554	Function
80 - FT-Output Buffer 1 [3)]	The output signal of a function table instruction. The output signal is the signal source „2401 - FT-Output buffer 1". The signal source contains the value of the FT-instruction output, which is assigned to the signal source 2401. The assignment is done by parameter *FT-target output 1* **1350** or *FT-target output 2* **1351**.
81 - FT-Output Buffer 2 [3)]	The output signal of a function table instruction. The output signal is the signal source „2402 - FT-Output buffer 2". The signal source contains the value of the FT-instruction output, which is assigned to the signal source 2402. The assignment is done by parameter *FT-target output 1* **1350** or *FT-target output 2* **1351**.
82 - FT-Output Buffer 3 [3)]	The output signal of a function table instruction. The output signal is the signal source „2403 - FT-Output buffer 3". The signal source contains the value of the FT-instruction output, which is assigned to the signal source 2403. The assignment is done by parameter *FT-target output 1* **1350** or *FT-target output 2* **1351**.
83 - FT-Output Buffer 4 [3)]	The output signal of a function table instruction. The output signal is the signal source „2404 - FT-Output buffer 4". The signal source contains the value of the FT-instruction output, which is assigned to the signal source 2404. The assignment is done by parameter *FT-target output 1* **1350** or *FT-target output 2* **1351**.
90 to 94 Obj 0x3003 DigOut 1 [4)] to Obj 0x3003 DigOut 5	Sources of CAN-objects. For communication module CM with CAN interface necessary.
95 - M/S Position Correction Done [32]	The master and slave operation was started and the position correction was done.
96 - M/S Position Correction Successful [2)]	The master and slave operation was started and the position correction was successful.
100 to 196	Operation modes inverted (LOW active)

1) Refer to the application manual "Electronic gear" for further details.
2) Refer to the application manual "Positioning" for further details.
3) Refer to the application manual "Function table" for further details.
4) Refer to the operating instructions of the expansion module with CAN interface.

16.3.1 Digital Signal

The signals selected for parameters Op. Mode *Multi-function-I/O MF3 X210B.3* **530**, *Digital Operation* **554** and Op. Mode *Digital Output 3* **532** can be linked with inverter functions.

Signal at digital input/output 1

175 -	Digital Signal 1	The Signal which is selected via Op. *Mode Multi-function-I/O MF3 X210B.3* **530**.

Signal at multifunction output MFO1

176 -	Digital Signal 2	The Signal which is selected via *Digital Operation* **554**. Set *Operation Mode* **550** = 1 - Digital.

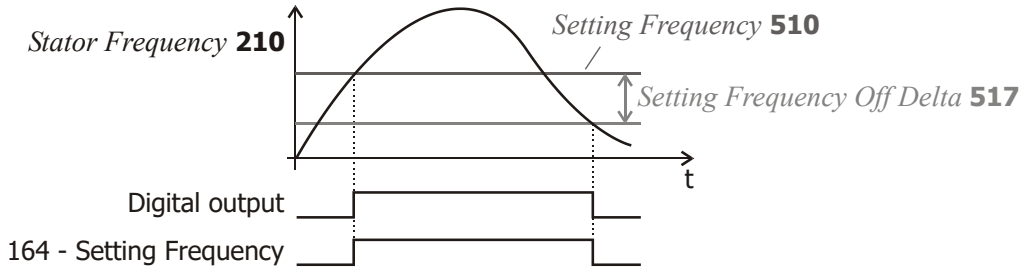
Signal at digital output 3 (relay output)

177 -	Digital Signal 3	The Signal which is selected via *Op. Mode Digital Output 3* **532**.

16.3.2 Setting Frequency

If operation mode 4 - "Setting Frequency" is selected for a digital output, the corresponding output becomes active if the actual value *Stator Frequency* **210** exceeds the value of *Setting Frequency* **510**. The relevant output is switched over again as soon as the *Stator Frequency* **210** falls below the value of "*Setting Frequency* **510** minus *Setting Frequency Off Delta* **517**". If the output stage is switched off (in example via STO), the digital signal "Setting frequency" is set to zero independent of the actual frequency.
Signal source 164 - "Setting Frequency" can be linked with inverter functions.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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



If *Setting Frequency Switch Off Delta* **517** > *Setting Frequency* **510** the output is never reset after the first switching on. Set up fitting values during commissioning.

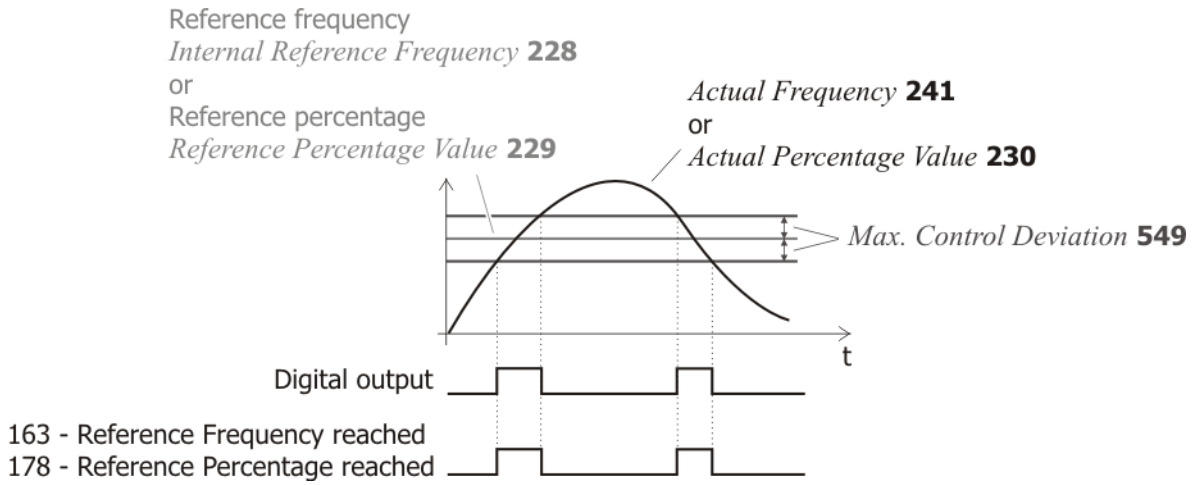
Multi-function-I/O MF3 X210B.3 **530**	or	4 - Setting Frequency
Op. Mode Digital Output 3 **532**		
Setting Frequency **510**		Set value [Hz]
For linking with functions		164 - Setting Frequency

16.3.3 Reference value reached

In operation mode 5 - "Reference Frequency reached" for a digital output, a signal is generated via the corresponding output when the actual frequency has reached the reference value.
In operation mode 6 - "Reference Percentage reached" for a digital output, a signal is generated via the corresponding output when the actual percentage value has reached the reference value.
Signal source 163 - "Reference Frequency reached" or 178 - "Reference Percentage reached" can be linked with inverter functions.
The hysteresis can be defined as a percentage of the adjustable range (Max - Min) via parameter *Max. Control Deviation* **549**.

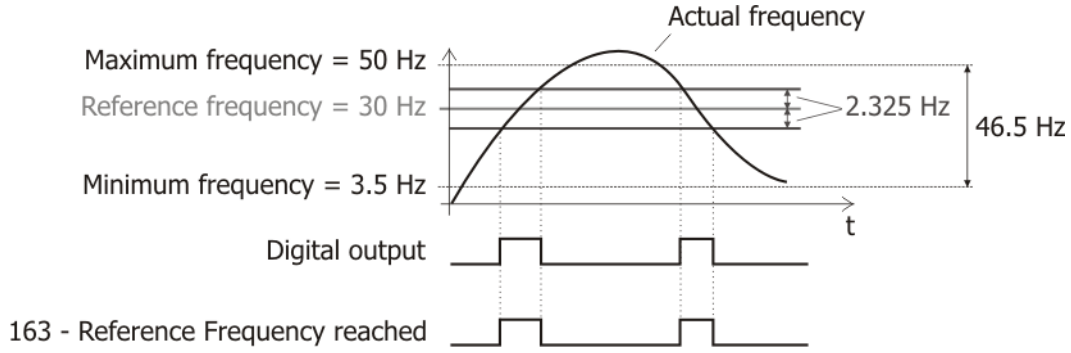
Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
549	Max. Control Deviation	0.01 %	20.00 %	5.00 %

Multi-function-I/O MF3 X210B.3 **530**	or	5 - Reference Frequency reached or 6 - Reference Percentage reached (*Configuration* **30** = x11, x30)
Op.Mode Digital Output 3 **532**		
Max. Control Deviation **549**		Set value [%].



Example:

$$\text{Max. Control Deviation [Hz]} = \Delta f \times \textit{Max. Control Deviation}\ \mathbf{549}\,[\%]$$
$$= (\textit{Maximum Frequency}\ \mathbf{419} - \textit{Minimum Frequency}\ \mathbf{418}) \times \textit{Max. Control Deviation}\ \mathbf{549}\,[\%]$$
$$= (50\,\text{Hz} - 3.5\,\text{Hz}) \times 5\% = 2.325\,\text{Hz}$$



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 ended. 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 Open brake 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. When the *Brake release time* **625** has elapsed, the drive is accelerated.
The stopping behavior of the drive depends on the configuration of the parameters *Operation Mode* **630**. This is described in chapter "Stopping Behavior".
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-Open brake" 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-Open brake" switches off the digital output assigned to the function when *Switch-Off Threshold* **637** is reached. The mechanical brake is activated.
Stopping Behavior 2, 5	Operation mode "41-Open brake" 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 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.

16.3.8 Warning Mask

The Warning mask signals via a digital signal if an afore configured warning applies. The configuration of the Warning mask is carried out 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 *Warning* **269** and *Controller Status* **275** is not affected by the Warning mask.

- Select a setting 1 … 43 for message activation.
- Select a setting 101 … 143 for deactivation of a message.

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 less the *Warning limit short-term Ixt* **405** has been reached.
12 - Warning Long-Term Ixt	Overload reserve for 60 s less the *Warning limit long-term Ixt* **406** has been reached.
13 - Warning Heat Sink Temperature	Max. heat sink temperature T_K of 80 °C minus the *Warning Limit Heat Sink Temp.* **407** has been reached.
14 - Warning Inside Temperature	Max. inside temperature T_i of 65 °C minus the *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 - Warning Motor Temperature	Warning behavior according to parameterized *Operation mode Motor temperature* **570** at max. motor temperature T_{PTC}.
18 - Warning Mains Failure	*Phase monitoring* **576** reports a phase failure.
19 - Warning Motor Protective Switch	*Operation Mode* **571** for the motor protective switch has triggered.
20 - Warning Fmax	The *Maximum frequency* **419** has been exceeded. The frequency limitation is active.
21 - Warning Analog Input MFI1A	The input signal is lower than 1 V/2 mA according to the operation mode *Error/Warning Behavior* **453**.

Create Warning Mask 536	Function
22 - Warning Analog Input MF4IA	The input signal on the analog input of an expansion module is lower than 1V/2mA according to the operation mode *Error/Warning Behavior* **453**.
24 - Warning Udc	The DC link voltage has reached the type-dependent minimum value.
25 - Application Warning	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 UD 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 is limited by the speed controller.
37 - Controller Torque Control	Switch-over of field-oriented control between speed and torque-controlled.
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 the intelligent current limits active.
42 - Contr. Intel. Curr. Lim. Motor Temp.	Max. motor temperature T_{PTC} reached, *Operation Mode* **573** for the intelligent current limits active.
43 - Controller Freq. 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 selected warning mask can be read out via the 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 results from hexadecimal addition of the individual operation modes and the matching 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 - Warning Motor Temperature
A	0000	0100	Mains	18 - Warning Mains Failure
A	0000	0200	PMS	19 - Warning Motor Protective Switch
A	0000	0400	Flim	20 - Warning Fmax

Warning code				*Create Warning Mask* 536
A	0000	0800	A1	21 - Warning Analog Input MFI1A
A	0000	1000	A2	22 - Warning Analog Input MFI2A
A	0000	2000	Sysbus	23 - Warning Systembus
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

The selected warning mask can be read out 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.

Output signals

The output of a warning message is signaled.

157 - 25 -	Warning Mask	1) 2)	Output of a warning message which is activated in *Create Warning Mask* **536**.

1) For linking with inverter functions
2) For digital output

Parameter *Warning* **269** and *Warning* **356** (error environment) show the warnings independent from the created Warning mask.
Parameter *Controller Status* **275** and *Controller Status* **355** (error environment) show the Controller Status independent from the created Warning mask.

16.3.9 Application warning mask

The Application Warning mask signals via a digital signal if an afore configured warning applies. The configuration of the Application Warning mask is carried out via *Create Appl. Warning Mask* **626**.
As soon as limit switches are reached or contouring error limits are exceeded, a warning can be issued. The warnings refer 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 *Warning Application* **273** is not affected by 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	The *Operation mode* **581** for V-belt monitoring 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 *Positive SW limit switch* **1145**).

Create Appl. Warning Mask 626	Function
12 - Warning neg. SW-Limit-Switch [1)]	Warning message indicating that the negative SW limit switch has been reached (parameter *Negative 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 trigger a warning. Selection is not effective with encoders without data track.
17 - Warning User 1	The signal set on digital input *User Warning 1* **1363** is active.
18 - Warning User 2	The signal set on 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 Warning User 1	Warning 17 is deactivated.
118 - Deactivate Warning User 2	Warning 18 is deactivated.

[1)] Refer to the application manual "Positioning" for further details.

The selected warning mask application can be read out via the parameter *Actual Appl. Warning Mask* **627**. The above operation modes of parameter *Create Appl. Warning Mask* **626** are encoded in the *Actual Appl. Warning Mask* **627**. The code results from hexadecimal addition of the individual operation modes and the matching 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 - Warning User 1
A	0100	User 2	18 - Warning User 2

Output signals

The output of a warning message is signaled.

215 - 27 -	Warning Mask, Application	**1)** **2)**	Output of a warning message which is activated in *Create Appl. Warning Mask* **626**.

[1)] For linking with inverter functions
[2)] For digital output

Parameter *Warning Application* **273** shows the Application Warnings independent from the created Warning mask.
In the error environment, *Application Warning Status* **367** shows the current warnings of the positioning functions independent from the created Warning mask.

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 the 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 - Iverter Release [1]	Signal on digital input MF4ID/STOA (X210A.3) and S7IND/STOB (X210B.2); the safety function STO is linked permanently.
71 - S2IND	Signal on digital input S2IND (X210A.4) or remote operation via communication interface.
72 - S3IND	Signal on digital input S3IND (X210A.5) or remote operation via communication interface.
73 - S4IND	Signal on digital input S4IND (X210A.6) or remote operation via communication interface.
74 - S5IND	Signal on digital input S5IND (X210A.7) or remote operation via communication interface.
75 - S6IND	Signal on 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 remote 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 connection *Timer 1* **83**.
159 - Timer 2	Output signal of the time function according to the input connection *Timer 2* **84**.
160 - Ready Signal	Frequency inverter is initialized and ready for operation.
161 - Run Signal	Signal enable STO (MF4ID/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 when the *Actual frequency* **241** has reached the reference frequency.
164 - Setting Frequency	Signal when the actual value *Stator Frequency* **210** exceeds the value of *Setting Frequency* **510**.
165 - Warning Ixt	The monitoring functions report an overload of the frequency inverter.
166 - Warning Heat Sink Temperature	Max. heat sink temperature T_K of 80 °C less the *Warning Limit Heat Sink Temp.* **407** reached.
167 - Warning Inside Temperature	Max. inside temperature T_i of 65 °C less 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}.

[1] Refer to the application manual "Safe Torque Off" for further details.

Digital Inputs		Function
169 - General Warning		Signal when *Warnings* **269** are displayed with a critical operating point.
170 - Warning Overtemperature		The value – "80 °C minus *Warning Limit Heat Sink Temp.* **407**" or – "65 °C minus *Warning Limit Inside Temp.* **408**" is reached.
171 - Output Comparator 1		The comparison according to the selected *Operation 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 *Operation 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 parameter *Multi-function-I/O MF3 X210B.3* **530**.
176 - Digital Signal 2		Signal according to parameter *Digital Operation* **554** on multi-functional output MFO1.
177 - Digital Signal 3		Signal according to parameter *Operation mode digital output 3* **532**.
178 - Reference Percentage reached		Signal when the *Actual percentage* **230** has reached the *reference percentage* **229**.
179 - Mains Failure		Failure of the mains voltage and power regulation active according to *Operation Mode* **670** for the voltage controller.
180 - Warning Motor Protection Switch		Parameterized *Operation Mode* **571** of the motor protection switch has triggered.
215 - Warning Mask, Application		The defined warning mask of parameter *Create Appl. Warning Mask* **626** signals a critical operating point.
216 - Application Warning		All warnings application are activated. Display is affected via parameter *Application Warnings* **273**.
270 to 276		Operation modes 70 to 76 of the digital inputs inverted (LOW active).
282 - Target Position Reached	[1]	*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**).
284 - STOA inverted	[2]	Inverted signal status on digital input MF4ID/STOA (first shutdown path STOA of safety function STO - „Safe Torque Off").
285 - STOB inverted	[2]	Inverted signal status on digital input S7IND/STOB (second shutdown path STOB of safety function STO - „Safe Torque Off").
292 - STOA	[2]	Signal status on digital input MF4ID/STOA (first shutdown path STOA of safety function STO - „Safe Torque Off").
293 - STOB	[2]	Signal status on digital input S7IND/STOB (second shutdown path STOB of safety function STO - „Safe Torque Off").
320 - MF4ID	[3]	Signal on digital input 1 of an expansion module EM or remote operation via communication interface.
321 - REMOTE 1	[3]	Signal on digital input 2 of an expansion module EM or remote operation via communication interface.
322 - REMOTE 2	[3]	Signal on digital input 3 of an expansion module EM or remote operation via communication interface.
520 - MF4ID inverted	[3]	Operation mode 320 inverted.
521 - REMOTE 1 inverted	[3]	Operation mode 321 inverted.
522 - REMOTE 2 inverted	[3]	Operation mode 322 inverted.

[1] Refer to the application manual "Positioning" for further details.
[2] Refer to the application manual "Safe Torque Off" for further details.
[3] Refer to the operating instructions of the expansion modules with digital inputs.

Digital Inputs		Function
526 - S2IND (Hardware)	1	Digital input S2IND (X210A.4)
527 - S3IND (Hardware)		Digital input S3IND (X210A.5)
528 - S4IND (Hardware)		Digital input S4IND (X210A.6)
529 - S5IND (Hardware)		Digital input S5IND (X210A.7)
530 - S6IND (Hardware)		Digital input S6IND (X210B.1)
532 - EM-MF4ID (Hardware)		Digital input 1 of an expansion module EM.
538 to 546		Operation modes 526 to 534 of the digital inputs inverted (LOW active).
547 – MF3ID		Signal on multifunction input MF3ID (X210B.3).
548 – MF2ID		Signal on multifunction input MF2ID (X210B.4).
549 and 550		Operation modes 547 and 548 of the digital inputs inverted (LOW active).
551 – MF3ID		Multifunction input MF3ID (X210B.3).
552 – MF2ID		Multifunction input MF2ID (X210B.4).
553 and 554		Operation modes 553 and 554 of the digital inputs inverted (LOW active).
604 - Warning Position Controller	2	Contouring error monitoring message. The contouring error monitoring range adjusted with parameter *Warning Threshold* **1105** was left.
614 - Homing Done		A homing operation was started and the reference position for positioning was set.
615 - Homing Requested		A homing operation was started. The signal is reset at the end of the reference travel operation.
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	3	Synchronization of the electronic gear is reached. The slave drive is engaged and operates at a synchronous angle with the master.
691 - Index Contr.: Warn. Phase Error	4	The phase error of the index control exceeded the *Warning limit* **597**.
692 - Index Contr.: Warning Period		Index signal period too short during index control.
700 - RxPDO1 Boolean1	5	Signal if an optional expansion module EM with system bus is used.
701 - RxPDO1 Boolean2		Signal if an optional expansion module EM with system bus is used.
702 - RxPDO1 Boolean3		Signal if an optional expansion module EM with system bus is used.
703 - RxPDO1 Boolean4		Signal if an optional expansion module EM with system bus is used.
710 to 713		Operation modes 700 to 703 for RxPDO2 with an expansion module EM with system bus.
720 to 723		Operation modes 700 to 703 for RxPDO3 with an expansion module EM with system bus.
730 - Sysbus Emergency		Signal if an optional expansion module EM with system bus is used.
810 to 814 Obj 0x3003 DigOut 1 to Obj 0x3003 DigOut 5	6	Source of CAN objects for CANopen-communication. Module CM with CAN interface necessary.

[1] The digital signal is independent of the configuration of the parameter *Local/Remote* 412.
[2] Refer to the application manual "Positioning" for further details.
[3] Refer to the application manuals "Positioning" and "Electronic gear" for further details.
[4] Refer to the application manual "Electronic gear" for further details.
[5] Refer to the operating instructions of the expansion modules with system bus.
[6] Refer to the operating instructions of the expansion modules with CAN interface.

Digital Inputs			Function
832 to 847	Obj 0x3005 Demux Out 1 to Obj 0x3005 Demux Out 16		Source of the demultiplexer output for CANopen-communication. Module CM with CAN interface necessary.
876 -	Position Comparator Out	[1]	The current actual value is in the range between *Switch-on position* **1243** and *Switch-off position* **1244**.
877 -	Position Comparator Out inverted		Operation mode 876 inverted.
887 -	MBC: Start Clockwise		Message clockwise operation of positioning controller.
888 -	MBC: Start Anticlockwise		Message anticlockwise operation of positioning controller.
891 -	Motion-Block Digital Signal 1		Message on status of a travel order during a positioning operation. The conditions set for *parameter Digital Signal 1* **1218** were fulfilled. „Start", „Reference value reached" and „End" of a travel order were evaluated.
892 -	Motion-Block Digital Signal 2		Message on status of a travel order during a positioning operation. The conditions set for *parameter Digital Signal 2* **1219** were fulfilled. „Start", „Reference value reached" and „End" of a travel order were evaluated.
893 -	Motion-Block Digital Signal 3		Message on status of a travel order during a positioning operation. The conditions set for *parameter Digital Signal 3* **1247** were fulfilled. „Start", „Reference value reached" and „End" of a travel order were evaluated.
894 -	Motion-Block Digital Signal 4		Message on status of a travel order during a positioning operation. The conditions set for *parameter Digital Signal 4* **1248** were fulfilled. „Start", „Reference value reached" and „End" of a travel order 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	[2]	Bit 0 to Bit 15 on output of de-multiplexer; de-multiplexed process data signal via system bus on input of multiplexers (parameter *DeMux Input* **1253**).
2401 to 2416	FT-Output Buffer 1 to FT-Output Buffer 16	[3]	Output signals from FT-instructions of the function table.

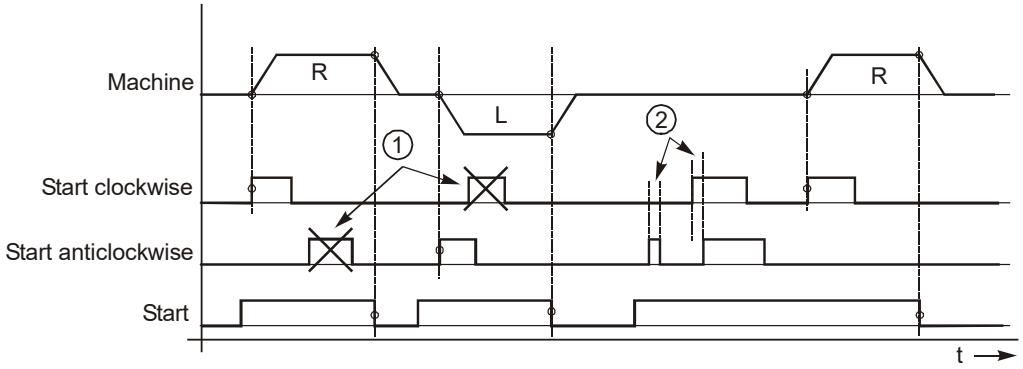
16.4.1 Start command

The 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 control* **87** and started by a Start clockwise pulse (Parameter *Start clockwise* **68**) or a Start anticlockwise pulse (*Parameter Start anticlockwise* **69**). By switching off the signal *Start 3-wire control* **87**, the drive is stopped.
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 control* **87** is switched on. Latching is cancelled when the latching signal is switched off.

[1] Refer to the application manual "Positioning" for further details.
[2] Refer to the operating instructions of the expansion modules with system bus interface.
[3] Refer to the application manual "Function Table" for further details.



(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 control* **87** is switched 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 -	Control 3-wire, sense of rot. via contacts	3-wire; control of direction of rotation and signal *3-wire control* **87** via contacts.
46 -	Control via 3-wire + KP, dir. of rot. via contacts + KP	3-wire and control unit; control of direction of rotation and signal *3-wire control* **87** via contacts or control unit.

For further operation modes of parameter *Local/Remote* **412**, refer to chapter „Bus Controller".

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 report can be given via the parameter *Program(ming)* **34** or the logic signal can be acknowledged with parameter *Error acknowledgment* **103**.

16.4.4 Timer

The time functions can be selected via the parameters *Operation mode Timer 1* **790** and *Operation mode Timer 2* **793**. The sources of the logic signals are selected with the parameters *Timer 1* **83** and *Timer 2* **84** and processed according to the configured timer functions.

16.4.5 Thermo contact

The monitoring of the motor temperature is a part of the error and warning behavior which can be configured as required. The parameter *Thermocontact* **204** links the digital input signal to the defined *Operation mode* **570** which is described in chapter 14.6 "Motor Temperature". The temperature monitoring via a digital input checks the input signal for the threshold value. Accordingly, a thermocontact 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, 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**.

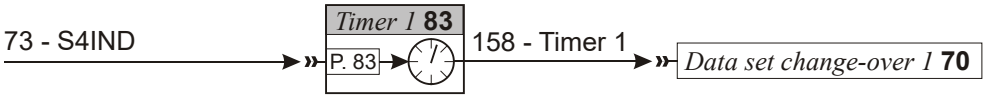
16.4.7 Data Set Change-Over

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 with the 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.

Activation		
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

If *Configuration* **30** = 110, 111, 410, 411, 430, 510, 530, 610, 611 or 630 is selected, in the factory setting a timer function is interconnected between the digital input S4IND and the data set change-over 1.



The data set change-over 1 is linked with timer 1:
Data set change-over 1 **70** = 158 – Timer 1
Timer 1 is linked with the digital input S4IND (terminal X210A.6):
Timer 1 = 73 – S4IND
In the factory setting the data set change-over 1 is not affected by the 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

As a function of the selected configuration, the reference figures are specified 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 the parameters *Fixed frequency change-over 1* **66**, *Fixed frequency change-over 2* **67** or the parameters *Fixed percent change-over 1* **75**, *Fixed percent change-over 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 frequencies 1 through 4 can be selected:

Fixed Percentage Control		
Fixed percentage change-over 1 **75**	*Fixed percentage change-over 2* **76**	Function / active fixed value
0	**0**	*Fixed Percentage* 1 **520**
1	**0**	*Fixed Percentage 2* **521**

Fixed Percentage Control		
Fixed percentage change-over 1 **75**	*Fixed percentage change-over 2* **76**	Function / active fixed value
1	**1**	*Fixed Percentage* 3 **522**
0	**1**	*Fixed Percentage* 4 **523**

0 = contact open 1 = contact closed

16.4.9 Motor Potentiometer

The parameters *Reference frequency source* **475**, and *Reference percentage source* **476** contain operation modes with motor potentiometer. The *Operation mode* **474** defines the behavior of the motor potentiometer function and the parameters *Frequency Motorpoti Up* **62**, *Frequency Motorpoti Down* **63** or *Percent Motorpoti Up* **72**, *Percent Motorpoti Down* **73** the connection with 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 shot-effect function. The shot-effect function is switched on via parameter *Operation mode* **435**.

16.4.11 User warning

For setting up external warnings parameters *User Warning 1* **1363** and *User Warning 2* **1364** can be used. Parameterization of a user warning enables triggering a warning in the device via a digital signal if a critical state in the plant occurs. The warning is displayed in *Warnings Application* **273** and can be transmitted to a higher-level control like a PLC. Please check parameter *Create warning mask application* **626** and chapter 16.3.9 „Application warning mask" for further explanations

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 *Operation 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 setting up external warnings parameters *User Warning 1* **1363** and *User Warning 2* **1364** can be used. Check chapter 16.3.9 „Application warning mask" for further details.

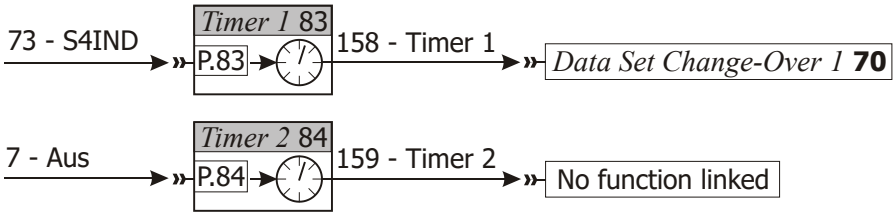
16.5 Function Modules

16.5.1 Timer

The timer function can be linked to various functions for time-control of digital signals.
The 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 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 delay in time 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 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 the digital signals (e.g. 73 - S4IND) are selected via the parameters *Timer 1* **83** and *Timer 2* **84**. In the factory setting Timer 1 is linked to digital input 4 and Timer 2 is switched off.
The output signal of the timer can be assigned to an inverter function or to a digital output. By default, *Data Set Change-Over 1* is linked to Timer 1 and Timer 2 is not linked.

Note:

The factory setting is *Time 2 Timer 1* **792** = 0. Signals at digital input S4IND are transmitted to the Data Set Change Over 1 without time delay.

Function	Parameter for input signal	Operation mode	Time constant	Function output signal	
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 with inverter functions
[2] For 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.

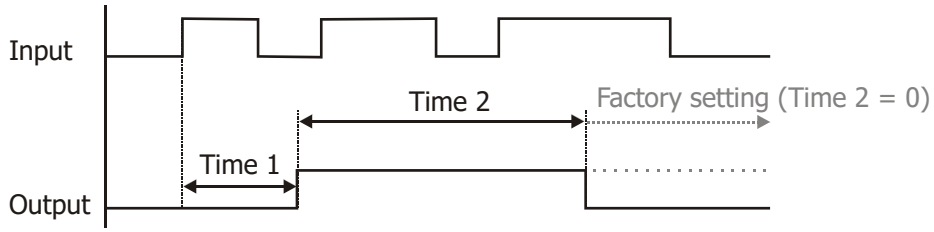
Select operation mode for:	Set time constants in:
Operation Mode Timer 1 **790**	*Time 1 Timer 1* **791** (signal delay) *Time 2 Timer 1* **792** (signal duration)
Operation Mode Timer 2 **793**	*Time 1 Timer 2* **794** (signal delay) *Time 2 Timer 2* **795** (signal duration)

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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

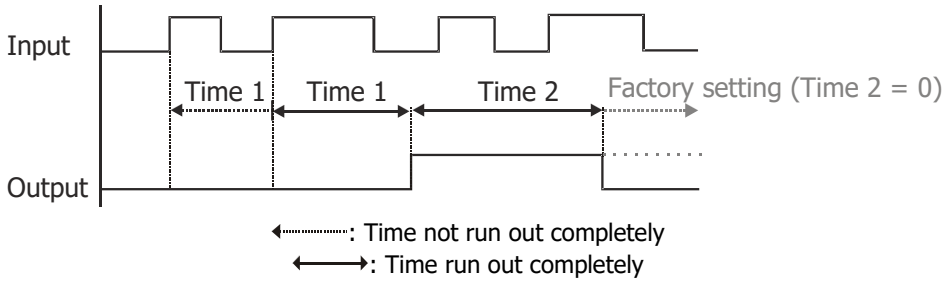
Parameter *Operation Mode Timer 1* **790** or *Operation Mode Timer 2* **793** = 1



As soon as the positive signal edge is received at the input, time 1 (signal delay) starts. After the expiry of time 1 (signal delay), the output signal is switched on for time 2 (signal duration).
In the settings of signal duration (*Time 2 Timer 1* **792** = 0 and *Time 2 Timer 2* **795** = 0) the timer does not reset the output signal.

Retrigger, positive edge

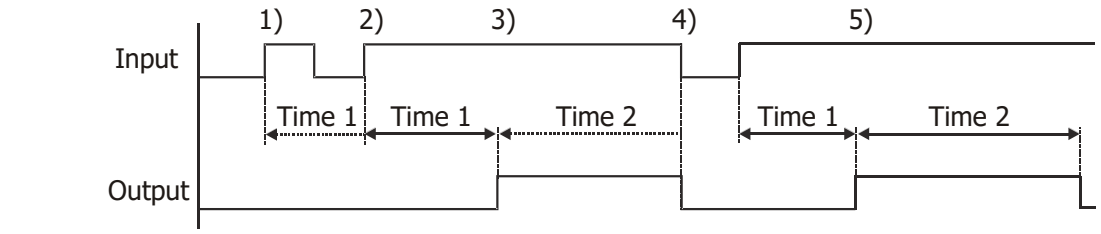
Parameter *Operation Mode Timer 1* **790** or *Operation Mode Timer 2* **793 =** 2



As soon as the positive signal edge is received at the input, time 1 (signal delay) is started. If a positive signal edge is detected within time 1(signal delay), time 1 starts again. After the expiry of time 1 (signal delay), the output signal is switched on for time 2 (signal duration).
In the settings of signal duration (*Time 2 Timer 1* **792** = 0 and *Time 2 Timer 2* **795** = 0) the timer does not reset the output signal.

AND connection, positive edge

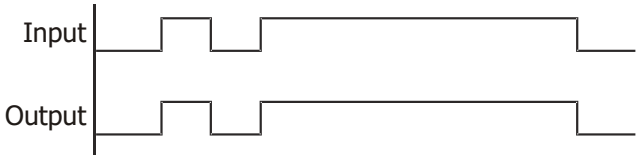
Parameter *Operation Mode Timer 1* **790** or *Operation Mode Timer 2* **793 =** 3



: Time not run out completely
: Time run out completely

[1] As soon as the positive signal edge is received at the input, time 1 (signal delay) is started.
[2] If a positive signal edge is detected within time 1 (signal delay), time 1 starts again (retrigger).
[3] After the expiry of time 1 (signal delay), the output signal is switched on for the time 2 (signal duration).
[4] Within the time 2 (signal duration), the output is switched off by the input signal (AND-connection).
[5] If the input signal is present during the whole time 2 (signal duration), the output signal remains on in this time.

Factory settings: Time 1= 0, Time 2 = 0



In the factory settings the output signal follows the input signal.

16.5.2 Comparator

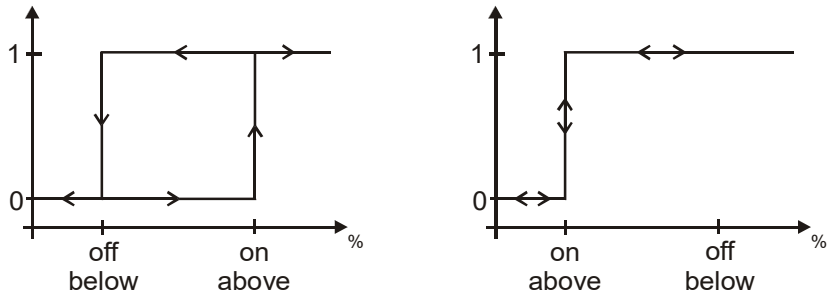
With the help of software functions Comparator 1 and 2, various comparisons of actual values with percentage-adjustable fixed values can be done.
The actual values to be compared can be selected from the following table with the parameters *Op. Mode Comparator 1* **540** and *Op. Mode Comparator 2* **543**.
If an expansion 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**.
4 - Abs. Actual Speed 1	*Speed Sensor 2 Speed* **220** > maximum 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 Temp., 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 - Abs. Analog Input MFI1A	*Analog Input MFI1A* **251** > input signal 100 %
100 to 107, 111, 112	Operation modes with signs (+/-).

The switch-on and switch-off thresholds for compactors 1 and 2 are set by the parameters *Comparator on above* **541**, **544** and *Comparator off below* **542**, **545**.
The percentage limits of the corresponding reference values are indicated.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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** = 7- Abs. Actual Frequency
Comparator On above **541** = 80.00 % (of *Maximum Frequency* **419**)
Comparator Off below **542 =** 50.00 % (of *Maximum Frequency* **419**)
Maximum Frequency **419**. = 50.00 Hz
Comparator will switch on if *Actual Frequency* **241** > 40.00 Hz
Comparator will switch off if *Actual Frequency* **241** < 25.00 Hz
Output signals
Digital signals indicate the result of the comparison.

Comparator 1

171 -	Output Comparator 1	1)	The comparison – selected via *Op. Mode Comparator 1* **540** – is true.
20 -	Comparator 1	2)	
172 -	Negated Output Comparator 1	1)	The comparison – selected via *Op. Mode Comparator 1* **540** – is true. The output level of the comparator is inverted.

Comparator 2

173 -	Output Comparator 2	1)	The comparison – selected via *Op. Mode Comparator 2* **543** – is true.
21 -	Comparator 2	2)	
174 -	Negated Output Comparator 2	1)	The comparison – selected via *Op. Mode Comparator 2* **543** – is true. The output level of the comparator is inverted.

1) For linking with inverter functions
2) For digital output

16.5.3 Function table

The function table allows to link external digital signals and internal logic signals of the frequency inverter with each other. Besides standard AND, OR and XOR combinations, different more advanced logic functions like RS Flip Flop are available. The corresponding output value can be used for further logic instructions and digital outputs. The logic instructions can be linked with each other for any complex interconnections.
Up to 32 logic instructions allow flexible adoption of various input signals.

Example:

A drive should start when:

- the enable signal AND the S5IND signal are set
  OR
- the enable signal AND the S6IND signal are set.

Refer to the application manual "Function table" for a more detailed description.

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 can be used.

Operation mode		Factory setting	
1252	Mux inputs	7 -	Off

The 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
1250	Mux input index (write) [1)]	0	33	1
1251	Mux input index (read)	0	33	1

1) Non-volatile (fixed parameterization):

0:	All indices in EEPROM
1…16:	One Index of 1…16 in EEPROM

Volatile:

17	All indices in RAM
18…33:	One Index of 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.

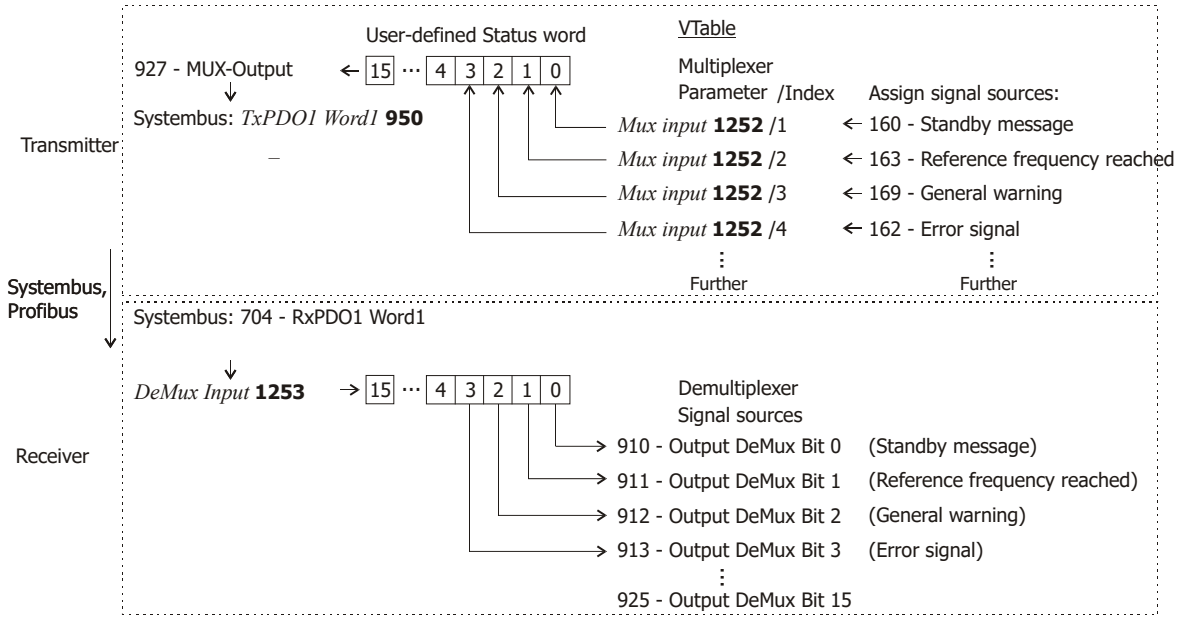
Demultiplexer:

The demultiplexer features an input *DeMux Input* **1253** whose signal can be for the process data RxPDO of the system bus.
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
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, 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. inputs* **1252** index 1 to index 16. (a setting for index 0 results in this setting being taken over for all other indices.)
- Assign a TxPDO process data parameter of the system bus to signal source "927 - Output MUX".

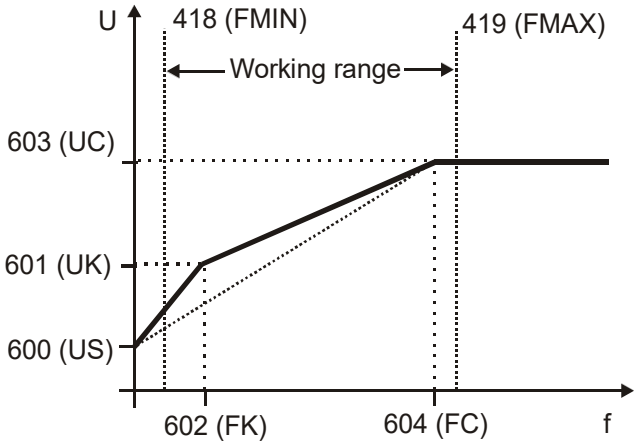
Settings on receiver:

- Assign the corresponding RxPDO signal sources of the system bus 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 rated 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 the parameter *Cut-off voltage* **603** and the 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**. An increase in voltage deviating from the linear course of the V/f-characteristic can be defined by the parameters *Voltage rise* **601** and *Rise frequency* **602**. The percentage parameter figure is calculated from the linear V/f-characteristic. Via the parameters *Minimum frequency* **418** and *Maximum frequency* **419**, the working range of the machine or the V/f-characteristic is 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 presetting the V/f-characteristic. In the case of three-phase 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.

$$U = \left[\left(\frac{UC - US}{FC - 0}\right) \cdot (FK \cdot FC) + US\right] \cdot (1 + UK) = \left[\left(\frac{400\ V - 5\ V}{50\ Hz - 0\ Hz}\right) \cdot (0.2 \cdot 50\ Hz) + 5\ V\right] \cdot 1.1 = \underline{\underline{92.4\ V}}$$

17.1 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 V/f characteristic is changed by addition of the calculated voltage pre-control.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 be 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 overload reserve of the frequency inverter can be used optimally by means of the intelligent current limits, in particular in applications with dynamic load alternations. The criterion to be selected via the 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 the 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 (T_C + T_{Motor}+ Ixt).

The threshold value selected via the 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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) there is a reduction of the output current when the threshold value is exceeded, with a distinction being made between long and short-term overload reserve. After the short-term overload (1 s) 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 (60 s), 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 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 a power reduction lasting 10 minutes.

Output signals

Digital outputs can signalize the achievement of a limit value – selected in *Operation Mode* **573**.

15 -	Warning Current Limitation	Intelligent Current Limits active. Output current is limited.
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. Tc	Intelligent Current Limits active. Maximum heat sink temperature Tc reached.
19 -	Controller Current Limit. Motor Temp.	Intelligent Current Limits active. Maximum motor temperature reached.

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 with the parameterized thresholds of P506 and P507.
1 - Udc-Limitation active	DC link limitation active. Overvoltage controller switched on, the Brake and Motor chopper are active and switch with the parameterized thresholds of P506 and P507. **Factory setting**.
2 - Mains Support active	Power failure regulation switched on. Brake and Motor chopper are active and switch with the parameterized thresholds of P506 and P507. Suitable for quick shutdown.
3 - Udc-Limit. & Mains Supp. active	Overvoltage controller and power failure regulation switched on, with motor chopper.
12 - Mains Support active, Chopper not active	Power failure regulation switched on. During the Mains Support, motor and brake chopper are deactivated. In all other cases motor and brake chopper are active and switch with the parameterized thresholds of P506 and P507.
13 - Udc-Limit. & Mains Supp. active, Chopper not active	Overvoltage controller and power failure regulation switched on. During the Mains Support, motor and brake chopper are deactivated. In all other cases motor and brake chopper are active and switch with the parameterized thresholds of P506 and P507.

In ANG 510 and 610, mains failure regulation is effected for a maximum of 1 second. In the case of longer mains failures, mains failure regulation cannot be guaranteed.

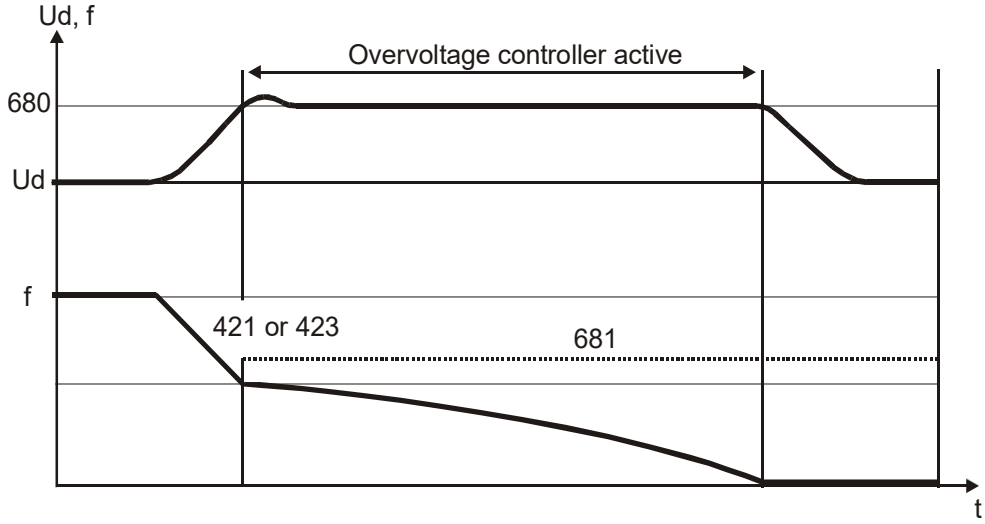
The function motor chopper is available in the field-oriented control methods (in configurations 210, 230, 410, 411 and 430).
When an operation mode with motor chopper is selected, set the *Trigger Threshold* **507** < (*Reference DC-Link Limitation* **680** - 10 V). See chapter 19.7.1 "Motor Chopper".

For synchronous motors (*Configuration* **30** = 5xx), the motor chopper function is deactivated to prevent damages to the motor. The other functions of the voltage controller are not affected by this.
For asynchronous motors in V/f control (*Configuration* **30** = 1xx), the motor chopper function is not operative. The other functions of the voltage controller are not affected by this.

The brake chopper is active dependent of the setting of *Reference DC-Link Limitation* **680**. See chapter 19.4 "Brake Chopper and Brake Resistance" for parameterizing the switching threshold.

Operation mode Overvoltage control

Voltage controller: Parameter *Operation mode* **670** = 1



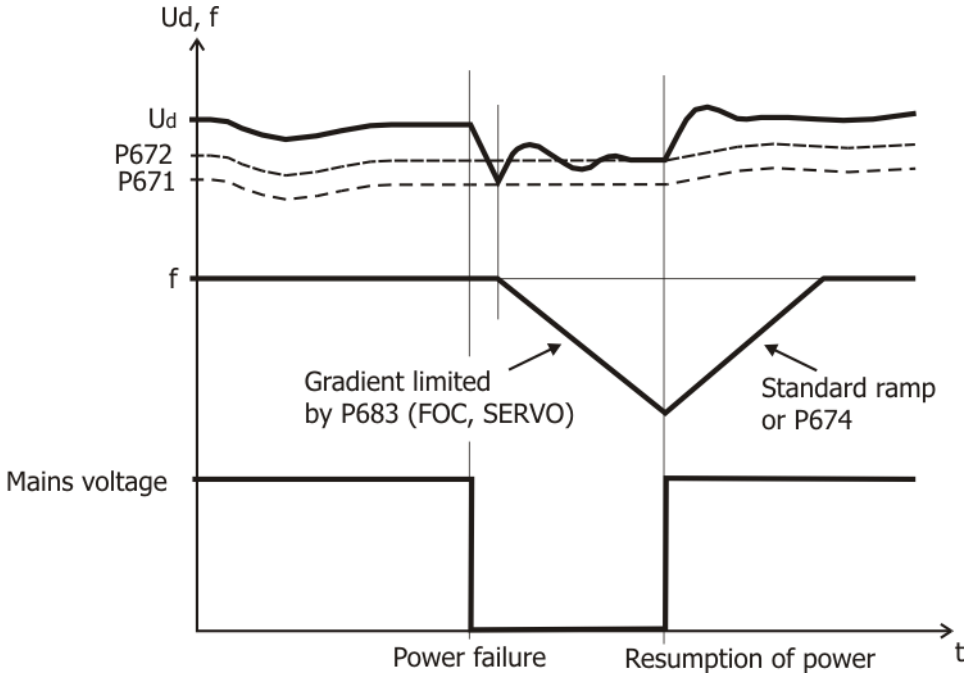
The overvoltage controller prevents a switch-off of the frequency inverter in generator operation. The reduction of the drive speed by a ramp gradient selected via the parameter *Deceleration Clockwise* **421** or *Deceleration Anticlockwise* **423** can lead to an overvoltage in the DC link. If the 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		Settings			
No.	**Description**	**ANG**	**Min.**	**Max.**	**Fact. sett.**
680	Reference DC link limitation	210	225	387.5	380 V
		410	425	775	760 V
681	Max. Frequency Rise	210/410	0.00 Hz	599.00 Hz	10.00 Hz

When an operation mode with motor chopper is selected, set the *Trigger Threshold* **507** < (*Reference DC-Link Limitation* **680** - 10 V). See chapter 19.7.1 "Motor Chopper".

Operation mode power failure regulation

Voltage controller: Parameter *Operation mode* **670** = 2



With the power 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. Using field oriented Control (FOC, SERVO) the reduction of the output frequency is done according to the configuration with a maximum of the current set by the parameter *Gen. Ref. Current Limit* **683**.

Gen. Ref. Current Limit **683** is active in configurations 410 and 610 (FOC and SERVO).

The threshold values of the voltage controller are calculated starting with the current DC link voltage with the parameters *Mains failure threshold* 671 and *Reference mains support value* 672.

Output signals

Digital signals indicate mains failure and power failure regulation.

179 -	Mains failure	1)	Mains failure and power failure regulation – selected via *Operation Mode* 670 of the voltage controller.
13 -	Mains failure	2)	

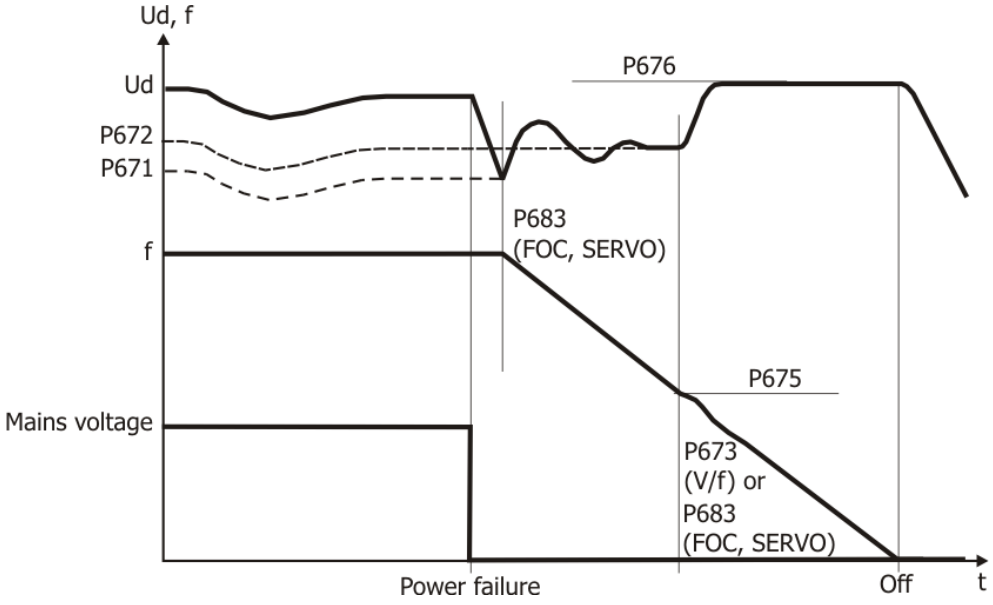
1) For linking with inverter functions
2) For digital output

If the mains voltage is restored before a switch-off is affected by the mains undervoltage detection system, the drive is accelerated to its reference frequency at the set acceleration or according to the 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 for 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 maximum reduction of the output frequency is done at the current set by the parameter *Gen. ref. current limit* **683** or the ramp *Mains support deceleration* **673** until the frequency limit *Shutdown threshold* **675** is reached. If the energy of the system for bridging the mains failure is not sufficient, the delay is affected at maximum ramp gradient as from 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 + 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 shutdown of the drive, but after falling below *Shutdown Threshold* **675**, the drive is still decelerated to standstill.
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 fault message "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		Settings			
No.	**Description**	**ANG**	**Min.**	**Max.**	**Fact. sett.**
675	Shutdown Threshold		0.00 Hz	599.00 Hz	0.00 Hz
676	Reference Shutdown Value	210	225	387.5	365
		410	425	775	730

Reference Shutdown Value **676** becomes effective below the frequency value *Shutdown Threshold* **675**.

The voltage controller uses the limit values of the DC link voltage. The frequency change necessary for this is parameterized by the generator reference current value or the ramp. The *Gen. ref. current limit* **683** or the ramp *Mains support deceleration* **673** defines the maximum deceleration of the drive necessary in order to reach the voltage value *Reference mains support value* **672**. The *Acceleration on mains resumption* **674** replaces the set values of the ramp parameters *Acceleration (clockwise)* **420** or *Acceleration anticlockwise* **422** if the figure set in the factory is changed. The voltage control in a mains failure changes from the frequency limit *Shutdown threshold* **675** from *Reference mains support value* **672** to the *Reference shutdown value* 676.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 configurations 2xx, 4xx and 5xx (FOC and SERVO).

The proportional and integrating part 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
677	Amplification	0.00	30.00	1 [1)]
				2 [2)]
678	Integral time	0 ms	10000 ms	8 ms [1)]
				23 ms [2)]

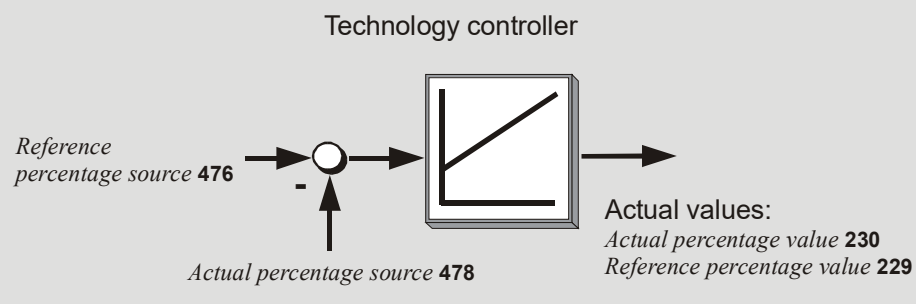
1) Configurations 1xx
2) Configurations 4xx, 2xx, 5xx, 6xx

The factory settings depend on the selected configuration and control procedure. According to the setup of parameter *Configuration* 30 there is the following assignment.

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



Comply with the following chapters of the manual:

Parameter	Chapter
Controller setpoint: *Reference Percentage Source* **476**	15.5 „Reference percentage channel“
Displays the current controller setpoint: *Reference Percentage Value* **229**	20.1 „Actual Values of the Frequency Inverter“
Actual controller value: *Actual Percentage Source* **478** is: - Analog signal at multifunction input: *Operation Mode* **452** - Frequency signal at digital input: *Operation Mode* **496**	18.3 „Technology Controller“ 16.1 „Multi-Function Input MFI1“ 15.11 „PWM-/repetition frequency input“
Displays the current actual controller value: *Actual Percentage Value* **230**	20.1 „Actual Values of the Frequency Inverter“

For the reference value, the technology controller also demands the assignment of an analog application figure with the 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.

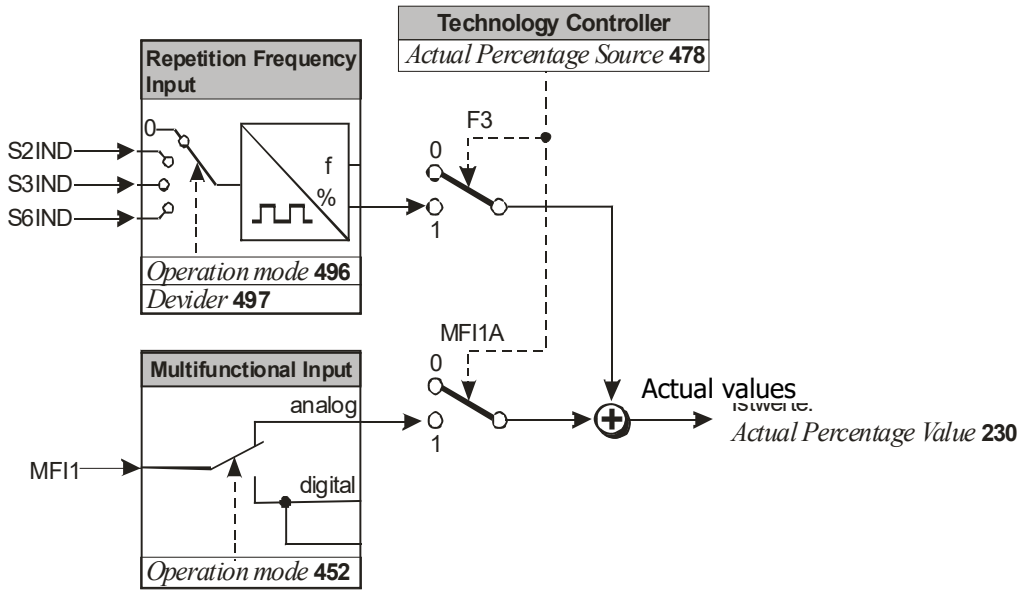
Actual percentage source **478**	Function
1 - Analog input MFI1A	The analog signal on the multifunction input 1 in analog *Operation mode* **452**.
32 - Repetition frequency input (F3)	The frequency signal on the digital input corresponding to the selected *Operation mode* **496**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
58	Technology Controller Release	Selection		6- On

Via parameter *Technology Controller Release* **58** the technology controller can be halted. The P and D part remain at the value before switching off. The output value and the I part resets with each switching off of the *Technology Controller Release* **58**.

The default assignment of parameter *Start clockwise* 68 to the logic signal of the technology controller must be observed:
Start Clockwise **68** = 13 - Technology Controller Start.
This assignment may not be changed. The technology controller becomes active with the controller release at digital input MF4ID/STOA.

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	Contents level control at defined motor speed with actual value missing.
3 - Liquid Level 2	Contents 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 the components

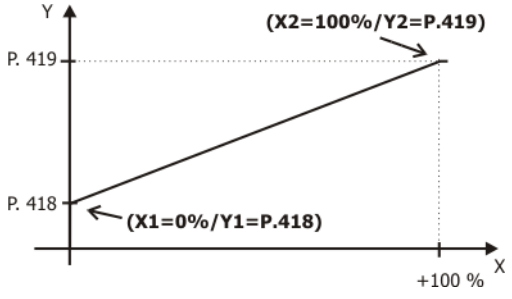
- proportional component *Amplification* **444**
- integral component *Integral time* **445**
- differential component *Derivative time* **618**

The sign of the amplification determines the direction of control, i.e. with a rising actual value and pos. sign of the amplification, the output frequency is reduced (e.g. in pressure control). With a rising actual value and neg. sign of the amplification, the output frequency is increased (e.g. in temperature control systems, refrigerating machines, condensers).
The integral component can be used to reduce the steady-state control deviation (deviation between actual value and reference value) over a period of time. If the integral component is too dynamic[1] the system will be unstable and oscillates. If the integral component is too passive[2] the steady-state control deviation will not be corrected adequately.
Therefore the integral component must be adjusted installation-dependent.
In the factory setting *Derivative time* **618** = 0 ms the differential component is disabled.
If the control behavior of the PI controller (or P controller) is too slow the setting of the differential component (*Derivative time* **618**) allows a faster control. If the differential component is enabled the system tends to oscillate, so that the differential component should be enabled and set carefully.
BONFIGLIOLI VECTRON recommends setting the values of *Integral time* **445** and *Derivative time* **618** higher than the sample time, which is 2 ms at the ANG device.
Parameter *Max. P-Component* **442** limits the frequency change at the controller output. This prevents oscillations of the system at steep acceleration ramps.
Via Parameter *Hysteresis* **443** changes of the integral component outside a specified range (hysteresis band) can be suppressed. This causes more passive behavior of the technology controller. This can be helpful when the stator frequency cannot follow the reference frequency of the Technology controller. *Hysteresis* **443** is related to *Rated frequency* 375, in most cases therefore 50 Hz.
The hysteresis acts as a limiter at the input of the integral part. Excessive differences between the stator current and the output of the controller technology are so limited and so prevent excessive integration of the integral value.

$\left\lvert \frac{f_{tech} - f_{stator}}{Rated\ frequency\ 375} \right\rvert \geq Hysteresis\ 443$	The deviation Δ between Reference frequency of the Technology Controller (f_{tech}) and Stator frequency (f_{stator}) is too big. The Integrator is halted.
$\left\lvert \frac{f_{tech} - f_{stator}}{Rated\ frequenz\ 375} \right\rvert < Hysteresis\ 443$	The Stator frequency (f_{stator}) can follow the reference frequency of the technology controller sufficiently. The deviation Δ is mall enough.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 Time	0 ms	1000 ms	0 ms

In modes 1,2,3 and 5, the output frequency is shifted along the ordinate axis to the *Minimum Frequency* **418**. The percentage of the technology controller output value corresponds to:
0 % = *Minimum Frequency* **418**
100 % = *Maximum Frequency* **419**



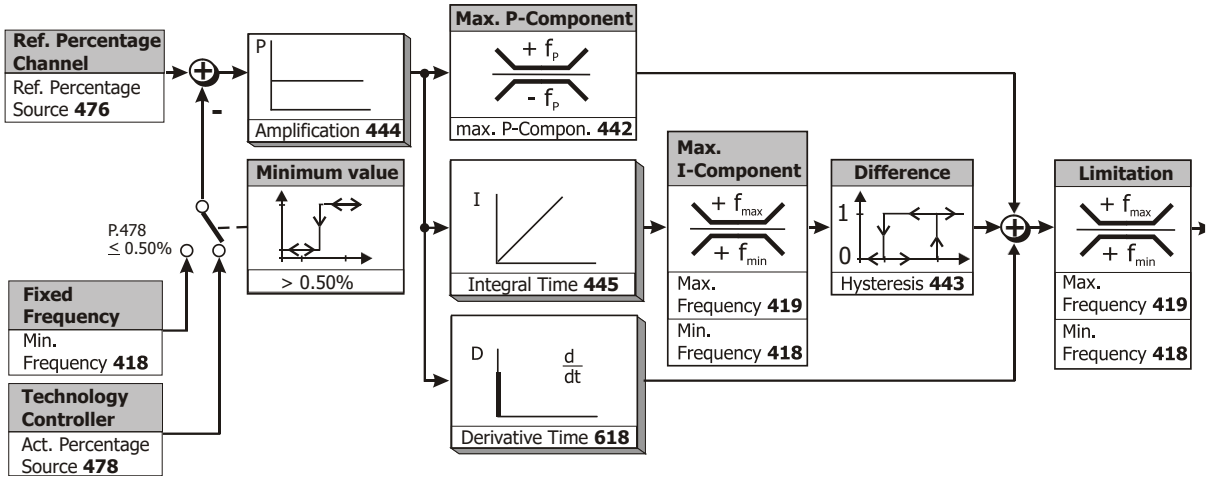
[1] Dynamic behavior: fast correction of deviations.
[2] Passive behavior: slow correction of deviations.

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 operates in motor clockwise operation. The direction of rotation can be changed via parameter *Change Sense of Rotation* **1199**. Refer to chapter 11.2.8 „Change sense of rotation".

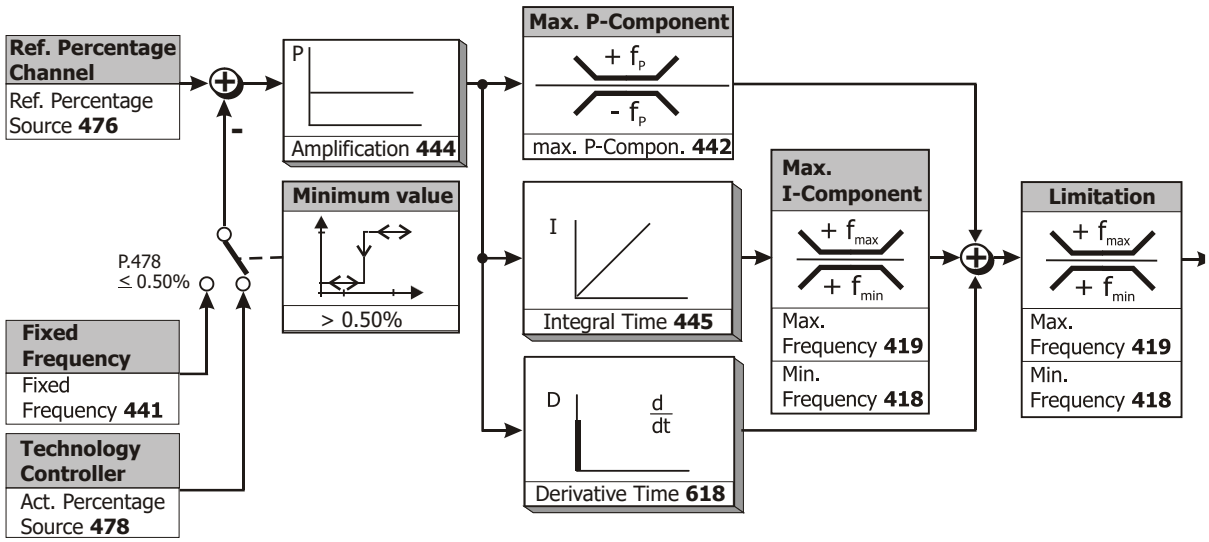
Operation mode standard, parameter *Operation mode* 440 = 1

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.



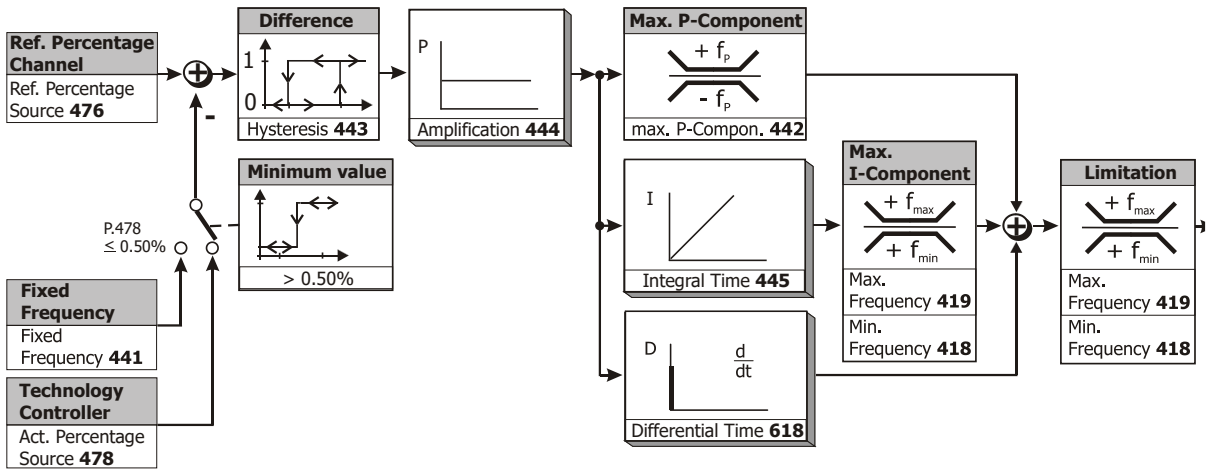
Operation mode filling level 1, parameter *Operation mode* 440 = 2

This operation mode can be used, for example, for contents 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 set to a value smaller than the *Minimum frequency* **418**, the output frequency is guided to *Minimum frequency* **418**. The frequency will not drop below *Minimum frequency* **418**.
If the actual value is available again, the controller continues operation automatically.
The Integral value is reset when the Actual value returns.



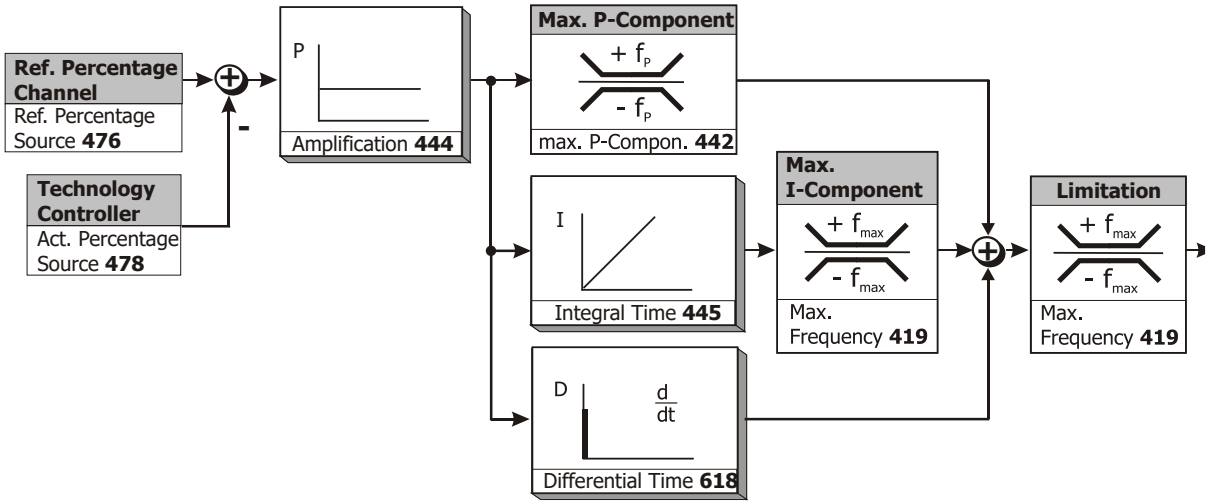
Operation mode filling level 2, parameter *Operation mode* 440 = 3

This operation mode can be used, for example, for contents 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 is done using the set Controller settings. Additionally, *Deceleration (clockwise)* **421** limits the ramp. If *Minimum frequency* **418** = 0 Hz, the power stage is switched 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 ≥ Reference value, the control output reached 0 Hz and *Minimum frequency* **418** = 0 Hz is set.



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**.

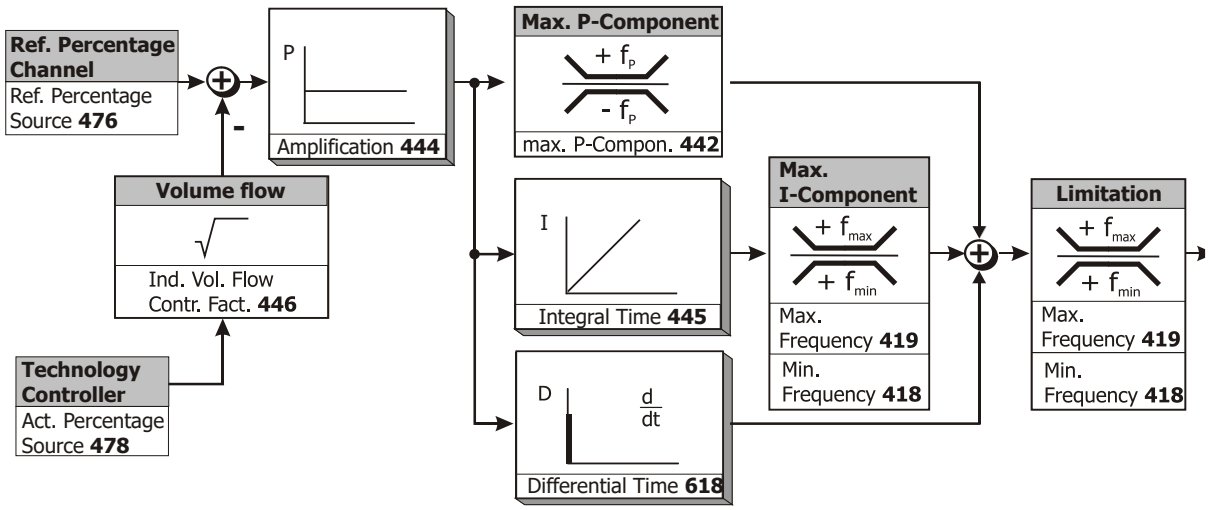


NOTICE

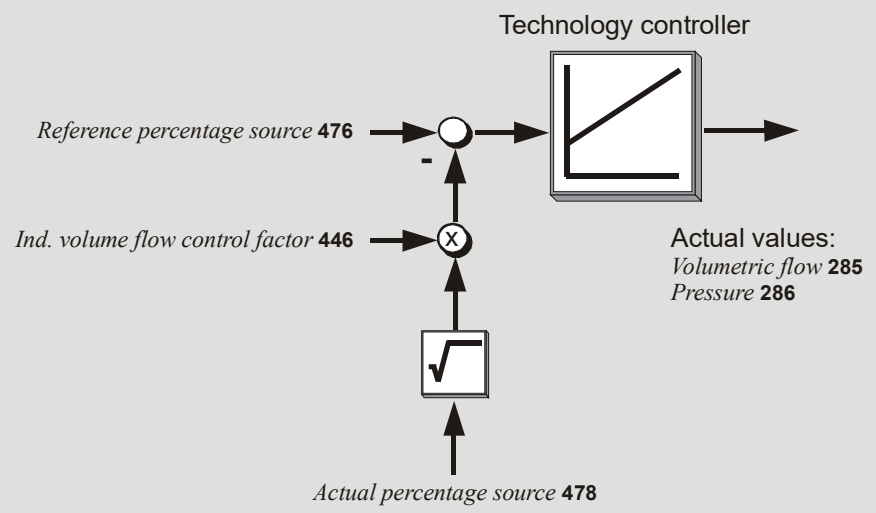
Minimum Frequency **418** is not limiting in mode "4-Speed". This can lead to a long-time operation of the motor in the current injection (current frequency <**624** *cutoff frequency*) in configurations `411` and `611`. Prevent an impermissible motor temperature rise through too long operation in the current injection. The operating mode "4-speed controller" can lead to drive reversal.

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.
Adaptation to the application in question and measurement are done via the *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 "Volume Flow and Pressure".
The output frequency is limited by the *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.
The activation of *Operation mode* **660** for the slip compensation enables as speed control without feedback. The stator frequency and speed are corrected depending on the load.
The slip compensation is activated during the guided commissioning. The *Stator Resistance* **377** is required to ensure a correct function and is measured during the guided commissioning.
If no guided commissioning is executed, the slip compensation can be activated manually. In these cases, enter the value for the *Stator Resistance* **377** manually according to the 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. The parameter *Amplification* **661** determines the correction of the speed and the effect of the slip compensation proportionally to the change of load. The *Max. Slip ramp* **662** defines the max. frequency change per second in order to avoid an overload in the case of a load change.
The parameter *Minimum frequency* **663** determines the frequency as from which the slip compensation becomes active.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 limit* **613** is fallen short of, the output frequency is raised back to the reference value.

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 is below the *Current limit* **613**, the output frequency is reduced to the required reference value again.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
613	I 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 value controller can be set via the proportional component, the parameter *Amplification* **611**, and the integrating component, the parameter *Integral time* **612**. If an optimization of the controller parameters is necessary in exceptional cases, a setting should be done by a jump alteration of the parameter *Current limit* **613**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
611	Amplification	0.01	30.00	1.00
612	Integral time	1 ms	10000 ms	24 ms

The dynamics of the current limit value controller and the voltage controller is influenced by the setting of the parameter *Dyn. voltage pre-control* **605**.

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. For this, the parameters *Amplification* **700** and *Integral time* **701** are available. The proportional and integration and component of the current controllers can be switched off by setting the parameters to zero.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 controller is to be done, the reference value jump during the flux-formation phase can be used for this. The reference value of the flux-forming current components leaps to the figure *Current during flux-formation* **781** with suitable parameterization and then changes controlled to the magnetizing current after the expiry of the *Maximum flux-formation time* **780**. The operating point necessary for the adjustment demands the setting of parameter *Minimum Frequency* **418** to the value 0.00 Hz, as the drive is accelerated after magnetizing. The measurement of the step response, 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 actual value for the flux-forming current component calculated internally 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**.

Settings	
Switching frequency	**Scanning frequency**
2 kHz [1)]	2 kHz
4 kHz	4 kHz
8 kHz	8 kHz
16 kHz	8 kHz

[1)] This switching frequency can be set for parameter *Min. switching frequency* **401**.

18.5.2 Extended Current Controller

For some machines it might be necessary, that for different current ranges different Amplification factors must be set up.
The following classification applies:

- 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 pre-assigned so that the parameters are not active and only the basic parameters are active.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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	8.00	0.00
775	Current above P. 700 is in effect	0.00	o * I_{FIN}	0.00

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
776	Current below P. 777 is in effect	0.00	o * I_{FIN}	0.00
777	Amplification low Current	0.00	8.00	0.00

I_{FIN} = Rated Output current of Frequency inverter
o: Overload capability of Frequency inverter

The motor autotuning changes the parameters.

18.5.3 Torque Controller

The torque-controlled configurations 230, 430, 530 and 630 can be used for sensorless torque control alternative to the speed control. The torque control is usable above the *Frequency Limit* **624**. Below the *Frequency Limit* **624** the current injection is active with the current reference frequency as reference value. In this case the torque is not controlled, but results depending on the load and the *Starting current* **623**. To achieve a starting in torque control, the reference frequency should be set higher than *Frequency Limit* **624**. This is guaranteed in example by setting *Minimum frequency* **418** > *Frequency Limit* **624.**

- f < *Frequency Limit* **624**: Current injection
- f ≥ *Frequency Limit* **624**: Direct Torque Control
- The *Frequency Limit* **624** is set automatically during the motor setup.

18.5.3.1 Torque Reference

The reference torque can be specified as follows:

- Set parameter *n-/T-Control Change-Over* **164** to "`6 - On`" or link it to a digital signal and switch this on.
- Via parameter *Reference Percentage Source 1* **476** select a source for the reference torque.

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 the calculated *Torque from Rated Mech. Power* **376** (Motor power) and *Rated Speed* **372** (Motor rated speed).

Parameter *Torque* **224** shows the actual torque.
Select an applicable operation mode for parameter *Operation Mode Flying Start* **645**. Refer to chapter 13.5 "Search Run".

18.5.3.2 Upper and lower limit of the frequency in Torque Control

In many cases limitation of the speed is required in the operating points with reduced or without load torque, because the speed regulates itself to the torque reference and the load behavior. To avoid an unintentional speed (mostly too high speeds, in some cases also too low speeds and avoidance of current injection), the frequency is limited by *Frequency upper limit* **767** and *Frequency lower limit* **768** by the speed controller.
As from the limit value the drive is controlled to maximum speed (*Frequency Upper Limit* **767** and *Frequency Lower Limit* **768)**, which corresponds to the behavior of the speed controller. Additionally, the controller limits the speed to *Maximum Frequency* **419**. This limitation is set by the speed controller – changes in the speed controller affect the speed behavior in the limit area of the 3 mentioned parameters.
In the current injection, the speed is limited additional to *Minimum Frequency* **418** – in Direct Torque Control this limit is not active.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 the speed in clockwise direction; negative values limit the speed in anticlockwise direction. In example, if both values are positive (> 0 Hz), anticlockwise movement is inhibited.

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.

18.5.3.3 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	The source is the multifunctional input 1 in analog *Operation mode* **452**.
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 value	Operation mode 110, inverted.

18.5.3.4 Switching over between speed control and torque control

Via the signal assigned to parameter *n-/T-Control Change-Over* **164**, you can switch between speed control and torque control. See chapter 16.4.6 "n-/M Control Change-Over".

18.5.4 Speed controller

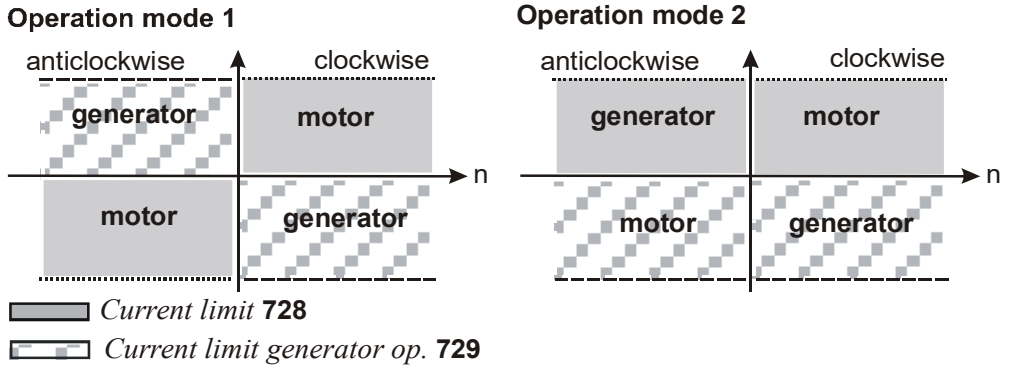
The source of the actual speed value is selected via parameter *Actual Speed Source* **766**. By default, speed sensor 1 is used as the actual speed source. If speed sensor 2 of an expansion module is to deliver the actual value signal for the speed controller, speed sensor 2 must be selected as the source. Alternatively, the speed controller can derive the actual speed value from the machine model in configurations 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 expansion 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	Speed synchronization by comparison between the calculated machine model and speed sensor 1 to increase speed accuracy. Can be set in configurations 4xx and 6xx. Adjustment for parameter *Integral Time Speedtracking* **515** is considered.
5 - Speedtracking EC 2	Speed synchronization by comparison between the calculated machine model and speed sensor 2 of an expansion module to increase speed accuracy. Can be set in configurations 4xx and 6xx. Adjustment for parameter *Integral Time Speedtracking* **515** is considered.
10 - Speed Sensor 3	The actual speed source is speed sensor 3 of an expansion module.[1)]

[1)] Only available if expansion 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 motor / generator	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 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 are to be set via the parameters *Amplification 1* **721**, *Integral time 1* **722**. For the second speed range, the parameters can be set via the parameters *Amplification 2* **723**, *Integral time 2* **724**. The distinction between the speed ranges is done by the parameter *Speed control switch-over limit* **738**. The parameters *Amplification 1* **721** and *Integral time 1* **722** are taken into account with the parameter *Speed control switch-over limit.* If parameter *Speed control switch-over limit* **738** is set to a value higher than 0.00 Hz, parameters *Amplification 1* **721**, *Integral time 1* **722** are active below the limit and parameters *Amplification 2* **723**, *Integral time 2* **724** are active above the limit.

The control deviation can be filtered with the *filter time constant* **754** if necessary. Therefore the operation with static control deviation with occasional undesired deviations can be stabilized, while at the same time the dynamic behavior in load change operation (speed change or changing torque demand) suffers.

The parameterized amplification at the current operating point can additionally be assessed via the parameter *Backlash damping* **748** depending on the control deviation. 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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	599.00 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.

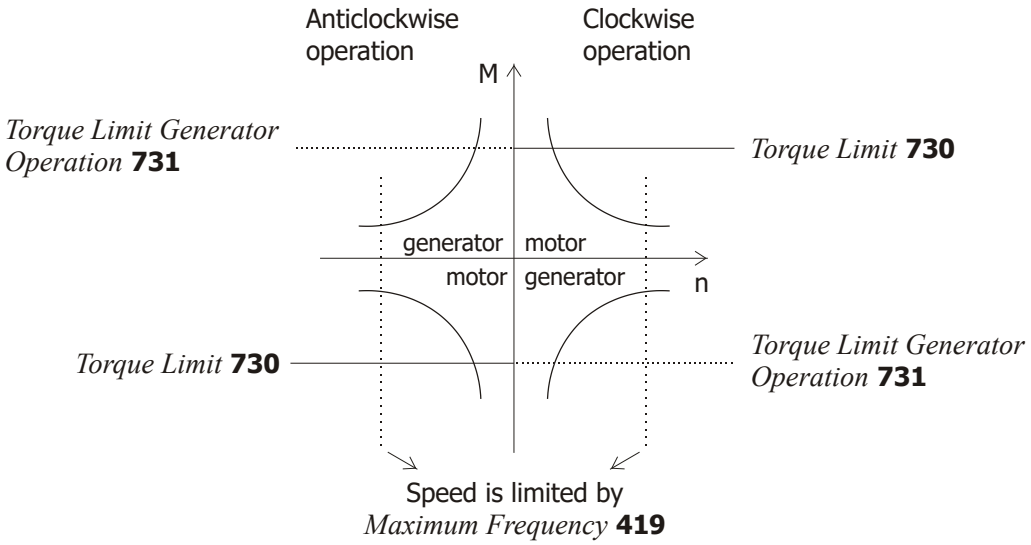
The optimization of the speed controller can be done with the help of a reference value leap. The amount of the leap is defined by the set ramp or limitation. The optimization of the PI controller should be done at the maximum admissible reference figure change rate. First, the amplification is increased 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 switch-over of the controller parameters is affected can be set via parameter *Speed control switch-over limit* **738**.

18.5.4.1 Limitation of Speed Controller

The output signal of the speed controller is the torque-forming current component Isq. The output and the I component of the speed controller can be limited via parameters *Current limit* **728**, *Current limit generator operation* **729**, *Torque limit* **730**, *Torque limit generator operation* **731** or *Power limit* **739**, *Power limit generator operation* **740**. The limits of the proportional component are set via parameter *P component torque upper limit* **732** and parameter *P component torque lower limit* **733**.
The output value of the controller is limited by an upper and a lower current limit, parameter *Current limit* **728** and parameter *Current limit generator operation* **729**. The limit values 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 operation* **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, generator 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 *Power limit* **739** and *Power limit generator operation.* **740**. The power limits are entered in kW.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
728	I limit	0.0 A	o · I_{FIN}	o · I_{FIN}
729	Current limit generator operation	-0.1 A[1]	o · I_{FIN}	o · 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·o·P_{FIN}	2·o·P_{FIN}
740	Power limit generator operation	0.00 kW	2·o·P_{FIN}	2·o·P_{FIN}

[1] If the minimum value is set, the value of *Current Limit* **728** shall be used.



18.5.4.2 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** and *Maximum reference percentage* **519**, but does not consider the *Gradient percentage ramp* **477** of the reference percentage value channel.
The assignment is done with the help of the parameters *Isq limit source motor operation* **734** and *Isq limit source generator operation* **735** for the torque-forming current component Isq.
The sources for the torque limits can be selected via the parameters *Torque limit source, motor op.* **736** and *Torque limit source generator op.* **737**.

Operation mode 736, 737	Function
101 - Analog input MFI1A	The source is the multifunctional input 1 in analog *Operation mode* **452**.
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.

18.5.4.3 Integral time speed synchronization

For speed synchronization and in order to increase the speed accuracy, the integrating portion of the speed control can be set via parameter *Integral time speed synchronization* **515**. The setup is effective in operation modes „4 – speed synchronization DG 1" and „5 – speed synchronization DG 2" for parameter *Actual speed source* **766**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
515	Integral time speed synch.	1 ms	60000 ms	5000 ms

18.5.5 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. The acceleration of the mass is a function of 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 during the acceleration processes.

18.5.6 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 3-phase machine. 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 changes within the Field controller parameters should only be done in the basic speed area.

- When an optimization of the Field controller is necessary, set the *Integral Time* **742** = *Act. Rotor Time Constant* **227** / 2, meaning to the half of the rotor time constant. In most application cases, this change is sufficient.
- When further optimizations are necessary, follow the step described in the following procedure.

Set the output frequency in a way (i.e. via the frequency reference value), that the actual value *Modulation* **223** = 80…90 % *Reference Modulation* **750**.
Now change the *Flux Reference Value* **717** from 100 % to 90 %. Oscillograph the actuating variable I_{sd}. The course of the signal of the flux-forming current I_{sd} should reach the stationary value after overshooting without oscillation.

- Change the parameters *Amplification* **741** and *Integral Time* **742** according to the application requirements.

Change the *Flux Reference Value* **717** back to 100 % und repeat the flux reference step while you can analyze the changes with the oscillograph. Repeat these steps if necessary.

If a quick transition into field weakening is necessary for the application, the integral time should be reduced. Increase the *Amplification* **741** in order to achieve a good dynamism of the controller.
An increased overshoot is necessary for a good control behavior in controlling of a load with low-pass behavior, e.g. an asynchronous motor.
Parameter *Reduction Factor Flux* **778** reduces the standstill current if a stopping behavior with the function "R->0, Stop" is selected. 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 of *Reduction Factor Flux* **778** becomes effective after the time of parameter *Holding Time* **638** is elapsed. The resulting standstill flux is calculated by multiplying *Reference Flux* **717** and *Reduction Factor Flux* **778**. After a start command the drive starts immediately and the flux is increased up to the reference value during the movement.
Because of the reduced flux the initially required torque-forming current component Isq is increased. The time needed to achieve the reference flux can be influenced by parameter *Ref. Isd Upper Limit* **743** which is set to the motor rated current after setup.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
778	Reduction Factor Flux	20.00%	100.00%	100.00%

18.5.6.1 Limitation of field controller

The output signal of the field controller, the integrating and proportional components are limited via parameter *Ref. Isd upper limit* **743** and parameter *Ref. Isd lower limit* **744**. The guided commissioning has set the parameter *Ref. Isd upper limit* **743** according to the parameter *Rated current* **371**.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 rated 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.

18.5.7 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 - V-Absolute 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 inductivity 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 unit step function by modifying the reference modulation (change-over between 95% and 50%). By means of an oscillographed 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. The parameter *Integral time* **752** should roughly correspond to the actual value *Act. rotor time constant* **227**.

18.5.7.1 Limitation of Modulation Controller

The output signal of the modulation controller is the internal reference flux. The controller output and the integrating part are limited via the parameter *Reference Imr lower limit* **755** or the product of *Rated magnetizing current* **716** and *Reference flux* **717**. The magnetizing current parameter forming the upper limit is to be set to the rated figure 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 noises can be reduced by changing over the parameter *Switching frequency* **400**. A reduction of the switching frequency should be up 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
400	Switching frequency	2 kHz	16 kHz	2 kHz [1)]
				4 kHz [2)]

The factory setting of parameter *Switching frequency* 400 depends on the setting of parameter *Configuration* **30**:
[1)] configurations 1xx
[2)] configurations 2xx / 4xx/ 5xx

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 adapted between the limits which can be set with the parameters *Switching frequency* **400** and *Min. switching frequency* **401**. If the *Min. switching frequency* **401** is larger than or equal to the *Switching frequency* **400**, the automatic reduction is deactivated.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 heat sink temp.* **580**. If the heat sink temperature falls below the threshold set via parameter *Reduction limit heat sink temp. Ti/Tk* **580** by 5 °C, the switching frequency is increased again step by step.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 the 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 fault is triggered when reaching an internal switching off temperature threshold.

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 off when the minimum ON-time has elapsed.
The minimum ON-time of the heat sink fan is set internally to 1 minute. When the temperature drops below the *Switch-on temperature* **39** during this time since starting, the fan will continue to operate until the running ON-time is reached.
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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 MF4ID/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.
The 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 - Control via keypad, dir. of rot. via contacts	The Start and Stop commands are controlled from the control unit and the direction of rotation is controlled via digital signals.
4 - Control via KP or cont., dir. of rot. via contacts	The Start and Stop commands are controlled from the control unit or via digital signals. The statement of the direction of rotation only with the help of the digital signals.
5 - Control 3-wire, dir. of rot. via contacts	3-wire; control of direction of rotation and signal *3-wire control* **87** via contacts.
13 - Control via keypad, dir. of rot. via keypad	The Start and Stop commands as well as the direction of rotation are controlled via the control unit.
14 - Control via KP or cont., dir. of rot. via contacts	The Start and Stop commands are controlled from the control unit or via digital signals. The statement of the direction of rotation only with the help of the operating unit.
20 - Control via cont., clockwise only	The Start and Stop commands are controlled via digital signals. Fixed direction of rotation, clockwise rotation only.
23 - Control via keypad, clockwise only	The start and stop commands are controlled via keypad. Fixed direction of rotation, clockwise rotation only.
24 - Control via cont. +KP, clockwise rot. only	The Start and Stop commands are controlled from the control unit or via digital signals. Fixed direction of rotation, clockwise rotation only.
30 to 34	Operation mode 20 to 24, anticlockwise direction of rotation only.
43 - Control via KP, dir. of rot. via contacts	The start and stop commands are controlled via digital signals. The statement of the direction of rotation comes from the operating unit or via digital signals.
44 - Control via cont.+ KP, sense of rot. via cont. + KP	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 - Control via 3-wire + KP, dir. of rot. via contacts + KP	3-wire and control unit; control of direction of rotation and signal *3-wire control* **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

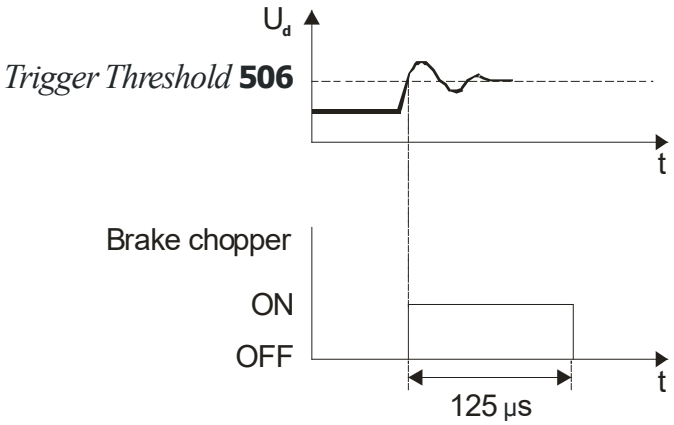
The frequency inverters feature a brake chopper transistor. The external brake resistor is connected to terminals Rb1 and Rb2. The parameter *Trigger threshold* **506** defines the switch-on threshold of the brake chopper. The generator output of the drive, which leads to the increase in the DC link voltage, is converted to heat by the external brake resistor above the limit set via parameter *trigger threshold* **506**.

Parameter		Settings			
No.	**Description**	**ANG**	**Min.**	**Max.**	**Fact. sett..**
506	Trigger threshold	210	225	1000.0 V	390
		410	425	2000.0 V	780
		510	550	2000.0 V	880
		610	725	2000.0 V	1180

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 "Error Messages") is displayed if the start command is issued to the frequency inverter.
If the DC link voltage exceeds the maximum value of 400 V for the ANG 210 series of devices or 800 V for the ANG 410 series of devices the error message F0700 is displayed (chapter "Error Messages").
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.



19.4.1 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 "Technical Data".

The following values must be known for dimensioning:

- Peak braking power $P_{b\ Peak}$ in W
- Resistance R_b in Ω
- Operation Time OT in %

Calculation of peak braking power $P_{b\ Peak}$

$$P_{b\,Peak} = \frac{J \cdot \left(n_1^{\,2} - n_2^{\,2}\right)}{182 \cdot t_b}$$

$P_{b\ Peak}$ = Peak braking power in W
J = Moment of inertia of drive system kgm²
n_1 = Speed of drive system before the braking operation in min^{-1}
n_2 = Speed of drive system after the braking operation in min^{-1}
t_b = Braking time in s

Calculation of resistance R_b

$$R_b = \frac{U_{d\,BC}^{\,2}}{P_{b\,Peak}}$$

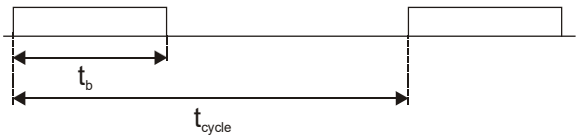
R_b = Resistance in Ω
$U_{d\ BC}$ = Switch-on threshold in V
$P_{b\ Peak}$ = Peak braking power in W

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 operation time OT

$$DC = \frac{t_b}{t_{cycle}}$$

OT = Operation time
t_b = Braking time
t_{cycle} = Cycle time



Example:
t_b = 48 s, t_{cycle} = 120 s

$$DC = \frac{t_b}{t_{cycle}} = 0.4 = 40\%$$

In the case of infrequent short braking operations, typical values of the operation 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 operating 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 Protection

The protection of the motor against impermissible temperature rise requires monitoring mechanisms for recognizing a thermal overload to prevent a possible damage to the motor.
The thermal state of a motor can be evaluated by different ways.
1) Direct monitoring by temperature sensors inside the motor winding (see chapter 19.5.1).

- PTC
- KTY
- PT100
- Thermal contact

2) Indirect monitoring of the motor temperature

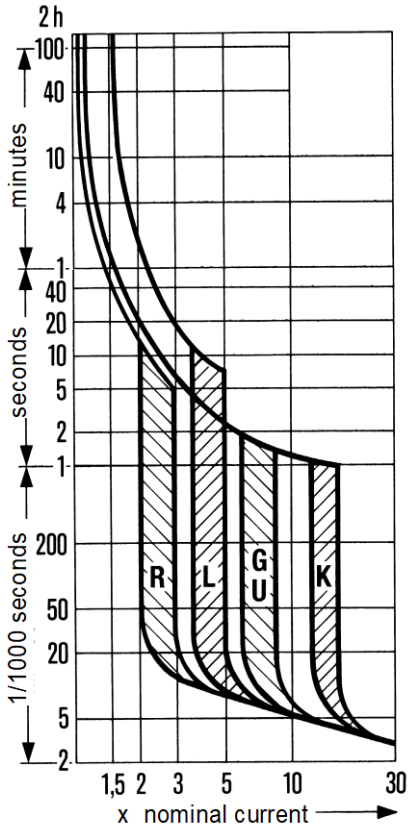
- Monitoring of the motor current based on the K characteristic of an integrated motor circuit breaker
- Emulation of the motor heating by using a temperature-relevant mathematical model I2t

The choice of thermal control is mainly determined by type and operating conditions of the motor.
For safe motor protection it is generally sufficient using one of the available possibilities.
A combination of the two groups and their simultaneous operation is possible.

19.5.1 Motor Protection Switch

Motor protection switches 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 protection switches 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, exclusively the K characteristic was realized in this function.
Unlike the operation of a conventional motor protection switch 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 protection switch 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 protection switch 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 protection switch.
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 protection switch 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.,Mul.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., Sing.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 -	I^2t, Single-Motor, Error Switch Off	See chapter 19.5.2.
51 -	I^2t, Multi-Motor Operation, Warning	See chapter 19.5.2.
52 -	I^2t, Single-Motor, Warning	See chapter 19.5.2.
61 -	I^2t, Multi-Motor Operation, Warning and Error Switch Off	See chapter 19.5.2.

Operation Mode **571**		**Function**
62 -	I²t, Single-Motor, Warning and Error Switch Off	See chapter 19.5.2.
101 -	K-Char.,Mul.Motor Op.,Err.Sw.Off, Latching	Like Operation modes 1,2 11, or 22. Additionally the integrated current over the time is stored when the device is switched odd and set to the stored value when switched on again.
102 -	K-Char., Sing.Motor,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 protection switch 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 protection switch activated by the data set. In the motor protection switches 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 protection switch is similar to that of motors connected alternately to the mains with their own protection switches.
In operation modes **101** and **111** additionally the integrated current over the time is stored when the device is switched odd and set to the stored value when switched on again.

Single motor operation

Parameter *Operation Mode* **571 =** `2, 22, 102` or `122`

In single motor operation, only one motor protection switch, 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 protection switch is similar to that of motors connected alternately to the mains with one common protection switch.
In operation modes **102** and **122** additionally the integrated current over the time is stored when the device is switched odd and set to the stored value when switched on again.

Reset stable

Parameter *Operation Mode* **571 =** `101, 102, 111` or `122`

The internal state of the motor protection switch is latched reset stable. These settings are to be used when regularly short mains interruptions occur. This way the motor protection is considered correctly for short mains failures or short shut downs of the application.

In settings 101, 102, 111 and 112 of *Operation Mode* **571** the same values should be set in all data sets.

Motor protection, in particular self-ventilation motors, is improved via the *Frequency limit* **572** which can be set as a percentage of the rated frequency. The measured output current in operating points below the frequency limit is assessed by a factor of 2 higher in the calculation of the trigger characteristic.

Parameter		**Settings**		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
572	Frequency Limit	0 %	300 %	0 %

Output signals

Digital signals indicate the triggering of the function "Motor Protection Switch".

180 -	Warning Motor Protection Switch	1)	Triggering of the function "Motor Protection Switch" according to *Operation Mode* **571** is signalized.
14 -		2)	

1) For linking with inverter functions
2) For digital output

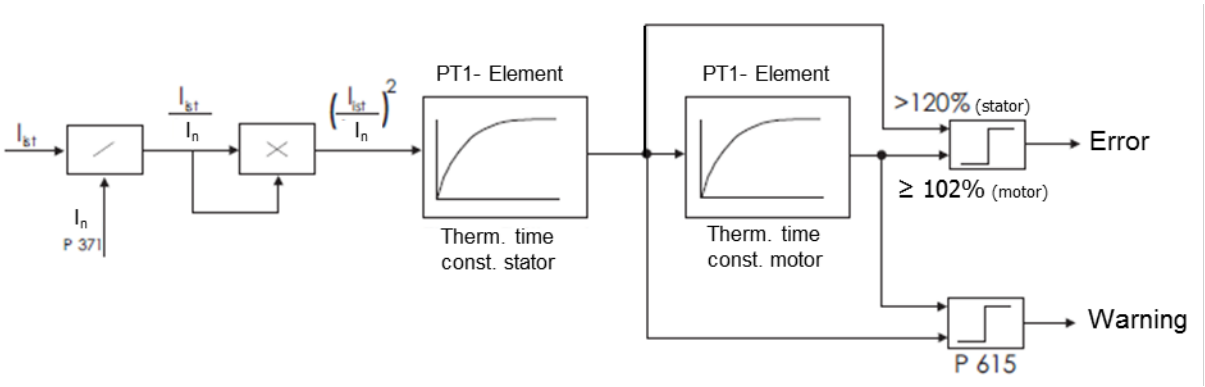
In calculation the tripping time the measured output current in operating points below the frequency limit is evaluated by a factor between 1 and 2. The determination of this factor is a function of the stator frequency. The increased thermal load of self-ventilated motors in the lower speed range is therefore considered.
The table shows in extracts factors for motor rated frequency 50Hz.

Frequency limit 572 →

Stator frequency [Hz]	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

To protect the motor against overload the I2t monitoring provides a further possibility for the user.
This kind of motor protection is mainly used in servo technology. When using servo motors the I2t-monitoring is a proven alternative to motor protection switch.
By integrating temperature-dependent parameters, measurable or known, the heating of a mathematical model is simulated.
The kind of the I^2t monitoring mode can be selected by *Operation Mode* **571.**
This parameter is switchable via data set.
The I^2t monitoring works by function $(I_{act}/I_n)^2$ as shown in the figure.
The monitored value is evaluated via a PT1 element with the thermal time constant of the stator.
If the output of PT1 element is bigger than 120%, then an error message is generated and the drive switches off. The threshold of 120% prevents, that an overshoot leads to an immediate shutdown.
In the application should be avoided exceeding 100% capacity of the stator winding permanently.



The output of the first PT1 element is linked to the input of the second PT1 element which includes the thermal motor time constant. This output may be permanently 100%. This corresponds to the complete thermal capacity of the motor. If 102% is reached, the drive switches off with an error message. Both outputs are connected to the adjustable alarm limit.

Operation Mode **571**		Function
42 -	I²t, Single-Motor, Error Switch Off	The I²t capacity of the motor is monitored with rated values from the active dataset. If the fixed threshold values exceed 100%$_{motor}$ (120%$_{stator}$), the drive switches off with fault "F0401" in the active dataset.
51 -	I²t, Multi-Motor Operation, Warning	The I²t capacity of the motors regarding their related ratings is monitored in each of the four data sets. If the *Warning Limit Motor I2t* **615** is reached, the warning message "A0200" is signaled from the active data set.
52 -	I²t, Single-Motor, Warning	The I²t capacity of the motor is monitored with rated values from the active dataset. If the *Warning Limit Motor I2t* **615** is reached, the warning message "A0200" is signaled from the active data set.
61 -	I²t, Multi-Motor Operation, Warning and Error Switch Off	The I²t capacity of the motors regarding their related ratings is monitored in each of the four data sets. If the *Warning Limit Motor I2t* **615** is reached, the warning message "A0200" is signaled from the active data set. If the fixed threshold values exceed 100%$_{motor}$ (120%$_{stator}$), the drive switches off with fault "F0401" in the active dataset. Both incidences are triggered from the active dataset.
62 -	I²t, Single-Motor, Warning and Error Switch Off	The I²t capacity of the motor is monitored with rated values from the active dataset. If the *Warning Limit Motor I2t* **615** is reached, the warning message "A0200" is signaled from the active data set. If the fixed threshold values exceed 100%$_{motor}$ (120%$_{stator}$), the drive switches off with fault "F0401" in the active dataset. Both incidences are triggered from the active dataset.

The thermal time constant of the motor is in the range from few minutes to a couple of hours. This motor-specific parameter is set via *Thermal time constant motor* **608**.
Substantially smaller is the thermal stator time constant. To protect the stator winding additional monitoring is required which is determined by *Thermal time constant stator* **609**.
These values can be taken from the corresponding motor data sheets. When estimated time constants are used because the required data are not available then an optimal thermal motor protection cannot be guaranteed.
A warning limit allows the user to prevent an imminent I²t-fault trip through appropriate measures. *Warning limit motor I2t* **615** is used to set the warning signal between 6% and 100% of thermal capacity.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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 Motor I²t	6%	100%	80%

Output signals

Digital signals indicate the triggering of the function "Motor Protection Switch".

180 -	Warning Motor Protection	1)	Triggering of the function "Motor Protection Switch" according to *Operation Mode* **571** is signalized.
14 -		2)	

1) For linking with inverter functions
2) For 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 functional behavior if the *Active Current* **214** or the torque-forming current component *Isq* **216** (field -oriented control method) drops below the *set Trigger Limit Iactive* **582** for a time longer than the set *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 - Error	The unloaded drive is switched off and fault message "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 an overriding 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		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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		Settings			
No.	**Description**	**ANG**	**Min.**	**Max.**	**Fact. sett..**
507	Trigger threshold	210	225	1000.0 V	390
		410	425	2000.0 V	800
		510	550	2000.0 V	900
		610	725	2000.0 V	1200

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 (chapter "Error Messages") is displayed when the frequency inverter is switched on.

The motor chopper function only works if activated via voltage Controller *Operation Mode* **670**. See chapter 18.2 "Voltage controller".

For synchronous motors (*Configuration* **30** = 5xx), the motor chopper function is deactivated to prevent damages to the motor. The other functions of the voltage controller are not affected by this.

Please note that by default the Motor chopper *Trigger Threshold* **507** and the *Trigger Threshold* **506** are set up with different values. Check, that the two thresholds are set up fittingly for your 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 *Current rotor time constant* **227** is calculated from the inductivity 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 multifunctional input 1
4 -	Temp. Meas. at 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. The *Operation mode* **452** of multifunction input MFI1 must be selected accordingly.
Operation mode 4 is available in configurations 210, 211 and 230. 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 by BONFIGLIOLI VECTRON 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 °C for copper and 36%/100 °C for aluminum at a temperature of 20 °C.
The temperature characteristic within the software is calculated via the aforementioned temperature coefficient and the parameter *Temperature adjustment* **467**. The adjustment temperature enables an additional optimization of the rotor time constant alongside the parameter *Rated slip correction factor* **718**.

Parameter		**Settings**		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
466	Temperature coefficient	0.00%/100 °C	300.00%/100 °C	39.00%/100 °C
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 expansion 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 affected. If the 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 fault message 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		**Settings**		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
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

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 the message "F1430".

Timeout: Track fault

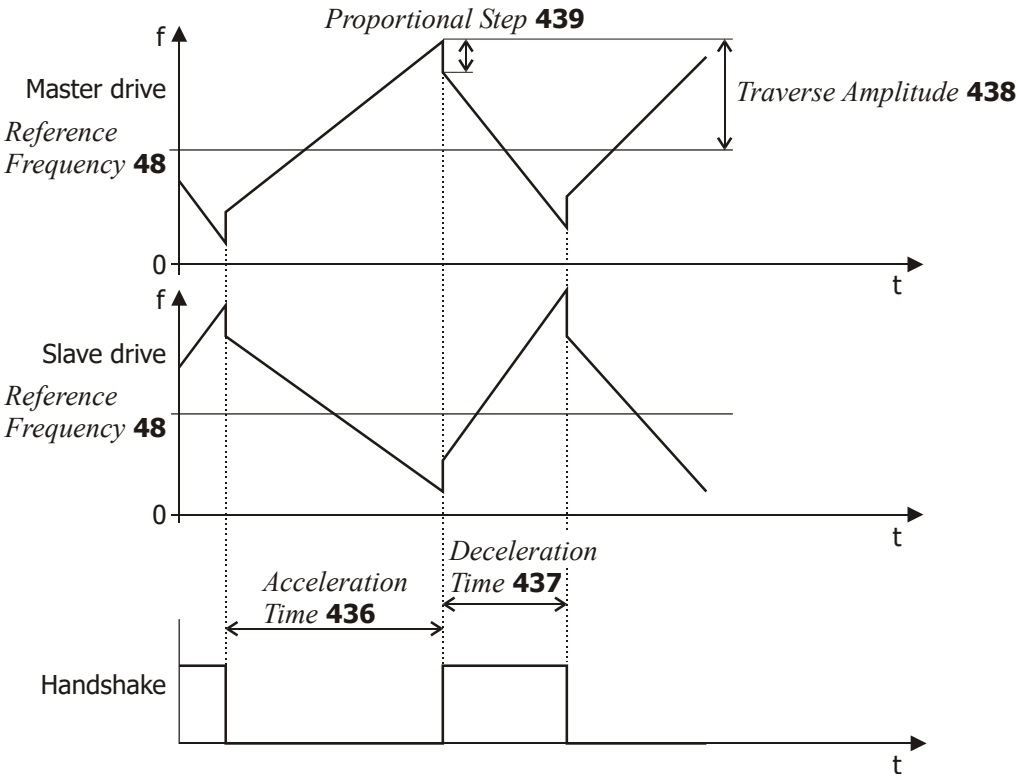
The actual speed measurement monitors the sequence in time of the signals in the quadruple evaluation of the speed sensor operation mode. If the speed sensor signal is faulty for the time selected with the parameter *Timeout: Channel fault* **762,** the fault is displayed with the message "F1431".

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 the 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.

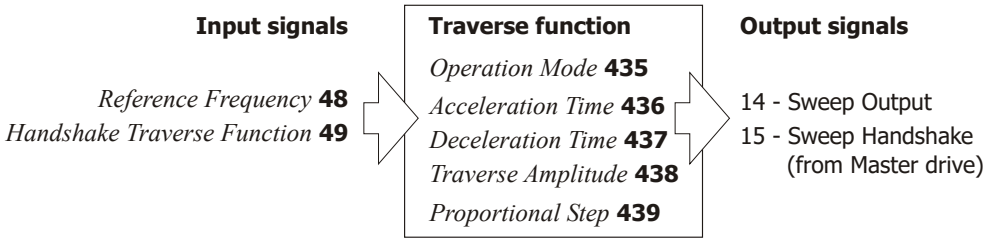
19.8 Traverse function

With the traverse function, a triangle-shaped frequency signal with the acceleration and deceleration times to be set is superimposed on the output frequency. The resulting signal courses 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 proceeds linearly to the limit *Traverse Amplitude* **438** and then reverses its direction. When the direction is reversed, a proportional step is affected. 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 with 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 affected. If the handshake signal is received before the frequency limit is reached, the direction is reversed immediately.

Parameter		Settings		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
436	Acceleration Time	0.01 s	320.00 s	5 s
437	Deceleration Time	0.01 s	320.00 s	5 s
438	Traverse Amplitude	0.01 %	50.00 %	10 %
439	Proportional Step	0.01 %	50.00 %	0.01%



Signal "14 – Traverse Output" 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 as soon as the *Reference frequency* **48** is reached for the first time. This frequency is reached via the values for *Acceleration (clockwise)* **420** and *Acceleration Anticlockwise* **422** and *Deceleration (clockwise)* **421** and *Deceleration anticlockwise* **423**. In shot-effect mode, the values for *Acceleration Time* **436** and *Deceleration Time* **437** are active.
The frequency range for shot-effect mode is limited by the *Minimum frequency* **418** and the *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**.

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 operating unit.

20.1 Actual Values of the 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 the Frequency Inverter

No.	Description	Function
222	DC –Link Voltage	Direct voltage in the DC link.
223	Modulation	Output voltage of the frequency inverter relative to the mains voltage (100% = U_{FIN}).
228	Internal ref. frequency	Sum of the *Frequency reference value sources* **475** as a reference value from the frequency reference value channel.
229	Reference percentage	Sum of the *Reference percentage sources* **476** as a reference value from the reference percentage channel.
230	Actual percentage value	Actual value signal on the *Actual percentage source* **478**.
243	Digital Inputs (Hardware)	Decimally coded status of the six digital inputs and of multifunctional input 1 in *Operation Mode* **452** - digital input. Displays the status of the physical inputs (See also *Digital Inputs* **250**).
244	Working hours counter	Operating 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 multifunctional input 1 in *Operation Mode* **452** - digital input. Depending of the setting of parameter *Local/Remote* **412** the hardware signals or Fieldbus/Systembus signals are displayed (See also *Digital Inputs(Hardware)* **243**)
251	Analog input MFI1A	Input signal on multifunctional input 1 in analog *Operation mode* **452**.
252	Repetition Frequency Input	Signal on repetition frequency input according to *Operation mode* **496**.
254	Digital Outputs	Decimally coded status of the two digital outputs and of multifunctional output 1 in *Operation mode* **550** – digital.
255	Heat sink temperature	Measured heat sink temperature.
256	Inside temperature	Measured inside temperature.
257	Analog output MF2OA	Output signal on multifunctional input 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 error code and abbreviation.
273	Application Warnings	Application Warning message with error code and abbreviation.
275	Controller Status	The reference value signal is limited by the controller coded in the controller status.
277	STO Status	Signal state of the shutdown paths STOA (digital input MF4ID/STOA) and STOB (S7IND/STOB) of the safety function "STO – Safe Torque Off".

Additionally to the described Actual values further Actual values are available for Fieldbus access. These are notable parameters *Current error* **260**, *Warnings* **270** and *Application Warnings* **274**, in which the respective feedback can be readout as a hexadecimal code (and without text). 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 *Operation level* **28** in the PARA menu branch defines the selection of the actual value parameters.

The digital inputs may seem deactivated in the actual value display 243, 250 (constant "0"). This can be caused by the used configuration or used functions (in example encoder or frequency input).

Input	Deactivation mechanism for Actual value display
S2IND	PWM / Rep. freq. input
S4IND	Track B (Encoder 1)
S5IND	Track A (Encoder 1)
S6IND	Track Z (Encoder 1) or PWM / Rep. freq. input
MFI1	Analog input

Settings:

For Encoder 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 displayed in **217**, speed in **218**.
PWM / Rep. freq. input: PWM is displayed in **258**, frequency in **252**.

20.1.1 STO Status

Parameter *STO Status* **277** can be used for an extended diagnosis of the two digital inputs STOA and STOB. The states of the inputs are bit coded displayed.

Bit	Significance	Function
0	1	Input STOA is missing.
1	2	Input STOB is missing.
2	4	Switch off input STOA.
3	8	Switch off input STOA.
4	16	Timeout STOA.
5	32	Timeout STOB.
6	64	Diagnosis error.
7	128	Frequency inverter error (Fault)

The signal statuses at the digital inputs STOA and STOB can be linked with inverter functions.

292 -	STOA	Signal status at digital input STOA
284 -	STOA inverted	Inverted signal status at digital input STOA
293 -	STOB	Signal status at digital input STOB
285 -	STOB inverted	Inverted signal status at digital input STOB

For further instructions refer to the application manual „STO – Safe torque off".

20.2 Actual Values of the 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.

Actual Values of the Machine		
No.	**Description**	**Function**
210	Stator Frequency	The output frequency (motor frequency) of the frequency inverter.
211	R.m.s current	Calculated effective output current (motor current) of the frequency inverter.
212	Output voltage	Calculated R.m.s. figure of the phase-to-phase voltage (motor voltage) of the frequency inverter.

Actual Values of the Machine		
No.	**Description**	**Function**
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.
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	Encoder1 speed	Calculation from speed sensor 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.
1057	MTPA adapted Ld	Currently used Inductivity Ld
1058	MTPA adapted Lq	Currently used Inductivity Lq
1075	Status SynRM State Machine	Status internal state machine
1076	Status SynRM MTPA	MTPA function status

The actual values can be read out and monitored in the VAL menu branch of the operating unit. The parameter *Operation level* **28** in the 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 maintenance 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.

Actual value memory		
No.	**Description**	**Function**
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 temp.	The maximum measured inside temperature in the frequency inverter.

Actual value memory		
No.	**Description**	**Function**
292	Average value inside temp.	The mean inside temperature calculated in the period of observation.
293	Peak value Iabs.	The highest abs. current calculated from the measured motor phases.
294	Average value Iabs	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. The parameter *Operation level* **28** in the PARA menu branch defines the selection of the actual value parameters to be selected.

The *Reset memory* **237** parameter 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 Vdc* **289**.
6 - Average Value Tc	Delete *Average value Vdc.* **290**.
7 - Peak Value Ti	*Reset Peak value Ti* **291**.
8 - Average Value Ti	Delete *Average value Ti.* **292**.
9 - Peak Value Iabs.	*Reset Peak value Iabs.* **293**.
10 - Average Value Iabs	*Delete Average Iabs* **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 Value 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 peak values stored.
101 - All Average Values	Delete average values and stored 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 System Value

The drive can be monitored via the actual value *Actual System Value* **242**.
The *Actual frequency* **241** to be monitored is multiplied by the *Actual system value factor* **389** and can be read out via the parameter *Actual system value* **242**, i.e. *Actual frequency* **241** x *Actual system value factor* **389** = *Actual system value* **242**.

Actual System Value		
No.	**Description**	**Function**
242	Actual System Value	Calculated frequency of drive.

20.4.2 Volume Flow and Pressure

The parameterization of the factors *Nominal Volumetric Flow* **397** and *Nominal Pressure* **398** is necessary if the matching actual values *Volumetric Flow* **285** and *Pressure* **286** are used to monitor the drive. The conversion is done using the electrical control parameters. *Volume flow* **285** and *Pressure* **286** are referred to the *Effective 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**.

Volume Flow and Pressure		
No.	**Description**	**Function**
285	Volumetric flow	Calculated volume flow with the unit m^3/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 Error List

The last 16 fault messages are stored in chronological order and the *No. of errors* **362** shows the number of errors which have occurred since initial commissioning of the frequency inverter. In the VAL menu branch of the control unit, the error code FXXXX is displayed. The meaning of the error key is described in the following chapter "Error Messages". Via the PC program, the number of operation hours (h), operation minutes (m) and the fault message can additionally be read out. The current operating hours can be read off via the *Operation hours counter* **245**. The fault report can be acknowledged via the keys of the operating unit and according to the assignment *Error acknowledgment* **103**.

Error List		
No.	**Description**	**Function**
310	Last error	hhhhh:mm ; FXXXX fault message.
311	Last error but one	hhhhh:mm ; FXXXX fault 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.

Error List		
No.	**Description**	**Function**
363	No. of self acknowledged errors	Total number of automatic error acknowledgment with synchronization.

21.1.1 Error Messages

The error code stored following a fault comprises the error group FXX and the following code number XX.

Code		Meaning
Error Messages		
F00	00	No fault has occurred.
Overload		
F01	00	Frequency inverter overloaded.
F01	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 and fan.
	01	Temperature sensor defective or ambient temperature too low.
Inside		
F03	00	Inside temperature too high, check cooling and fan.
	01	Inside temperature too low, check electrical cabinet heating.
Motor Connection		
F04	00	Motor temperature too high or sensor defective, check connection S6IND.
	01	Motor protection switch tripped, check drive.
	02	V-belt monitoring reports no load on the drive.
	03	Phase failure, check motor and wiring.
	04	Deviation Position Controller. Please check Application manual Positioning.

Code		Meaning
	05	Start monitoring. Check brake & limiting parameters at start, like in example *Current limit* **728**, Intelligent currents, 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.
	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	Power failure, check mains voltage and circuit.
	03	Phase failure, check mains fuses 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.
Electronics voltage		
F08	01	Electronics voltage DC 24 V too low, check control terminal.
	04	Electronics voltage too high, check wiring of control terminals.
Brake chopper		
F10	10	Brake Chopper Overcurrent; refer to chapter 19.4 "Brake Chopper and Brake Resistance".
Output frequency		
F11	00	Output frequency too high, check control signals and settings.
	01	Max. frequency reached by control, check deceleration ramps and connected brake resistor.
	10	Overspeed. Check Application manual "Crane 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 units connected to shut-down paths; check cabling and EMC.
	04	Software self-diagnosis has detected an internal error. Consult BONFIGLIOLI customer service.
	05	Fault message 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 protective circuitry.
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 on multifunctional input 1 faulty, check signal.
	02	Reference value MF4IA faulty, check signal.
	07	Overcurrent on multifunctional input 1, check signal.
	21	Resolver fault. Check resolver connection and speed.
	22	Resolver counting fault. Check resolver connection.
	23	Resolver pole pair number incorrect. Check parameter of pole pairs.
	24	Resolver connection fault. 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.

Code		Meaning
	33	Encoder 2: Division Marks Fault. Check encoder settings.
	34	Too less Division Marks Fault. Check encoder settings.
	35	Too many Division Marks Fault. Check encoder settings.
	36	Encoder 1: Division Marks Fault. Correct *Division Marks* **491** of encoder 1; refer to chapter 11.4.2 "Division marks, speed sensor 1".
	37	The encoder is disabled. In configurations 210, 211 and 230 an encoder must be activated. Set parameter *Operation Mode* **490** to an evaluation mode (not to "0 – off). If an expansion module is installed and parameter *Actual Speed source* **766** is set to "2 – Speed Sensor 2", parameter *Operation Mode* **493** (speed sensor 2) must be set to an evaluation mode.
	50	KTY Temperature Measurement Failure. Check KTY connection.
	54	External error; drive responded according to parameter setting for *Operation mode ext. error* **535**. Error was triggered via the logic signal or digital input signal assigned to parameter *External error* **183**.
Positioning		
F14	4n	Positioning function fault. Please check Application manual Positioning.
	5n	
	6n	
	7n	
	9n	
Positioning		
F15	nn	Positioning function fault. Please check Application manual Positioning.
Modbus and VABus		
F20	10	Communication error according to 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
	28	RxPDO3 length error
	2A	CAN RxPDO1 Timeout
	2B	CAN RxPDO2 Timeout
	2C	CAN RxPDO3 Timeout
DeviceNet		
F20	5x	DeviceNet Fault. Please check DeviceNet manual.
System bus		
F21	nn	Fault message on system bus master when a fault at system bus slave occurs, nn = node-ID of slave (hex)
F22	00	Communication fault, system bus, timeout sync-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 recognition		
F24	nn	Unknown CM module. Check compatibility firmware and CM module.

Code		Meaning
EM module recognition		
F25	nn	Unknown CM module. Check compatibility firmware and EM module.
Industrial Ethernet		
F27	nn	Industrial Ethernet Fault. Please check manual of used Ethernet Module.
EtherCAT		
F28	nn	EtherCAT fault.
User Error VPLC		
F30	3n	User triggered Error of Internal PLC. Please check the application manual VPLC.
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 fault is triggered, due to the expectation that a faulty programming of the PLC or the function table is at hand. Additionally the PLC / Function table is stopped (P. 1399 = 0 only in RAM).

In error occurrence the signal 162 - "Error Signal" is set. The signal can be linked with inverter functions.

Output signals in error occurrence

Errors are indicated by digital signals.

162 -	Error Signal	1)	Monitoring function signals an error which is displayed in parameter *Current Error* **259**.
3 -		2)	

1) For linking with inverter functions
2) For digital output

In addition to fault messages mentioned, there are further fault messages. However these messages are only used for internal purposes and are not listed here. If you receive fault messages which are not listed here, please contact the BONFIGLIOLI customer service.
Please store the parameter file on your PC before contacting BONFIGLIOLI.

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.

Error Environment		
No.	**Description**	**Function**
330	DC –Link Voltage	Direct voltage in the DC link.
331	Output voltage	Calculated output voltage (motor voltage) of the frequency inverter.
332	Stator frequency	The output frequency (motor frequency) 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 on multifunctional input 1 in analog *Operation mode* **452**.
346	Analog output MF2OA	Output signal on multifunctional input 1 in *Operation mode* **550** – analog.
349	Repetition frequency output	Signal at repetition frequency output.
350	Status of digital inputs	Decimally coded status of the six digital inputs and of multifunctional input 1 in *Operation mode* **452** - digital input.
351	Status of digital outputs	Decimally coded status of the two digital outputs and of multifunctional 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	Warning status application	The application warnings coded in warning status.

The *Checksum* **361** parameter shows whether the storage of the error environment was free of errors (OK) or incomplete (NOK).

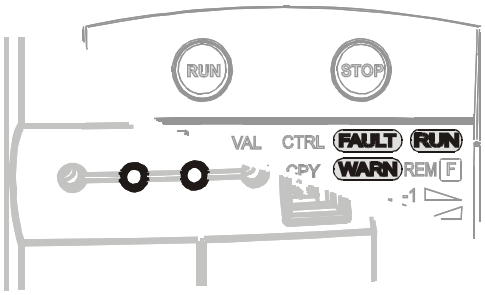
Error Environment		
No.	**Description**	**Function**
361	Checksum	Check protocol of the error environment.

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.



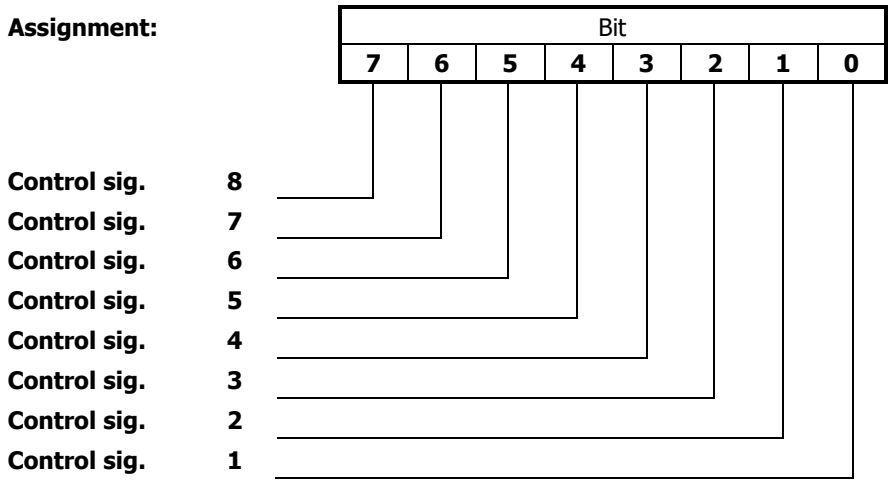
Status Display

green LED	red LED	Display	Description
off	off	-	No supply voltage.
on	on	-	Initialization and self-test.
flashes	off	RUN flashes	Ready for operation, no output signal.
on	off	RUN	Operating message.
on	flashes	RUN + WARN	Operational message, current *warning* **269**.
flashes	flashes	RUN + WARN	Ready for operation, current *warning* **269**.
off	flashes	FAULT flashes	*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 figure 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 **ABCDE**
| |
Controller code Controller abbreviation

Code				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 the case of a 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	The DC link voltage has exceeded the *Reference UD 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 is 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 TK reached, intelligent current limits *of Operation mode* **573** active.
C	10	00	PTClim	Max. motor temperature reached, intelligent current limits *of Operation mode* **573** active.
C	20	00	Flim	The 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 an early message 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 warning mask application* **626** have no influence on the warnings displayed. Via the actual value parameters *Warning* **269**, *Application Warnings* **273**, *Warning status* **356** (in error environment) and *Warning status application* **367** (in error environment), all warnings present at the time of the error are always displayed.

Coding of the warning status

AXXXX | Warning code

ABCDE | Abbreviation for the warning

Meaning of code displayed by parameter *Warning status* **356**:

Code				Warning Status
A	00	00	-	No warning message present.
A	00	01	Ixt	Frequency inverter overloaded (A0002 or A0004).
A	00	02	IxtSt	Overload for 60 s relative to the rated output of the frequency inverter.
A	00	04	IxtLt	Short-time overload for 1 s relative to the rated output of the frequency inverter.
A	00	08	Tc	Max. heat sink temperature T_K of 80 °C less the *Warning Limit Heat Sink Temp.* **407** reached.
A	00	10	Ti	Max. inside temperature T_i of 65 °C less the *Warning Limit Inside Temp.* **408** reached.
A	00	20	Lim	The controller stated in *Controller status* **275** limits the reference value.
A	00	40	INIT	Frequency inverter is being initialized.
A	00	80	PTC	Warning behavior according to parameterized *Operation mode Motor temp.* **570** at max. motor temperature T_{Motor}.
A	01	00	Mains	*Phase monitoring* **576** reports a phase failure.
A	02	00	PMS	Motor protection switch 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	40	00	UDC	The DC link voltage has reached the type-dependent minimum value.
A	80	00	WARN2	In *Warning status application* **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

The output of a warning message is signaled.
169 - General Warning[1] The output of a warning message in *Warnings* **269** is signaled.
11 - Warning, General[2]

[1] For linking with inverter functions
[2] For digital output

Meaning of code displayed by parameter *Application Warning Status* **367**:

Code				Warning Status
A	00	00	NO WARNING	No warning message present.
A	00	01	BELT	Warning V-belt by *Operation mode* **581**.
A	00	02	SW-LIM CW	The positive SW limit switch was reached (parameter *Positive SW limit switch* **1145**).
A	00	04	SW-LIM CCW	The negative SW limit switch was reached (parameter *Negative 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 adjusted with parameter *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 on digital input *User Warning 1* **1363** is active.
A	01	00	User 2	The signal set on digital input *User Warning 2* **1364** is active.

Output signals

The output of an application warning message is signaled.

216 -	Application Warning	1)	The output of a warning message in *Application Warnings* **273** is signaled.
26 -	Warning, Application	2)	

1) For linking with inverter functions
2) For digital output

23 Parameter List

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 the frequency inverter, o: overload capacity of frequency inverter

- *(210)* value for ANG210 devices
- *(410)* value for ANG410 devices
- *(510)* value for ANG510 devices
- *(610)* value for ANG610 devices

ANG 210 devices: Udmax= 400 V, ANG 410 devices: Udmax=800 V,
ANG 510 devices: Udmax= 900 V , ANG 610 devices: Udmax= 1200 V

At the control unit KP500 parameter numbers > 999 are displayed hexadecimal at the leading digit (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 the Machine			
210	Stator Frequency	Hz	0.00 ... 599.00	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 the Frequency Inverter			
222	DC-Link Voltage	V	0.0 ... U_{dmax}-25	20.1
223	Modulation	%	0 ... 100	20.1
	Actual Values of the 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 the 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

No.	Description	Unit	Display range	Chapter
	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 the 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
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 ... 599.00	20.2
	Actual Values of the System			
242	Actual System Value	Hz	0.0 ... 599.00	20.4.1
	Actual Values of the 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 ... 599.00	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 MF2OA	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
	Actual Values of the Machine			
235	Flux-forming voltage			20.2
236	Torque-forming voltage			20.2
	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

	No.	Description	Unit	Display range	Chapter
		Error List			
	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
	321	Error 12	h:m; F	00000:00; FXXXX	21.1
		Error List			
	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 ... 599.00	21.2
	333	Encoder 1 Frequency	Hz	0.00 ... 599.00	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 MF2OA	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
		Error List			
	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

No.	Description	Unit	Display range	Chapter
	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
	Self-configuration			
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(ming)	-	0 ... 9999	10.9
37	Start Positioning of Axle	-	Selection	0
	Fan			
39	Switch-on temperature	deg.C	0 ... 60	19.2
	Shot effect function			
⊗ 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 perc. value change-over 1	-	Selection	16.4.8
76	Fixed perc. value 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 control	-	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
	Digital inputs			
204	Therm. Contact	-	Selection	16.4.5

			Actual value memory			
		237	Reset memory	-	Selection	20.3
			Controlled 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	U/min	96 ... 60000	11.1
☑	▤	373	No. of pole pairs	-	1 ... 24	11.1
	▤	374	Rated cosine 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			
☑	▤ ⊗	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 rise time anticlockwise	ms	0 ... 65000	15.7

	No.	Description	Unit	Setting range	Chapter
		Traverse function			
⊗	435	Operation mode	-	Selection	19.8

	No.	Description	Unit	Setting range	Chapter
⊗	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
	445	Integral time	ms	0 ... 32767	18.3
	446	Ind. volume flow control factor	-	0.10 ... 2.00	18.3
		Block Frequencies			
	447	1. blocking frequency	Hz	0.00 ... 599.00	15.9
	448	2. blocking frequency	Hz	0.00 ... 599.00	15.9
	449	Frequency hysteresis	Hz	0.00 ... 100.00	15.9
		Multifunctional input 1			
	450	Tolerance band	%	0.00 ... 25.00	16.1.1.3
	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
	454	Point X1	%	0.00 ... 100.00	16.1.1.1
	455	Point Y1	%	-100.00 ... 100.00	16.1.1.1
	456	Point X2	%	0.00 ... 100.00	16.1.1.1
	457	Point Y2	%	-100.00 ... 100.00	16.1.1.1
		Positioning			
	458	Operation mode	-	Selection	13.6
	459	Signal source	-	Selection	13.6.1
	460	Positioning distance	U	0.000 ... 1 10^6	13.6.1
	461	Signal correction	ms	-327.68 ... 327.67	13.6.1
	462	Load correction	-	-32768 ... 32767	13.6.1
	463	Activity after positioning	-	Selection	13.6.1
	464	Waiting time	ms	0 ... 3.6 10^6	13.6.1
		Temperature Adjustment			
	465	Operation mode	-	Selection	19.7.2
	466	Temperature coefficient	%/100	0.00 ... 300.00	19.7.2
	467	Adjusting temperature	deg.C	-50.0 ... 300.0	19.7.2
		Positioning			
	469	Reference orientation	°	0.0 ... 359.9	0
	471	Positioning frequency	Hz	1.00 ... 50.00	0
	472	Max. positional error	°	0.1 ... 90.0	0
		Motor Potentiometer			
	473	Ramp Keypad Motorpoti	Hz/s	0.00 ... 999.99	15.10.3
	474	Operation mode	-	Selection	15.10
		Frequency reference channel			
	475	Reference frequency source	-	Selection	15.4
		Reference percentage channel			
	476	Reference percentage source	-	Selection	15.5
		Percentage ramp			
	477	Gradient percentage ramp	%/s	0 ... 60000	15.8
		Technology Controller			
	478	Actual percentage source	-	Selection	18.3

	No.	Description	Unit	Setting range	Chapter
		Positioning			
	479	time constant positioning contr.	ms	1.00 ... 9999.99	0
		Fixed Frequencies			
	480	Fixed frequency 1	Hz	-599.00 ... 599.00	15.6.1
	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
		Speed Sensor 1			
⊗	490	Operation mode	-	Selection	11.4.1
⊗	491	Division Marks	-	1 ... 8192	11.4.2
		PWM-/repetition frequency input			
⊗	496	Operation mode	-	Selection	15.11
⊗	497	Divider	-	1 ... 8192	15.11
		Brake Chopper			
	506	Trigger threshold	V	225 ... 1000.*0 (210)* 425 ... 2000.*0 (410)* 550 ... 2000.*0 (510)* 725 ... 2000.*0 (610)*	19.4
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	507	Trigger threshold	V	225 ... 1000.*0 (210)* 425 ... 2000.*0 (410)* 550 ... 2000.*0 (510)* 725 ... 2000.*0 (610)*	19.7.1
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	521	Fixed percentage 2	%	-300.00 ... 300.00	15.6.3
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	523	Fixed percentage 4	%	-300.00 ... 300.00	15.6.3
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	532	Operation mode digital output 3	-	Selection	16.3
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		No.	Description	Unit	Setting range	Chapter
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		544	Comparator On above	%	-300.00 ... 300.00	16.5.2
		545	Comparator Off below	%	-300.00 ... 300.00	16.5.2
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			Multifunctional output 1			
		550	Operation mode	-	Selection	16.2
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		570	Motor Temp. Operation Mode	-	Selection	14.6
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	✎	571	Operation mode	-	Selection	19.5
	✎	572	Frequency Limit	%	0 ... 300	19.5
			Intelligent current limits			
	✎	573	Operation mode	-	Selection	18.1
	✎	574	Power Limit	%	40.00 ... 95.00	18.1
	✎	575	Limitation time	min	5 ... 300	18.1
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	✎	576	Phase supervision	-	Selection	14.7
		578	Allowed no. of auto-acknowl.	-	0 ... 20	14.8
		579	Restart delay	ms	0 ... 1000	14.8
			Pulse Width Modulation			
		580	Reduction Limit Ti/Tc	deg.C	-25 ... 0	19.1
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	✎	581	Operation mode	-	Selection	19.5.2
	✎	582	Trigger limit Iactive	%	0.1 ... 100.0	19.5.2
	✎	583	Delay time	s	0.1 ... 600.0	19.5.2
			V/f characteristic			
☑	✎	600	Starting voltage	V	0.0 ... 100.0	17
☑	✎	601	Voltage rise	%	-100 ... 200	17
☑	✎	602	Rise frequency	%	0 ... 100	17
☑	✎	603	Cut-off voltage	V	60.0 ... 560.0	17
☑	✎	604	Cut-off frequency	Hz	0.00 ... 599.00	17
	✎	605	Dyn. voltage pre-control	%	0 ... 200	17.1
			Current limit value controller			
	✎	610	Operation mode	-	Selection	18.4.2
	✎	611	Amplification	-	0.01 ... 30.00	18.4.2
	✎	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
			Error/Warning Behaviour			
		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

		No.	Description	Unit	Setting range	Chapter
☑		623	Starting Current	A	0.0 ... o · I_{FIN}	13.1.1.1
☑		624	Frequency Limit	Hz	0.00 ... 100.00	13.1.1.2
		625	Brake release time	ms	-5000 ... 5000	13.1.1.3
			Warning application			
		626	Create Appl. Warning Mask	-	Selection	16.3.9
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		630	Operation mode	-	Selection	0
			Direct current brake			
☑		631	Braking current	A	0.00 ... $\sqrt{2}\cdot I_{FIN}$	13.2.3
		632	Braking time	s	0.0 ... 200.0	13.2.3
☑		633	Demagnetizing time	s	0.1 ... 30.0	13.2.3
		634	Amplification	-	0.00 ... 10.00	13.2.3
		635	Integral time	ms	0 ... 1000	13.2.3
			Stopping Behavior			
		637	Switch-off threshold	%	0.0 ... 100.0	0
		638	Holding time	s	0.0 ... 200.0	13.2.2
			Search Run			
		645	Operation mode	-	Selection	13.5
		646	Brak. time after search run	s	0.0 ... 200.0	13.5
		647	Current / rated motor current	%	1.00 ... 100.00	13.5
		648	Amplification	-	0.00 ... 10.00	13.5
		649	Integral time	ms	0 ... 1000	13.5
			Auto Start			
		651	Operation mode	-	Selection	13.4
			PWM-/repetition frequency input			
		652	PWM-Offset	%	-100.00 ... 100.00	15.11
		653	PWM-Amplification	%	5.0 ... 1000.0	15.11
			Slip compensation			
☑		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
			Voltage controller			
		670	Operation mode	-	Selection	18.2
		671	Mains failure threshold	V	-200.0 ... –50.0	18.2
		672	Reference mains support value	V	-200.0 ... –10.0	18.2
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		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 ... 387.5 *(210)* 425 ... 775 *(410)*	18.2
		677	Amplification	-	0.00 ... 30.00	18.2
		678	Integral time	ms	0 ... 10000	18.2
		680	Reference DC link limitation	V	225 ... 387.5 *(210)* 425 ... 775 *(410)*	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

		No.	Description	Unit	Setting range	Chapter
☑		714	Magnetizing current 80% flux	%	1 ... 80	11.2.3
☑		715	Magnetizing current 110% flux	%	110 ... 197	11.2.3
☑		716	Rated magnetizing current	A	0.01·I_{FIN} ... o·I_{FIN}	11.2.3
			Field Controller			
☑		717	Reference Flux	%	0.01 ... 300.00	18.5.7
			Further motor parameters			
☑		718	Rated slip correction factor	%	0.01 ... 300.00	11.2.4
			Frequency Limits			
		719	Slip Frequency	%	0 ... 10000	15.2
			Speed controller			
		720	Operation mode	-	Selection	18.5.5
☑		721	Amplification 1	-	0.00 ... 200.00	18.5.5
		722	Integral time 1	ms	0 ... 60000	18.5.5
☑		723	Amplification 2	-	0.00 ... 200.00	18.5.5
		724	Integral time 2	ms	0 ... 60000	18.5.5
			Acceleration Pre-Control			
		725	Operation mode	-	Selection	18.5.6
		726	Minimum acceleration	Hz/s	0.1 ... 6500.0	18.5.6
		727	Mech. time constant	ms	1 ... 60000	18.5.6
			Speed controller			
		728	Current Limit	A	0.0 ... o · I_{FIN}	18.5.5.1
		729	Current limit generator operation	A	-0.1 ... o · I_{FIN}	18.5.5.1
		730	Torque limit	%	0.00 ... 650.00	18.5.5.1
		731	Torque limit generator operation	%	0.00 ... 650.00	18.5.5.1
		732	P comp. torque upper limit	%	0.00 ... 650.00	18.5.5.1
		733	P comp. torque lower limit	%	0.00 ... 650.00	18.5.5.1
			Speed controller			
		734	Isq limit source motor operation	-	Selection	18.5.5.2
		735	Isq limit source gen. operation	-	Selection	18.5.5.2
		736	Torque limit source motor operation	-	Selection	18.5.5.2
		737	Torque limit source gen. operation	-	Selection	18.5.5.2
☑		738	Speed control switch-over limit	Hz	0.00 ... 599.00	18.5.5
		739	Power Limit	kW	0.00 ... 2·o·P_{FIN}	18.5.5.1
		740	Power limit generator operation	kW	0.00 ... 2·o·P_{FIN}	18.5.5.1
			Field Controller			
		741	Amplification	-	0.0 ... 100.0	18.5.7
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☑		743	Ref. Isd upper limit	A	0 ... o·I_{FIN}	18.5.7.1
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			Speed controller			
		748	Backlash damping	%	0 ... 300	18.5.5
			Modulation Controller			
		750	Reference modulator	%	3.00 ... 105.00	18.5.8
		752	Integral time	ms	0.0 ... 1000.00	18.5.8
		753	Operation mode	-	Selection	18.5.8
		754	Filter time constant	ms	0...128	18.5.5
		755	Reference Imr lower limit	A	0.01·I_{FIN} ... o·I_{FIN}	18.5.8.1
		756	Control deviation limitation	%	0.00 ... 100.00	18.5.8.1
			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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		Speed Sensor Monitoring			
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	766	Source of actual speed value	-	Selection	18.5.5
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	767	Frequency upper limit	Hz	-599.00 ... 599.00	18.5.4.2
	768	Frequency lower limit	Hz	-599.00 ... 599.00	18.5.4.2
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	770	Frequency lower limit source	-	Selection	18.5.4.3
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☑	775	Current above P. 700 is in effect	A	0.00· ... o·I_{FIN}	18.5.2
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	779	Min. Flux-Formation Time	ms	1 ... 10000	13.1.2
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☑	781	Current during flux formation	A	0.1·I_{FIN} ... o·I_{FIN}	13.1.2
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	790	Operation mode Timer 1	-	Selection	16.5.1
	791	Time 1 Timer 1	s/m/h	0 ... 650.00	16.5.1.1
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	793	Operation mode Timer 2	-	Selection	16.5.1
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		Self-configuration			
	796	SET-UP Select	-	Selection	9.5
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		Filter encoder 1			
	1193	EC1: Filter time constant	us	0...32000	11.4.4
		Further motor parameters			
⊗	1199	Change Sense of Rotation	-	Selection	11.2.8
		Mux/DeMux			
	1250	Mux Input Index (write)	-	EEPROM: 0 ... 16 RAM: 17 ... 33	16.5.4
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	1363	User warning 1	-	Selection	16.4.11
	1364	User warning 2	-	Selection	16.4.11

At the control unit KP500 parameter numbers > 999 are displayed hexadecimal at the leading digit (999, A00 ... B5 ... C66).

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