Variable frequency drive (VFD)

Medium voltage 2.3 kV – 13.8 kV

User Manual

en

# MVH 2.0 Series

RIGHT FROM THE START

AuCom

MOTOR CONTROL SPECIALISTS

READ THESE INSTRUCTIONS BEFORE USE!

# IMPRINT

**Publisher**

AuCom MCS GmbH & Co. KG
Borsigstraße 6
49324 Sendenhorst
GERMANY

Phone: +49 2526 93880 0
Internet: www.aucom.com
E-mail: sales@aucom.com

**Document reference, date of creation**

MVH2.0_BA_1.0.1_en 22.11.2023

**Validity**

Product: **MVH 2.0 SERIES**

# INTRODUCTION

## GENERAL INFORMATION

*PRODUCT IDENTIFICATION*

| | |
|---|---|
| Model: | MVH 2.0 Series |
| Product type: | Speed regulation and control of medium voltage three-phase motors |
| Product group: | Variable frequency drive (VFD) |

*MANUFACTURER*

AuCom MCS GmbH & Co. KG
Borsigstraße 6
49324 Sendenhorst
GERMANY

| | |
|---|---|
| Phone: | +49 2526 93880 0 |
| Internet: | www.aucom.com |
| E-mail: | sales@aucom.com |
| Support: | www.aucom.com/contact-us/support-enquiry |


*DOCUMENT INFORMATION*

| | |
|---|---|
| Title: | MVH 2.0 Series |
| Document type: | User Manual |
| Document reference: | MVH2.0_BA_1.0.1_en |
| Document part number: | 710-25096-00C |

*VALIDITY*

| | |
|---|---|
| Hardware – Main control unit: | as of version HC4 |
| Hardware – I/O Interface unit: | as of version HC4 |
| Hardware – Operating unit (HMI): | as of version TPC1031Kt |
| Firmware – Main control unit: | as of version 2.27.10 |
| Firmware – I/O Interface unit: | as of version 2.27.10 |
| Firmware – Operating unit (HMI): | as of version 2.27.10 |

*CHANGE LOG*

| Version | Change | Initiator | Date |
|---|---|---|---|
| 1.0.0 | Initial version | AuCom, (FB) | 26.10.2023 |
| 1.0.1 | Minor corrections: chapters 2.2.4 and 3.2 | AuCom, (FB) | 22.11.2023 |

*Tab. 1-1 MVH 2.0 User Manual – Change log*

## NOTES ON THIS USER MANUAL

This document contains important information for safe, effective, and efficient use of the MVH 2.0 variable frequency drive (VFD).

***SOURCE USER MANUAL*** The source user manual was written in German language.

***STORAGE*** This user manual is an integral part of the MVH 2.0 product and must always be kept in the immediate vicinity of the MVH 2.0 frequency inverter.

***TARGET AUDIENCE*** This user manual is intended for the personnel responsible for the installation, *commissioning,* and *maintenance* of the product. You can find further information on qualification requirements and access level of the personnel in chapter "1.3 Target Audience and Qualification".

***CHAPTER OVERVIEW***

**Chapter „1 Safety"**
General safety instructions relevant to the product.

**Chapter „2 Product Overview"**
Basic information on the MVH 2.0 frequency inverter and its intended use.

**Chapter „3 Structure and Functions"**
Mechanical and electrical design of the VFD cabinet and its main components as well as functional outline of the MVH 2.0.

**Chapter „4 Operating and Display"**
Presentation and explanation of all relevant elements for the initial commissioning and operation of the MVH 2.0.

**Chapter „5 VFD Operation"**
Presentation and explanation of the MVH 2.0 operating functions for effective and efficient operation.

**Chapter „6 Maintenance"**
Measures for planning and carrying out maintenance work to maintain the MVH 2.0 target state and optimise its availability.

**Chapter „7 Troubleshooting"**
Information on causes and remedial measures of potential malfunctions as well as instructions for restoring the MVH 2.0 to its target state.

**Chapter „8 Transport, Storage, and Installation"**
Information and instructions on maintaining the MVH 2.0 in its intended condition during transport and storage as well as general installation instructions.

**Chapter „9 Disposal"**
Instructions for the proper and environmentally friendly disposal of the MVH 2.0 after final decommissioning.

**Chapter „10 Spare Parts"**
Ordering information on available spare parts and accessories for the MVH 2.0 product.

## SYMBOLS AND REPRESENTATIONS

***WARNINGS***

In this user manual, safety and protection levels are classified as DANGER, WARNING, CAUTION and NOTICE.

**DANGER**

Warns of an electric shock hazard with a high degree of risk which, if not avoided, may result in death or serious injury.

**WARNING**

Warns of an electric shock hazard with a medium degree of risk which, if not avoided, may result in death or serious injury.

**CAUTION**

Warns of a hazard (general hazard location) with a low degree of risk which, if not avoided, may result in minor or moderate injury.

**NOTICE**

Warns of situations that can lead to property damage if not avoided.

If several different levels of hazards are combined in one warning, the highest level of warning is always selected. Warnings about personal hazards may include warnings about property damage.

***WARNING STRUCTURE***

The warnings used in this user manual are each indicated by:

- a warning symbol,
- a signal word to indicate the extent of the hazard,
- an indication of the nature and source of the hazard,
- an indication of the possible consequences if the hazard is not avoided, and
- the measures to be taken to avoid the hazard.

*Warning symbol*

**Signal word**

**Nature and source of the hazard**

Possible consequences of not avoiding the hazard.

- ➢ Measure 1 to be taken to avoid the hazard
- ➢ Measure 2 to be taken to avoid the hazard
- ➢ ...

***INFORMATIVE NOTES***

In this user manual, additional information of a general nature or for more detailed information on specific matters is given as a NOTE or as a DISPOSAL NOTE.

**NOTE**

Indicates specific information relating to the use or operation of the product.

***NOTES ON DISPOSAL***

In this user manual, instructions for proper and environmentally friendly disposal are shown as DISPOSAL NOTES

**DISPOSAL NOTE**

Indicates the regulations for the disposal of old electrical appliances.

***REFERENCES***

To increase the efficiency of this user manual, reference is made to exemplary instructions or further chapters for the description of the same procedure or further information.

**CHAPTER REFERENCE**

- Indication of the process/topic as well as indication of the referenced chapter number and the chapter title.

***LABELLING OF INSTRUCTIONS***

The *beginning* of a *general* instruction sequence on how to perform an action sequence is introduced as follows:

**INSTRUCTION – Title of the instruction**

***START***

The *beginning* of an instruction sequence *with indication of the required authorisation (user level)* to perform an action sequence is introduced as follows:

**INSTRUCTION – Title of the instruction**

***START*** ***USER LEVEL: „Name"***

The action steps of the action sequence of an instruction are indicated as follows:

**STEP 1:** ...

- Result 1 of the first action step
- Result 2 of the first action step
- ...

**STEP 2:** ...

- Result 1 of the second action step
- Result 2 of the second action step
- ...

The end of a general or specific instruction sequence is indicated as follows

***END***

***TYPOGRAPHIC CONVENTIONS***

In this user manual, *italics* are used for names of:

- Parameters and functions,
- Parameter setting options,
- Alarm and fault messages, and
- Common terms of particular importance.

# TABLE OF CONTENTS

# LIST OF ABBREVIATIONS

### *ABBREVIATIONS*

| Acronym | Description |
|---|---|
| ACC | AuCom Compact Cabinet |
| AFA | AuCom Front Access |
| ADA | AuCom Double Access |
| AI | analog input |
| AO | analog output |
| DCS | distributed communication system |
| DI | digital input |
| DO | digital output |
| FE | functional earth |
| FRT | fault ride through |
| HMI | human machine interface |
| IGBT | insulated-gate bipolar transistor |
| I/O | inputs/outputs |
| LV | low voltage |
| MV | medium voltage |
| NO | normal open |
| NC | normal closed |
| PE | protective earth |
| PLC | programmable logic controller |
| [pu] | per unit |
| VFD | variable frequency drive |

### *SYMBOLS USED IN FORMULAS*

| | |
|---|---|
| VC | vector control |
| $\Delta\varphi$ | Phase angle difference |
| f | frequency |
| I | el. current |
| n | speed |
| $\vartheta$ | temperature |
| $R_s$ | stator resistance |
| U | el. voltage |
| $\triangleq$ | corresponds to |

# 1 SAFETY

To use the MVH 2.0 product safely, you must read, understand, and observe all the information in this user manual before use. This user manual must always be available when working on and with the product.

*GENERAL UNDERSTANDING OF SAFETY*

MVH 2.0 frequency inverters are designed so that no hazards arise when the product is used in accordance with the given instructions. However, operation of the MVH 2.0 requires the frequency inverter to be connected to medium voltage. Therefore, dangerous, high voltages are present in the VFD cabinet, which can lead to personal hazards and damage of the system if the product is not used as intended.

This chapter includes al safety-related information for safe use of the product.

*SAFETY PRECAUTIONS*

Technical training is available for all personnel involved in the operation and maintenance of the equipment. For more information, contact AuCom or your local supplier.

## 1.1 WARNING SIGNS ON THE VFD CABINET

The following warning signs are attached to the MVH 2.0 cabinet and must be observed:

| Warning sign | Description |
|---|---|
|  | ➢ Indicates a hazardous location with an electric shock hazard. |
|  | ➢ General reference to a hazardous point with reference to the relevant documentation. |

## 1.2 INTENDED USE

MVH 2.0 frequency inverters are used for stepless speed control of three-phase drives (asynchronous and synchronous motors) on the medium voltage level (2.3kV to 13.8kV).

This user manual serves as a specification for the intended use of the product and must be strictly adhered to. The user manual must be available for all activities connected with the product.

*QUALIFIED AND AUTHORISED PERSONNEL*

Only appropriately qualified and authorised personnel can carry out work on and with the product during the entire product life cycle.

*TRANSPORT AND STORAGE*

You must observe and comply with all instructions and relevant technical data on transport and storage conditions.

*PERSONAL PROTECTIVE EQUIPMENT*

At all times, you must observe the regulations on the use of personal protective equipment (PPE).

*PLANT CONSTRUCTION*

You must comply with all applicable country-specific, local, and industry-specific ordinances and regulations for the safety and construction of the plant.

*ENVIRONMENT AND INSTALLATION*

You must observe and comply with all instructions and information on ambient conditions and installation conditions.

*OPERATION*

All components of the application (frequency inverter, drive, power supply and its fuse protection) must be coordinated with each other regarding their rated variables, their function, and all parameter settings.

*PRODUCT MODIFICATION AND DISCLAIMER*

Modification or manipulation of the MVH 2.0 is not permitted.

Modification or tampering with the MVH 2.0 means that the product is being used outside of its specification and is therefore a non-intended use, which can cause personal injury and damage to the system. Any consequences of improper use of the product are not covered by AuCom Support and will void the guarantee or warranty. AuCom excludes all liability for improper use and any consequences that may arise from it.

*MISUSE*

Any use that does not correspond to the intended use of the MVH 2.0 product is considered misuse.

**DANGER**

**Danger in case of misuse**

Misuse of the MVH 2.0 can result in death, serious personal injury, and damage to the equipment.

- Never operate the product unless all safety devices of the MVH 2.0 are functioning properly or are ready for operation.
- Never operate the product at a voltage level that does not correspond to the specified VFD input voltage.
- Never connect drives to the product whose rated voltage and current are not matched to the rated values of the MVH 2.0.
- Never put the product into operation unless all parameter settings of the MVH 2.0 have been adjusted to the connected drive and the application.
- Never modify or manipulate the product with hardware and/or software components not specified by AuCom.
- Never use spare parts that are not specified by AuCom.

## 1.3 TARGET AUDIENCE AND QUALIFICATION

The MVH 2.0 Series frequency inverters are intended for use by qualified personnel in commercial areas of various industries where frequency inverters are used to control the speed of three-phase medium voltage motors.

This user manual is intended for qualified personnel for the commissioning, operation, and maintenance of this product. According to their training and experience, qualified personnel are able to recognise risks when using the product and its applications and to avert potential hazards to persons and system components.

For commissioning and operation, the product offers four different user levels, each adapted to different tasks. Each level requires different qualifications and authorisation.

*USER LEVEL „STANDARD"*

At this user level, the technical personnel have basic technical knowledge for applications of frequency inverters on the medium voltage level. This user level allows the start/stop control of MV AC motors via the frequency inverter.

This user level does not require a password to operate the drive. Instructions for the operating personnel are given in this user manual.

*USER LEVEL „OPERATOR"*

The technical personnel have advanced expertise for applications of frequency inverters on the medium voltage level. This user level allows start/stop control of MV AC motors via the frequency inverter, reading of all parameter settings. It also lets you program a limited set of parameters (operation and maintenance).

This user level requires the entry of the corresponding *Operator* password. Instructions of are carried out based on this user manual as well as MVH 2.0-specific training on the extended application of the product.

***USER LEVEL „ENGINEER"***

The technical personnel have advanced expertise for applications of frequency inverters on the medium voltage level. This user level allows start/stop control of MV AC motors via the frequency inverter as well as reading and setting all parameters (commissioning, operation, and maintenance).

This user level requires the entry of the corresponding *Engineer* password. The instruction of the operating personnel is carried out based on the complete technical documentation as well as training by experts.

***USER LEVEL „MANUFACTURER"***

This user level is password protected and is the exclusive responsibility of the manufacturer.

## 1.4 SAFETY INSTRUCTIONS

### 1.4.1 FIVE SAFETY RULES OF ELECTRICAL ENGINEERING

For all work on the MVH 2.0 you must apply the five safety rules of electrical engineering according to DIN VDE 0105 in the following order:

1. Switch off
2. Lock against reclosure
3. Check that lines and equipment are dead
4. Ground and short circuit all phases
5. Cover, partition, or screen adjacent line sections

To restart the equipment, follow the five safety rules is done in reverse order.

### 1.4.2 SAFE OPERATION

***DELIVERY INSPECTION***

**WARNING**

- Do not use the VFD if there is moisture in the VFD cabinet, parts are missing, or parts were damaged during unpacking.
- If the packing list does not correspond to the model number indicated on the nameplate you *must not* install the VFD.
- When transporting or lifting the VFD, make sure that the means of transport is suitable for the weight and dimensions of the VFD. If this is not the case, the VFD may be damaged during handling.

***INSTALLATION***

**CAUTION**

- Follow the instructions in this manual. Installation must only be carried out by qualified personnel.
- Install the VFD only on suitable surfaces (metal or concrete) and away from combustible materials to avoid fire hazard.
- Do not touch the electronic components inside the VFD cabinet directly during installation as this may cause electrostatic damage to the VFD.

- Only install or remove PCBs und ESD-compliant conditions (antistatic protection).
- Tighten screws and other parts according to the specified torques.
- Make sure that no metal chips, wire debris and other small parts can enter the VFD cabinet to prevent damage to the VFD during operation.

### *ELECTRICAL CONNECTION*

**WARNING**

- Never connect the phases of the medium voltage (L1, L2, L3) to the VFD output terminals (2U, 2V, 2W).
- Electrical connections must only be made by qualified personnel and in accordance with the relevant standards for electrical work.
- Make sure that all power supplies and auxiliary voltages are switched off before wiring to avoid electric shock or fire.
- Ground the VFD cabinet properly to avoid electrostatic charges.

### *OPERATION*

**WARNING**

- Before applying mains supply voltage, make sure that the supply voltage corresponds to the rated voltage of the VFD.
- Make sure that the main circuit wiring is correctly connected, and terminal screws are tightened with the specified torques.
- The VFD must not be energised until the wiring is completed and the cabinet doors are closed. Never open a cabinet door when the medium voltage supply is switched on to avoid the risk of electric shock.
- If *automatic start* after MV loss is enabled, you must take appropriate safety precautions in the periphery of the VFD to prevent personnel injury and damage to the property.
- As soon as the VFD is switched on, the terminals of the VFD are live. This also applies to stop mode. Do not touch the terminals as this may cause an electric shock.
- Do not disconnect the power supply for the fans while the VFD is in operation as this may cause overheating and damage to the VFD system. This will also cause the control system to shut down.
- For water-cooled VFDs, the cooling water supplied by the customer must meet the specifications.
- Do not reset a fault message until it the start command has been disabled. Resetting fault messages when the start command is active can lead to personal injury and damage to the equipment.

### MAINTENANCE AND INSPECTION

**WARNING**

- Make sure that the VFD output is isolated and earthed before starting any work on the VFD.
- If the load can remain in operation while the VFD is being serviced, you must isolate the VFD from the motor to avoid electrical shock.
- Never troubleshoot or service the VFD with the medium voltage switched on. You must switch off the VFD before opening a cabinet door and follow all interlocking and safety instructions.
- To avoid injuries from the residual voltage of the main circuit capacitors, wait at least 10 min after disconnection or failure of the power supply and make sure that the voltage indicators on the power cells are off before carrying out maintenance and inspection work.
- Only qualified personnel can perform maintenance, inspection, and repair work.

### DISPOSAL

**CAUTION**

Dispose of all used components or parts properly.

### OTHERS

**WARNING**

You must not modify the VFD. Any modification to the VFD is the sole responsibility of the manufacturer.

# 2 PRODUCT OVERVIEW

## 2.1 IMPORTANT NOTES ON THE PRODUCT

MVH 2.0 Series frequency inverters for drives with variable speed offer the following solutions for the use of medium voltage motors with regard to:

*INTENDED USE OF THE VFD*

- Intelligent control of medium voltage AC synchronous and asynchronous motors (induction motors)
- Motor soft start (extension of motor life cycle)
- Motor speed control
- Energy saving through optimised power consumption of the motor at different speed and power requirements
- Reactive power control during motor running

*INDUSTRIES*

Typical industries:

- Chemistry/Petrochemistry
- Cement
- Mining and Minerals
- Water/Wastewater projects
- Power generation
- Metallurgy
- Light industry
- Ventilation and air-conditioning technology
- Others ...

*AREAS OF APPLICATION*

Typical application areas:

| **Power generation** | **Chemistry/Petrochemistry** | **Mining and Minerals** |
|---|---|---|
| Booster fan | Aeration fan | Main fan |
| Induced draft fan | Induced draft fan | Axial flow fan |
| Forced draft fan | Forced draft fan | De-scaling pump |
| Pipeline transportation pump | Water pump | Mud pump |
| Water injection pump | Sewage pump | Cleaning water pump |
| Feed water pump | Hot water circulating pump | Feeding pump |
| Submerged pump | Lift station | Stirring pump |
| Oil transfer pump | Cleaning water pump | Drainage pump |
| Brine pump | Water supply pump | Conveyor drive |
| Circulating water pump | Extruder | |
| **Cement** | **Metallurgy** | **Municipal projects** |
| Kiln draft fan | Induced draft fan | Booster fan |
| Kiln gas blower | Forced draft fan | Condensation pump |
| Separator fan | Blast furnace blower | Slurry pump |
| Cement mill fan | Blast fan | Water storage pump |
| Dust removal fan | Converter fan | Circulating water pump |
| Circulating fan | Electric furnace fan | Boiler feed pump |
| Grate cooler | Slag-flushing pump | Compressor |
| Raw mill fan | Feeding pump | |
| Raw material mill | Water-delivery pump | |

| | |
|---|---|
| Coal mill | Mud pump |
| Clinker cooler fan | De-scaling pump |
| Kiln drive | Oxygen compressor |
| Forced draft fan | |
| **Light industry** | **Others** |
| Gas blower | Pump test stand |
| Hydraulic pump | VFD power supply test stand |
| Cleaning pump | Motor test stand |
| Axial flow pump | Wind channel test |
| Compressor | Kneading machine |
| Shredding machine | |

*Tab. 2-1 MVH 2.0 – Typical areas of application*

### 2.1.1 MVH 2.0 MV FREQUENCY INVERTER OVERVIEW

The VFD cabinet consists of the following units:

- *Transformer cabinet,* with multi-level transformer,
- *Power cell cabinet,* with power cells for the VFD power electronics,
- Control/feeder cabinet, with operating elements in the low voltage (LV) section and connections for mains supply and motor feeder with optional switching and disconnection devices in the bulkheaded medium voltage section (MV),
- Cooling fans for the transformer cabinet and the power cell cabinet.

For frequency inverters with lower power (kVA), the multi-level transformer and the power cells are in a combined cabinet panel. This applies to the following cabinet type:

- ACC - AuCom Compact Cabinet

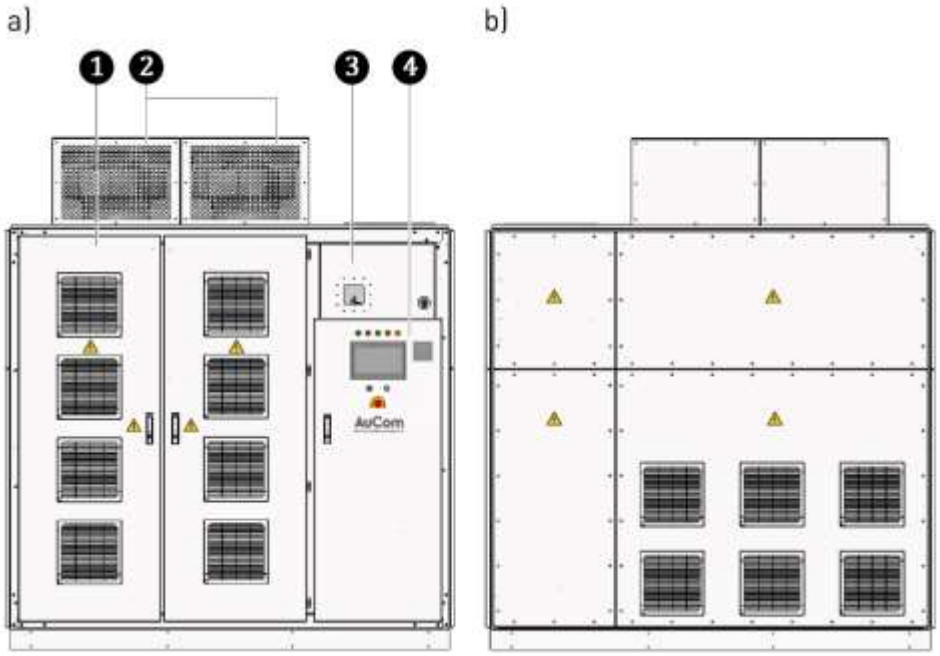



*Fig. 2-1 Typical integrated VFD cabinet design: ACC-AuCom Compact Cabinet*
*a) Front view*
*b) Rear view*

1. Combined Transformer/Power cell cabinet
2. Cooling fans
3. Connection/switching panel (MV)
4. Control panel with operating and display elements (e.g., operating unit (HMI) with touchscreen (LV)

For frequency inverters with higher power (kVA), the multi-level transformer and the power cells are in separate cabinet panels. This applies to the following cabinet types:

- AFA – AuCom Front Access, and
- ADA – AuCom Double Access.

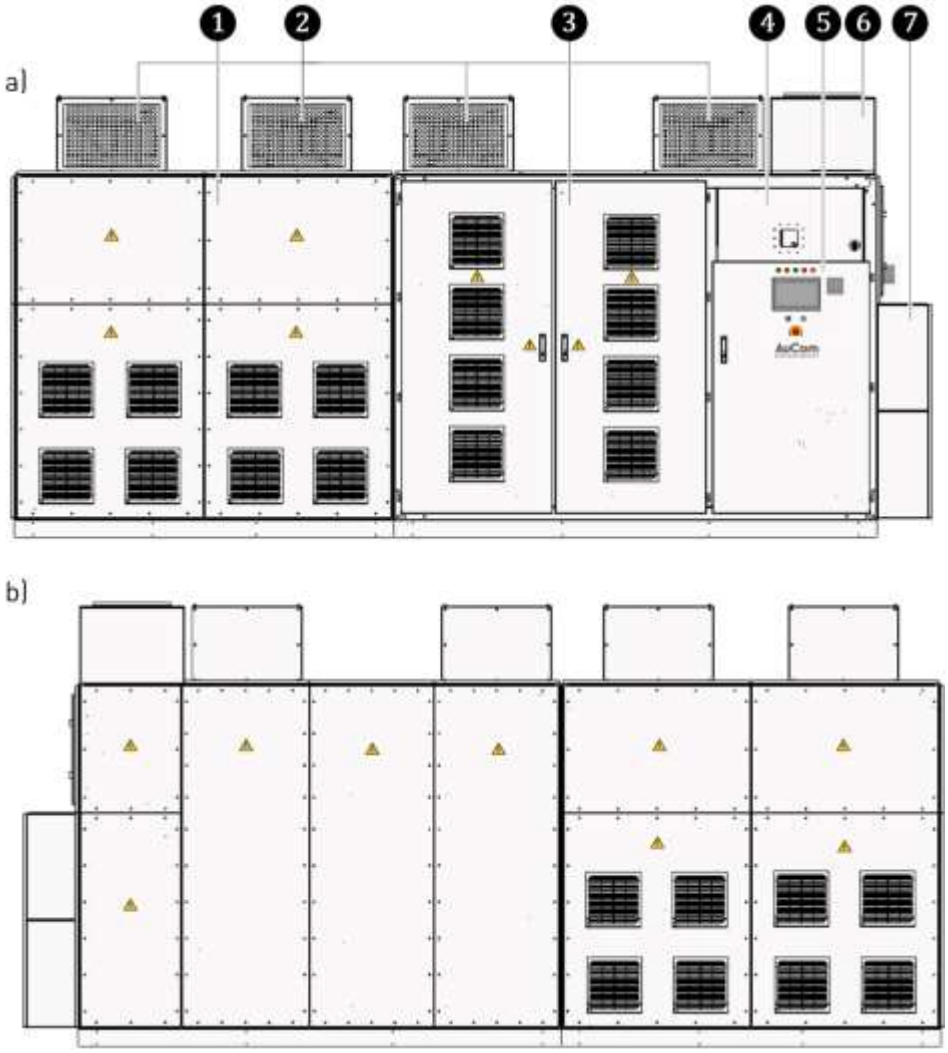



*Fig. 2-2 Typical separate VFD cabinet design: AFA-AuCom Front Access*
*a) Front view*
*b) Rear view*

1. Transformer cabinet
2. Cooling fans
3. Power cell cabinet
4. Connection/switching panel (MV)
5. Control panel with operating and display elements (e.g., operating unit (HMI) with touchscreen (LV)
6. Optional cable entry for MV supply line from above (customer side)
7. Optional cable entry for MV motor feeder from above (customer side)

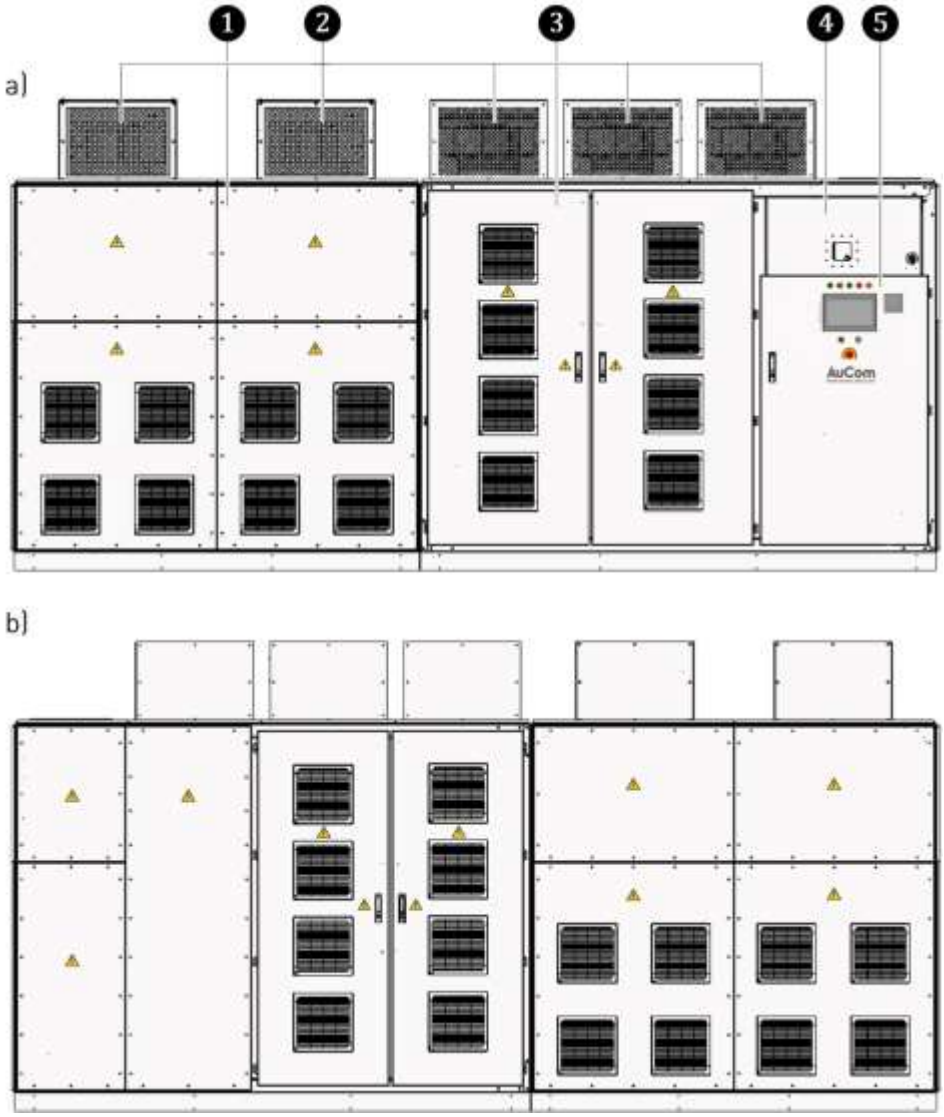



*Fig. 2-3 Typical separate VFD cabinet design: ADA-AuCom Double Access*
*a) Front view*
*b) Rear view*

1. Transformer cabinet
2. Cooling fans
3. Power cell cabinet
4. Connection/switching panel (MV)
5. Control panel with operating and display elements (e.g., operating unit (HMI) with touchscreen (LV)

**NOTE**

The *ADA cabinet type can also be equipped with an:*

- optional cable entry for MV supply line from above (customer side), and an
- optional cable entry for MV motor feeder from above (customer side)

### 2.1.2 HAZARDOUS AREAS

*POWER CELL CABINET*

Inside the power cell cabinet, dangerous, high voltages are constantly present at the corresponding connections and tracks during VFD standby and operation.

The power cell cabinet provides cabinet doors for maintenance and repair work. Each door can be locked and has a door contact switch. You must not open the doors of the power cell cabinet during VFD standby or operation!

If one of the doors is unlocked and opened during VFD operation or standby, the door contact opens and the VFD is switched off (that is, if parameter *Open cabinet door: Fault selection* is set accordingly).

**WARNING**

Danger due to electric shock!

With the parameter setting *Open cabinet door: Fault selection = Alarm* there is a risk of death or injury from electric shock if you come in contact with live parts in the power cell cabinet.

- The VFD is always delivered with the factory parameter setting: *Open cabinet door: Fault selection = Fault.*
- Using the VFD with parameter setting: *Open cabinet door: Fault selection = Alarm* is not recommended.

**WARNING**

Danger due to electric shock!

Dangerous residual voltage is still present at input terminals R, S, T on the power cell, even after the VFD has been switched off.

To mitigate risk of injury from electric shock if you come in contact with live parts on the power cell:

- Switch off the medium voltage feed through upstream main switching element.
- Apply the five safety rules (see Five safety rules of electrical engineering).
- Wait at least 10 min after the power cell status indicator has gone out before starting any work on the power cells.

### 2.1.3 CONFORMITY

#### EU DECLARATION OF CONFORMITY

AuCom MOTOR CONTROL SPECIALISTS
BENSHAW Applied Motor Controls

RIGHT FROM THE START

## EU Declaration of Conformity

(Directive 2014/30/EU)

| | |
|---|---|
| **Product type:** | MVH Variable Frequency Drive |
| **Manufacturer:** | AuCom MCS GmbH & Co.KG |
| **Address:** | Borsigstraße 6 |
| | 48324 Sendenhorst |

This declaration of conformity is issued under the sole responsibility of the manufacturer

| | |
|---|---|
| **Product identification:** | MVH 2.0 (Full Drive); MVH S 2.0 (Start Drive); MVH D 2.0 (Dual Drive) |

All available design variants listed in the product code of 10/07/2023 are considered.

The object of the declaration described above is in conformity with the following relevant Union harmonisation legislation(s):

**2014/30/EU:** DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility; Official Journal of the European Union L96/79, 29/03/2014

Conformity to the directives is verified through total compliance with all the specifications applicable to the product in the following standards:

**IEC-61800-3:2017:** Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods

**IEC-61800-4:2002:** Adjustable speed electrical power drive systems - Part 4: General requirements; Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV

**IEC-61800-5-2:2016:** Adjustable speed electrical power drive systems - Part 5-2: Safety requirements – Functional

**Signed for on behalf of AuCom MCS GmbH & Co.KG**

Sendenhorst, 10/07/2023
**Place/ Date of issue**

Patrick van der Kooy, Quality-Manager
**Name, Function, Signature**

## NORMS AND STANDARDS

| Standard | Definition |
|---|---|
| IEC 62271-200:2011 | high-voltage switchgear and control gear - Part 200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV |
| IEC 61439-1:2020 | low-voltage switchgear and control gear assemblies - Part 1: General rules |
| IEC 61439-2:2020 | low-voltage switchgear and control gear assemblies - Part 2: Power switchgear and control gear assemblies |
| IEC 60073-2002 | Basic and safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators |
| IEC 60204-11: 2018 | Safety of machinery - Electrical equipment of machines - Part 11: Requirements for equipment for voltages above 1000 V AC or 1500 V DC and not exceeding 36 kV |
| IEC 60529: 2013 | Degrees of protection provided by enclosures (IP Code) |
| IEC 60664-1: 2020 | Insulation coordination for equipment within low-voltage supply systems - Part 1: Principles, requirements and tests |
| IEC 61800-3: 2019-04 | Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods |
| IEC 61800-4: 2002 | Adjustable speed electrical power drive systems - Part 4: General requirements; Rating specifications for a.c. power drive systems above 1000 V AC and not exceeding 35 kV |
| IEC 61800-5-1: 2007+A1:2016 | Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy |
| IEC 61800-5-2: 2016 | Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional |
| IEEE 519: 2022 | IEEE Standard for Harmonic Control in Electric Power Systems |

*Tab. 2-2 Norms and Standards*

## 2.1.4 LABELLING OF THE PRODUCT

### NAME PLATE

All relevant information describing the MVH 2.0 product is summarised on the nameplate. The nameplate is attached to the outside of the VFD cabinet and shows the following information:

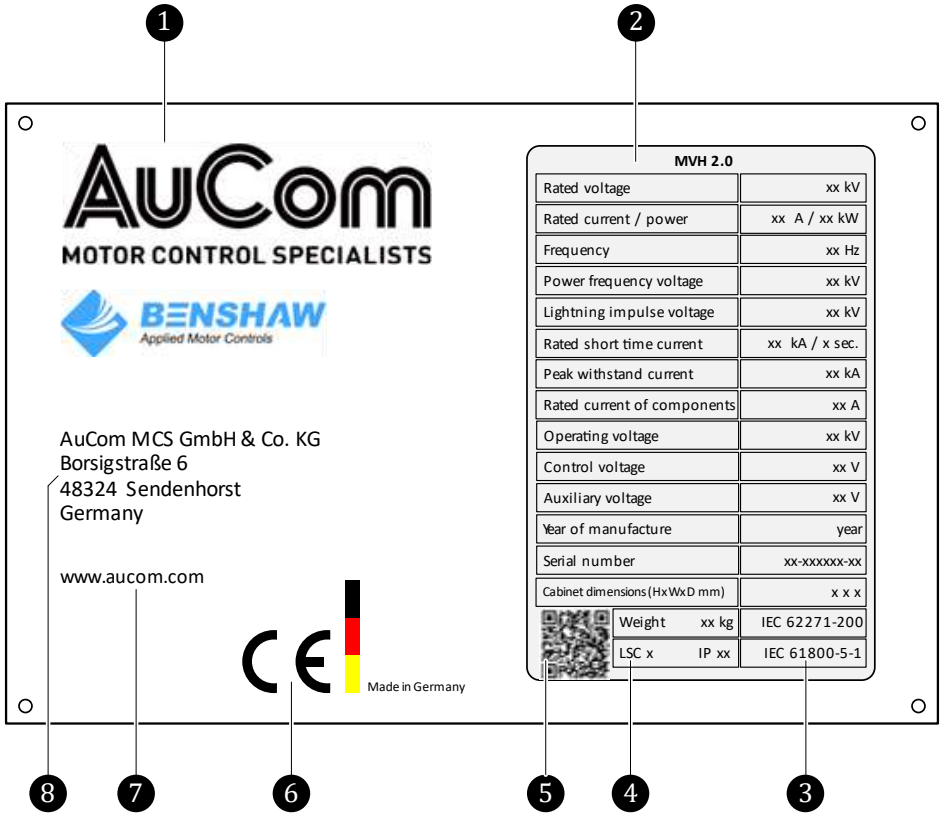



*Fig. 2-4 MVH 2.0 – Name plate*

1. Company logo of the manufacturer
2. Technical product data
3. Product standards (IEC)
4. Category of operational availability (LSC: Loss of service continuity)
5. QR code
6. CE marking
7. Manufacturer's website
8. Manufacturer's address

*TECHNICAL PRODUCT DATA*

| Technical specification | Description |
|---|---|
| Rated Voltage value | Mains supply voltage |
| Rated current / power | Rated current/rated power at the VFD output |
| Frequency | Mains supply frequency |
| Power frequency voltage | AC withstand voltage |
| Lightning impulse voltage | Impulse withstand voltage |
| Rated short time current | Rated short time withstand current |
| Peak withstand current | Rated impulse withstand current |

| Technical specification | Description |
|---|---|
| Current | Rated current (VFD output) |
| Operating voltage | Rated voltage (VFD output) |
| Control voltage | - |
| Auxiliary voltage | - |
| Year of Manufacture | - |
| Serial number | - |
| LSC x | Loss of Service Continuity: class x |
| IPxx | IP protection class according to IEC 60529:1989 |
| Weight | Weight of the VFD system |

*Tab. 2-3 Technical data on the nameplate*

***QR CODE*** In addition to the data on the nameplate, the QR code shown on the nameplate contains further information on the delivered MVH 2.0 product.

You can scan the QR code using a camera or a smartphone or a PC/notebook. Once scanned, you are automatically linked to this page on the AuCom website:

https://www.aucom.com/contact-us/support-enquiry

You can use the above link to submit a support request for further information.

## PRODUCT CODE

| Ordering identifier | | | | | | | | | | | Ordering option |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | |
| MVH 2.0 | - | A | I | 5 | - 060 | - 060 | - 048 | A | - ACC | - | ⇒ |

Cabinet type:
ACC = AuCom Compact Cabinet
AFA = AuCom Front Access, front side access only
ADA = AuCom, Double Access, two-sided access

VFD cooling method:
A = air-cooled
W = water-cooled*

Rated current at VFD output $I_{rms}$** [A]

Rated voltage at VFD output $U_{rms}$*** [V]

Rated voltage at VFD input $U_{rms}$** [V]

Rated frequency at VFD input:
5 = 50 Hz
6 = 60 Hz

I = IEC
U = UL

A = Asynchronous motor
S = Synchronous motor

AuCom MV frequency inverter, H2 product type:
MVH 2.0 = Frequency inverter
MVHS 2.0 = Start inverter
MVHD 2.0 = Dual inverter

| | 10 | | 11 | | 12 | | 13 | | 14 |
|---|---|---|---|---|---|---|---|---|---|
| ⇒ | CF | - | I | - | NCB | - | MB | - | 0 |

Earthing switch at VFD output:
0 = without earthing switch
1 = with earthing switch

NB = ohne VFD-Bypass
MB = DOL start without VFD
SB = automatic bypass with VFD
SB2 = automatic multi-motor bypass with VFD

NCB = without cell bypass
MCB = Cell contactor bypass
ICB = Cell IGBT bypass
RMB = redundant cell contactor bypass
RIB = redundant cell IGBT bypass

I = with main contactor
N = without main contactor

CF = Disconnector with fuses
C1 = Disconnector without fuses
F1 = Fuses
ND = without separator

* available on request!

** see table below *Rated currents*

*** see the tables below for *Available rated mains voltages at the VFD input* and *Available rated voltages of the VFD*

*Tab. 2-4 Ordering identifiers and ordering options in the product code*

## NOTES ON MODEL SELECTION

Model selection of the MVH 2.0 depends on the motor type to be driven, the motor ratings, and the load characteristics. For special or atypical loads, motors or environments, follow the advice and recommendations below.

***EXTREME ENVIRONMENTAL CONDITIONS***

When used in extreme environments, e.g., at high ambient temperatures or at high altitudes (> 1500 m) or ambient temperatures (> 40 °C), the power of the MV frequency inverter must be reduced. This may result in a drive with a higher rated power being required for the application (see *Ordering identifier 7*).

**CAUTION**

The MV frequency inverter is not designed for operation in potentially explosive atmospheres. As a result, it must not be installed in such conditions.

**NOTE**

- The connected load determines the output current that the VFD must apply.
- The above recommendations do not cover all cases of special loads and motors. Contact AuCom or your local supplier to confirm the model required.

## ORDERING IDENTIFIER AND ORDERING OPTIONS

The ordering identifier is shown at the top of table "Tab. 2-4 Ordering identifiers and ordering options in the product code".

***ORDERING IDENTIFIER 1*** Name of the product line of the frequency inverter (VFD)

***ORDERING IDENTIFIER 2*** VFD model selection according to the type of motor used in the application

Ordering identifier 2 is used to identify the application for which the VFD is to be used. There is no difference in the technical design.

***ORDERING IDENTIFIER 3*** VFD model selection according to IEC standard or UL standard

*I = IEC*

The VFD complies with the relevant, valid standards of the *International Electrotechnical Commission (IEC)* with regard to product safety.

*U = UL*

The VFD complies with the relevant, valid standards of the *National Electrical Manufacturers Association (NEMA)* with regard to product safety.

***ORDERING IDENTIFIER 4*** Selection of the VFD rated frequency

Selection of this ordering option depends on the frequency of the mains voltage supply (MV) at the place of installation. There is no difference in the technical design.

*ORDERING IDENTIFIER 5* Selection of rated voltage at VFD input

The following table shows the rated mains supply voltages for the VFD at its input (other rated voltages available on request, contact your local supplier):

| Rated mains supply voltages $U_{rms}$*** | | | |
|---|---|---|---|
| Ordering option | [V] | Ordering option | [V] |
| 023 | 2300 | 072 | 7200 |
| 033 | 3300 | 083 | 8300 |
| 042 | 4160 | 100 | 10000 |
| 048 | 4800 | 110 | 11000 |
| 050 | 5000 | 120 | 12000 |
| 060 | 6000 | 125 | 12470 |
| 066 | 6600 | 132 | 13200 |
| 069 | 6900 | 138 | 13800 |

*Tab. 2-5 Rated mains supply voltages available at the VFD input*

*ORDERING IDENTIFIER 6* Selection of rated voltage at VFD output

The following table shows the rated voltages available for the VFD at its input (other rated voltages available on request, contact your local supplier):

| Rated VFD voltages $U_{rms}$*** | | | |
|---|---|---|---|
| Ordering option | [V] | Ordering option | [V] |
| 023 | 2300 | 072 | 7200 |
| 033 | 3300 | 083 | 8300 |
| 042 | 4160 | 100 | 10000 |
| 048 | 4800 | 110 | 11000 |
| 050 | 5000 | 120 | 12000 |
| 060 | 6000 | 125 | 12470 |
| 066 | 6600 | 132 | 13200 |
| 069 | 6900 | 138 | 13800 |

*Tab. 2-6 Rated voltages available at the VFD output*

***ORDERING IDENTIFIER 7*** Selection of rated current at VFD output:

| Rated current $I_{rms}$** | | | |
|---|---|---|---|
| Ordering option | [A] | Ordering option | [A] |
| 0031 | 31 | 0360 | 360 |
| 0040 | 40 | 0364 | 364 |
| 0048 | 48 | 0400 | 400 |
| 0061 | 61 | 0425 | 425 |
| 0077 | 77 | 0462 | 462 |
| 0086 | 86 | 0500 | 500 |
| 0096 | 96 | 0550 | 550 |
| 0104 | 104 | 0600 | 600 |
| 0115 | 115 | 0660 | 660 |
| 0130 | 130 | 0750 | 750 |
| 0154 | 154 | 0800 | 800 |
| 0165 | 165 | 0960 | 960 |
| 0173 | 173 | 1000 | 1000 |
| 0195 | 195 | 1200 | 1200 |
| 0205 | 205 | 1250 | 1250 |
| 0220 | 220 | 1445 | 1445 |
| 0243 | 243 | 1540 | 1540 |
| 0304 | 304 | | |

*Tab. 2-7 Rated currents available at the VFD output*

*Rated VFD current $I_{rms} < 250$ A:*
The VFD is supplied without any precharge system.

*Rated VFD current $250\text{ A} \leq I_{rms} < 500\text{ A}$:*
The VFD includes an integrated device for precharging the power cells.

*Rated VFD current $I_{rms} \geq 500$ A:*
The VFD is equipped with an additional transformer precharge panel.

***ORDERING IDENTIFIER 8*** Selection of the VFD cooling type

*Water-cooled* option available on request, contact your local supplier.

***ORDERING IDENTIFIER 9*** Selection of the VFD cabinet type.

**NOTE**

Each cabinet type is equipped with a control/feeder panel for connecting the mains voltage supply line and the customer's motor feeding line.

*ACC = AuCom Compact Cabinet*
This cabinet type is equipped with a combined transformer/power cell panel. The cable entry and cable exit are in the bottom of the control/feeder panel. Service access is via doors at the front of the VFD.

*AFA = AuCom Front Access*
This cabinet type is equipped with both, a transformer panel, and a power cell panel. The MV supply line entry is located at the top of the control/feeder panel. The motor feeding line exit is located at the side extension of the control/feeder panel. Service access is via doors at the front of the VFD.

*ADA = AuCom Double Access*
This cabinet type is equipped with both, a transformer panel, and a power cell panel. The MV supply line entry and the motor feeding line exit are located at the bottom of the control/feeder panel. Service access is via doors at the front and rear of the VFD.

***ORDERING IDENTIFIER 10*** Selection of the VFD regarding a *disconnecting device* for the medium voltage at the VFD input.

***ORDERING IDENTIFIER 11*** Selection of the VFD regarding a *main contactor/circuit breaker* for the medium voltage at the VFD input.

***ORDERING IDENTIFIER 12*** Selection of the VFD regarding the power cell bypass options.

*NCB = without cell bypass*

*MCB = Cell contactor bypass*
Each power cell uses an integrated *contactor (K)* as a cell bypass, which short-circuits the cell output of a faulty power cell.

*ICB = Cell IGBT bypass*
Each power cell uses two integrated *IGBTs* as a cell bypass, which short-circuits the cell output of a faulty power cell.

*RMB = redundant cell contactor bypass*:
Each phase is equipped with one *additional power cell*. *All* power cells use an internal *contactor* bypass (K) as cell bypass.

*RIB = redundant cell IGBT bypass*
Each phase is equipped with one *additional power cell* is used per phase. *All* power cells use two internal *IGBTs* as cell bypass.

**NOTE**

- The selected ordering option applies to all power cells of the VFD.
- With *MCB* or *ICB* power cells, the *Neutral point shift* function is applied in the event of a fault.
- With *RMB* or *RIB* power cells, the *full VFD power* is still available in the event of a fault.

***ORDERING IDENTIFIER 13*** Selection of the VFD regarding bypass of the entire VFD.

*NB = without VFD bypass*
Motor operation is only possible via the VFD.

*MB = DOL-Start ohne VFD*
Direct online start (DOL) of the motor via MV mains is possible.

*SB = automatic bypass with VFD*
The motor is started via the VFD. Then, the motor is switched over to the MV mains via a VFD bypass.

*SB2= automatic multi-motor bypass with VFD*
This VFD enables sequential starting of multiple motors. Each motor is bypassed after its start sequence is completed.

***ORDERING IDENTIFIER 14*** Selection of the VFD regarding a *disconnector/earthing switch* at the VFD output.

## 2.2 PRODUCT DATA

### 2.2.1 FEATURES OF THE MVH 2.0

#### FUNCTIONS

MVH 2.0 VFDs are suitable for speed regulation and control of medium voltage three-phase motors. The VFD offers the following functions and features:

***VOLTAGE LEVELS*** VFD applications for medium voltage levels from 2.3 kV to 13.8 kV

***ADJUSTABLE FREQUENCY RANGE*** Motor speed is controlled via an adjustable frequency range from 0 to 80 Hz.

***MOTOR CONTROL METHODS***

- Asynchronous motor (induction motor) according to *extended U/f control characteristic*
- Synchronous motor (externally excited, permanently excited, reluctance motor) according to *extended U/f control characteristic*
- Asynchronous motor (induction motor) with/without *speed sensor* according to open/closed loop vector control
- Synchronous motor with/without *rotor position sensor* according to open/closed loop vector control

***START-/STOP MODES*** Various, adjustable start/stop characteristics for the motor such as acceleration and deceleration ramps as well as motor coasting

***„FLYING START"*** Connection of the VFD to a rotating motor

***n* OR f* SETPOINT SETTING*** You can specify the required speed/frequency setpoint either manually on site via the touchscreen of the operating unit (HMI) or remotely via an analogue input (AI), digital inputs (DI) or via the distributed control system (DCS).

***VFD OPERATING MODES*** You can control the VFD either manually on site via the touchscreen of the operating unit (HMI) or remotely via a distributed control system (DCS) or via digital inputs (DI).

***DISTRIBUTED CONTROL SYSTEM (DCS)*** The VFD can be integrated into a distributed control system. The following communication protocols are available: Modbus, Profibus and Profinet (others on request).

***SIMULATION MODE*** The VFD provides a test mode that simulates operation without the medium voltage being connected.

***DIFFERENT LOAD TYPES*** Motor control of the VFD can be optimally adapted to different load types such as fans and pumps.

***STATIC AND DYNAMIC PARAMETER IDENTIFICATION*** Automatic determination of motor parameters, for the pre-assignment of control parameters in case of missing motor data for idle start and start under load.

***MOTOR REVERSE MODE*** Reverse the motor rotation direction via the VFD.

***TORQUE BOOST*** Increase the starting torque up to 10 Hz for asynchronous motors and up to 5 Hz for synchronous motors.

***OVEREXCITATION BOOST*** Prevents overvoltage in the power cells in regular operation for drives with higher load inertia (regenerative operation of the motor).

***LIMITATION OF VFD OUTPUT CURRENT*** Set the maximum VFD output current to optimally adapt the VFD to the load.

*SYNCHRONOUS TRANSFER OPERATION*
Enables smooth and seamless switching of the motor between VFD operation and mains operation (with optional synchronous control cabinet).

*MASTER-/SLAVE CONTROL FUNCTIONS*
VFD double or multi frequency inverter operation (see master/slave settings)

*SWITCHABLE MOTOR-PARAMETER SETS*
You can choose from up to four different motor parameter sets, e.g., for multiple VFD operation.

*SELF-ADJUSTMENT OF THE VFD OUTPUT VOLTAGE*
Adjust the VFD output voltage to the motor operating point when the input voltage is fluctuating.

*EXCITATION CONTROL FOR SYNCHRONOUS MOTORS*
Controls/regulates the excitation system for synchronous motors via the touchscreen of the operating unit (HMI) or automatically via a constant power factor.

*FUNCTION FOR SHORT-TERM MAINS FAILURE*
The VFD can bridge short-term MV mains failures without switching off.

*AUTOMATIC RESTART AFTER MV MAINS FAILURE*
You can program the VFD to restart automatically after the MV mains voltage has been restored or after short-term mains failures, (provided the start command is still alive).

*AUTOMATIC RAMP INTERVENTION*
Monitors the VFD output current (overcurrent criterion) as well as power cell DC voltage (overvoltage criterion) and adjusts the acceleration or deceleration rate.

*MOTOR OVERLOAD PROTECTION – THERMAL REPLICA*
In case of a large overload or a prolonged overcurrent operation of the motor, the VFD protects the motor via a motor thermal replica with inverse tripping characteristic.

*SKIP RANGES FOR UNAUTHORISED FREQUENCIES*
Sets frequency ranges (blocked frequencies) where motor operation is not permitted.

*PRE-CHARGING OF THE POWER CELLS AND TRANSFORMER PRE-MAGNETISATION*
Transformer pre-charging cabinet for charging the power cells and pre-magnetisation of the multi-level transformer to reduce high inrush currents (rated currents ≥ 500 A).

### Options

*POWER CELL BYPASS TECHNIQUE*
Bridging of defective power cells without VFD shutdown, optionally as cell contactor bypass or cell IGBT bypass

*NEUTRAL POINT SHIFT TECHNIQUE*
In the event of a power cell failure, the neutral point of the VFD output voltage is shifted automatically to ensure symmetrical motor voltage. This comes in addition to the power cell bypass option.

*PROTECTION AND CONTROL DEVICE*
Optional protection and control device with special motor, transformer, and line protection function, as well as extended control functions, e.g., for synchronous motor transfer function (VFD < -> MV mains)

## FAULT AND ALARM MESSAGES

The MVH 2.0 can detect a variety of possible issues during VFD operation. The causes of malfunctions are indicated as *alarm messages* or *fault messages* on the display of the HMI. These messages can be transmitted to a distributed control system (DCS) via the various communication protocols available.

All alarm and fault messages are logged in the event recorder with a date and time stamp, in a non-volatile memory.

*ALARM MESSAGES*
An *alarm message* gives information about the cause of an active issue that *does not* switch off the VFD operation. As soon as the cause of the alarm has been resolved, the alarm message is reset automatically.

*FAULT MESSAGES*

A *fault message* gives information about the cause of an active issue that switches off VFD operation or blocks an active motor start command. After the cause of the fault has been resolved, the fault message must be reset so that the VFD can be put in operation and allow the motor to start.

### 2.2.2 DIMENSIONS AND WEIGHTS

Dimensions, weight, and space requirements for a VFD cabinet depend on the:

- VFD cabinet type,
- VFD rated power, and
- Cooling method of the VFD.

The VFD cabinet dimensions and weight will vary greatly according to the above criteria. The exact specifications are only known when the product code is defined.

For detailed information, contact AuCom.

### 2.2.3 ENVIRONMENT

*INSTALLATION ENVIRONMENT*

**CAUTION**

The MV frequency inverter is not designed for operation in potentially explosive atmospheres. As a result, it must not be installed in such conditions.

To ensure that the MV VFD is stable, reliable, and offers long service life,

- install the equipment indoors away from corrosive gases, flammable gases, conductive dust, dripping liquids, salt, and combustion fumes.
- The ambient temperature should be in the range of -5 ... 45 °C. If the environment exceeds these values, you must make provisions to provide safe and reliable temperature control of the equipment.
- The site should have protective measures to prevent the invasion of small animals such as snakes and mice. All conduits entering or exiting the VFD cabinets must be sealed to prevent ingress of any vermin (including insects such as spiders).

*CABINET CLEARANCE*

The following clearance requirements are necessary to ensure the smooth flow of cooling air and ease of operation and maintenance:

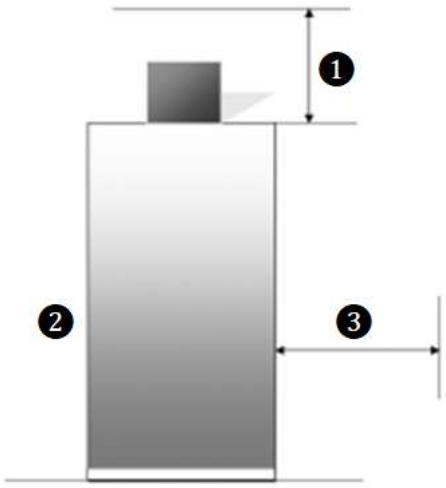



*Fig. 2-5 Cabinet clearance:*
*a) Double side service zone*
*b) Single side service zone*

1. Top fan maintenance space: > 1400 mm
2. Front maintenance space: > 1600 mm
3. Back maintenance space
   a) Double side service zone: > 1600 mm
   b) Single side service zone: > 100 mm

### 2.2.4 TECHNICAL DATA

| Item | Specification |
|---|---|
| MVH 2.0 rated power | 210 ... 28000 KVA |
| Rated voltage | 2.3 ... 13.8 kV (-20 % ... +5 %)* |
| Rated frequency (VFD input) | 50/60 Hz (-10 % ... +10 %) |
| Auxiliary voltage | IEC: 400 V AC, 3-phase, 50/60 Hz |
| Control voltage | 230 V AC, 50/60 Hz (other voltages on request) |
| Rated input power factor | ≥ 0.96 |
| Efficiency | > 96 ... 98 % depends on selected VFD options |
| Output frequency | 0 ... 80 Hz |
| Speed accuracy | ± 0.5 % (open loop vector control)<br>± 0.1 % (closed loop vector control)<br>± 0.5 % (extended U/f characteristic with slip compensation) |
| Instantaneous overcurrent protection | 150 % (refer to VFD output rated current) |
| Overload capacity | 120 % overload for 120 s (refer to VFD output rated current) |
| Torque limitation | 10 % ... 150 % (refer to motor rated current) |
| Analog inputs | 4 Stck.: 0/4 ... 20 mA |
| Analog outputs | 4 Stck.: 0/4 ... 20 mA |
| Host communication (DCS) | RS485 interface (electrical, galvanically isolated),<br>Communication protocols:<br>Modbus RTU, Profinet, Profibus DP (optional**),<br>Modbus TCP (optional**) |
| Acceleration and deceleration (ramp) time | 5 ... 6000 s (adjustable) |
| Digital inputs/outputs | 14 Digital inputs (DI), 22 digital outputs (DO) |
| Operating temperature | -5 ... +40 °C (other temperature range on request) |
| Storage temperature | -25 ... +55 °C |
| Transportation temperature | -25 ... +55 °C |
| Cooling method | Forced cooling with fans (AF) |
| Rel. humidity | < 95 %, non-condensing |
| Altitude | ≤ 328 ft (1000 m). When altitude is higher than 328 ft (1000 m), derate VFD current and voltage by 1% for each 32.8 ft (100 m) |
| Dust | Non-conductive, non-caustic, < 6.5 mg/dm$^3$ |
| Protection class | IP30/type 1 |
| Cabinet colours | ANSI 61 grey; RAL7035 |

* MVH2.0 will be derated from -10 % to -20 %, but no Trip
For other voltage variation level: available as non-standard (contact AuCom for further information)

** Additional communication modules required!

*Tab. 2-8 MVH 2.0 – Technical data*

**NOTE**

Contact AuCom or your local supplier if you require information beyond this table.

## 2.3 SCOPE OF SUPPLY

### 2.3.1 AIR-COOLED VFD CABINETS

- 1 x VFD cabinet
- Number of cooling fans according to cabinet type (the cooling fans are packed separately for transport)
- Number of power cells according to cabinet type (the power cells are packed separately for transport if the rated current of the power cells is at least 250 A)

Accessories:

- 1 x switch crank for disconnector/earthing switch (if VFD is equipped with disconnector/earthing switch),
- 2 x key for cell cabinet
- 2 x key for key switch,
- 4 x replacement filter mats

# 3 STRUCTURE AND FUNCTIONS

## 3.1 Principles of the Procedure

To use a medium voltage three-phase motor with infinitely variable speed control, you require a frequency inverter. The frequency inverter's task is to provide the mains voltage according to the motor's U/f control characteristics. In this way, the corresponding operating voltage and frequency is provided for each required motor speed [rpm].

The following figure shows the single line diagram of a typical application. The frequency inverter is connected between the feeding MV mains supply and the MV motor.

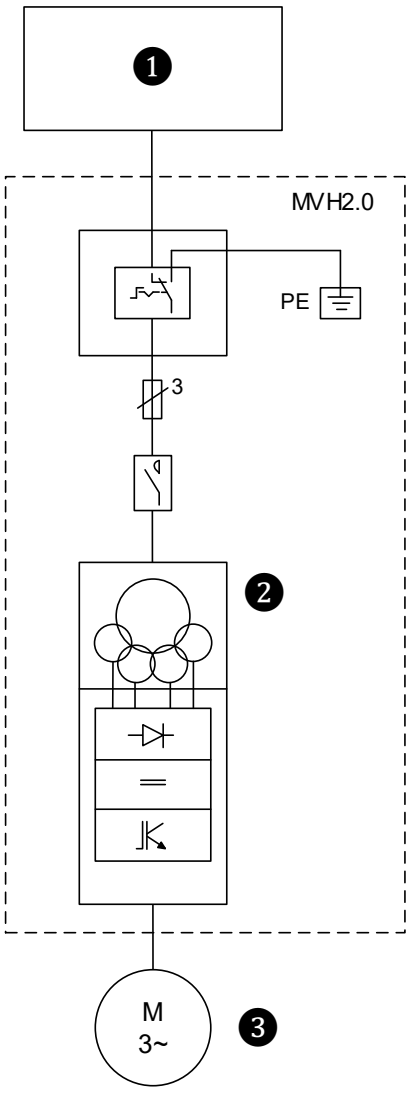



*Fig. 3-1 VFD application– Single line diagram*

1. Medium voltage (MV)
2. VFD
3. MV three-phase motor

***MAIN CIRCUIT*** The MV mains voltage (L1, L2, L3) providing constant magnitude and frequency is connected to the primary winding (1U, 1V, 1W) of the multi-level transformer in the VFD cabinet. The multi-level transformer is equipped with several secondary windings (multi-level), and converts the primary medium voltage into several, secondary, 3-phase AC low

voltage systems (R, S, T; constant magnitude and frequency). Each of these three-phase low voltage systems serves as input voltage for a *power cell*.

The power cells (Ax, Bx, Cx) represent the power electronics of the VFD, and converts the three-phase AC low voltage systems into controlled, chopped DC voltages. The power cell outputs are connected in series to form three strings (phases A, B, C). The input of the three phase strings (A1, B1, C1) is combined to form an isolated neutral point N. The phase strings output forms the three-phase controllable AC voltage system A, B, C via the power cells (A6, B6, C6).

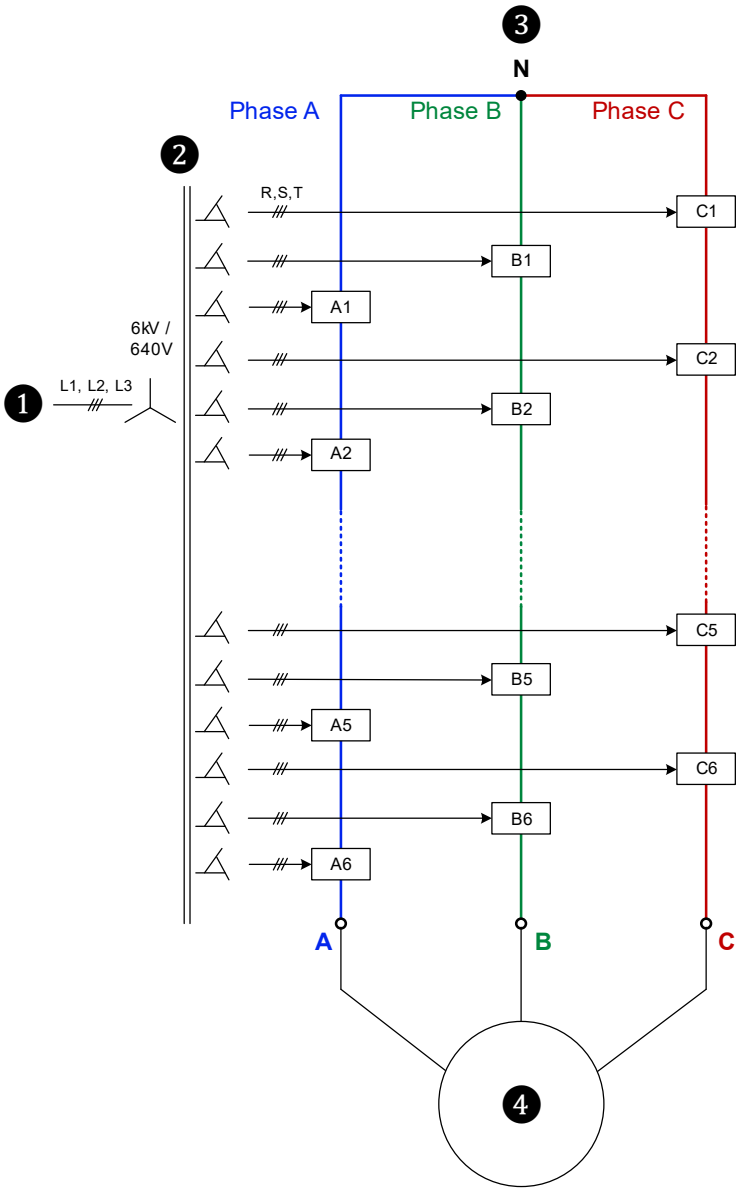



*Fig. 3-2 VFD main circuit of a 6 kV motor*

1. MV mains voltage supply
2. Multi-level transformer
3. Power cells Ax, Bx, Cx
4. 6 kV motor

### *GENERAL VFD TOPOLOGY – BREAKDOWN SCHEME*

The MVH 2.0 comprises:

- a multi-level transformer
- several power cells
- a VFD control system

The following figure represents the basic hardware topology of an 11 kV VFD.

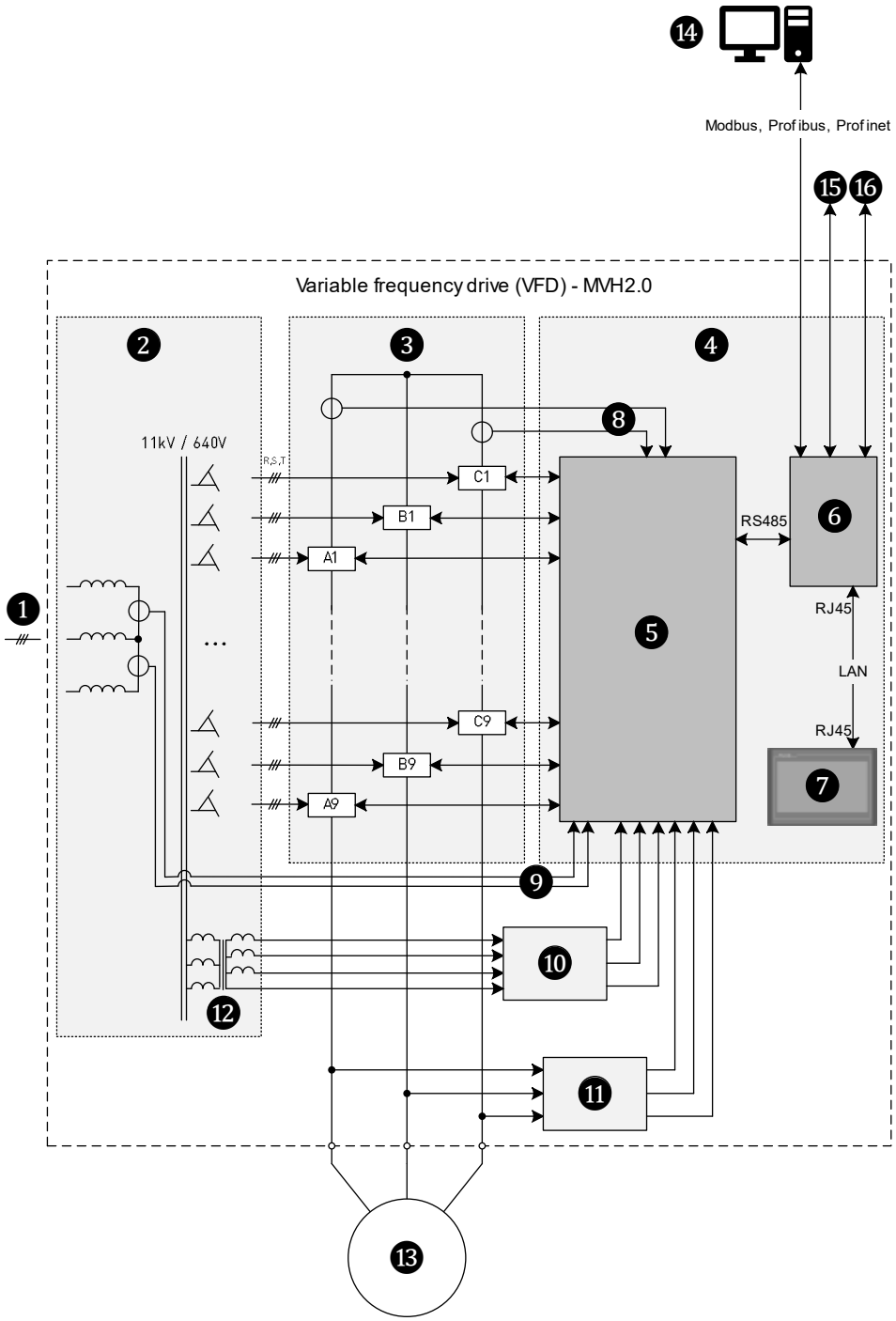



*Fig. 3-3 MVH 2.0 – Standard topology for an 11 kV VFD*

1. MV mains voltage supply
2. Multi-level transformer
3. Power cells
4. VFD control system:
5. -Main control unit
6. -Interface unit (PLC) for inputs and outputs (I/O)
7. -Operating unit (HMI) with touchscreen
8. Current measurement at VFD output
9. Current measurement at VFD input
10. Voltage measurement at VFD input
11. Voltage measurement at VFD output
12. Transformer's 400 V AC auxiliary winding
13. 11 kV motor
14. Distributed control system (DCS)
15. Signals of digital inputs and outputs (DI, DO)
16. Signals of analog inputs and outputs (AI, AO)

***INPUT – ISOLATING TRANSFORMER***

The input isolation transformer is a three-phase dry-type rectifier transformer, using forced air-cooling.

The primary side is a Y connection, which is directly connected to the medium voltage incoming line. The secondary windings are an extended delta connection, which provides isolated three-phase power input to each power cell. The quantity of secondary windings and cells is determined by the VFD output voltage level and structure.

To minimise the harmonic content on the input side, the secondary windings of the same phase are phase-shifted by the extended delta connection method. The phase difference between the windings is calculated using the following formula:

Phase shift angle = (60 °) / n

where: n = number of cells in each phase

***FORMING THE VFD-VOLTAGE SYSTEM A, B, C***

The three-phase AC voltage system at the VFD output (A, B, C) is formed by several low voltage power cells, each with a three-phase input (R, S, T), and a single-phase output (L1, L2) per phase. The power cells are fed by the multi-level transformer secondary windings. Output terminals L1 of the first power cell per phase are combined to form the virtual neutral point N (star point). The output terminals L2 are each connected to the output terminals L1 of the following power cells.

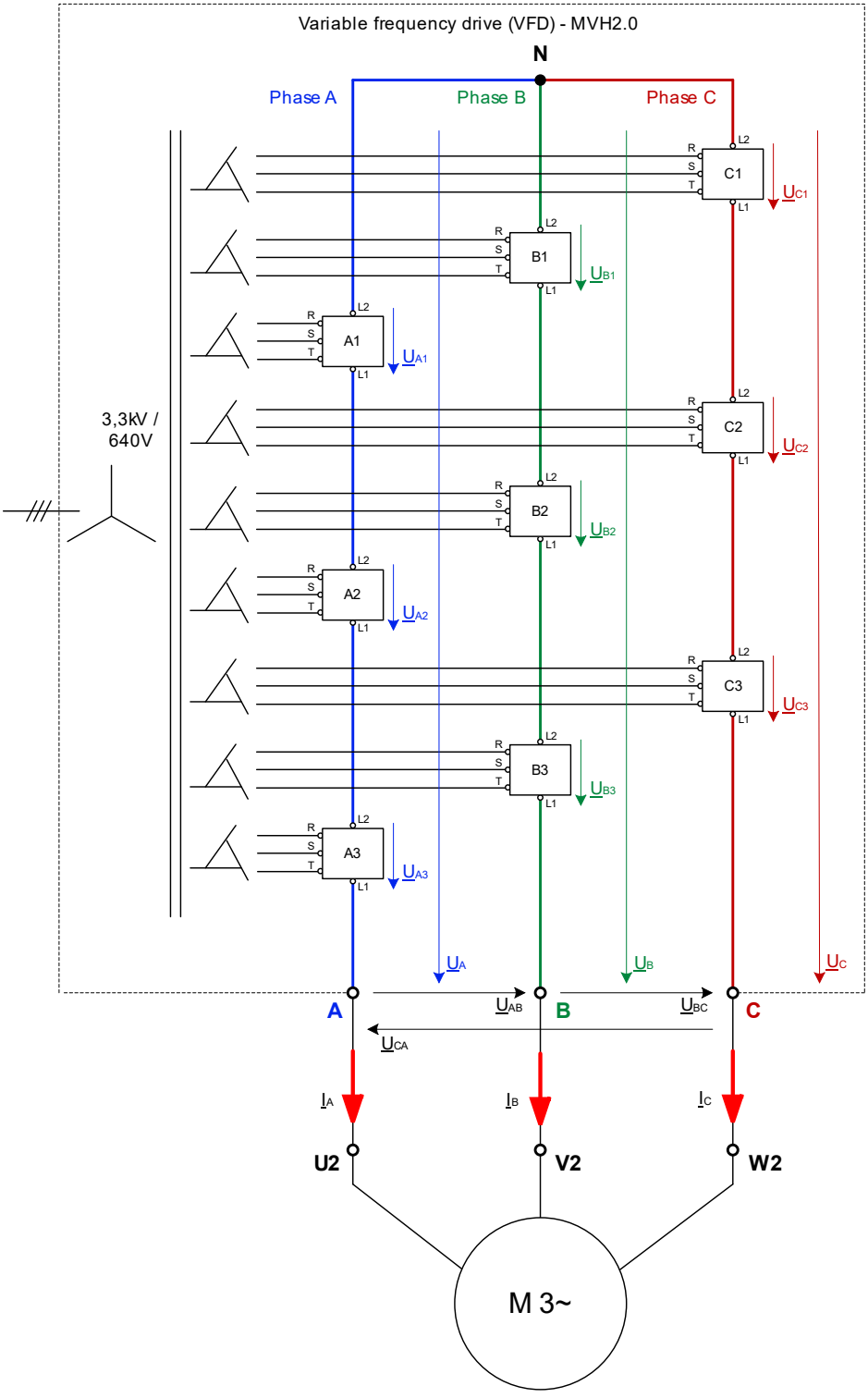



*Fig. 3-4 Main circuit – Example: Voltage formation at 3.3 kV VFD output*

A chopped DC voltage is applied to the output terminals (L1 and L2) of each power cell. Series connection of the power cell outputs per phase leads to a superposition of the power cell output voltages, which form the phase voltage for each phase.
This way, an almost sinusoidal three-phase AC voltage system with an isolated neutral point N is created at the VFD output terminals (A, B, C).

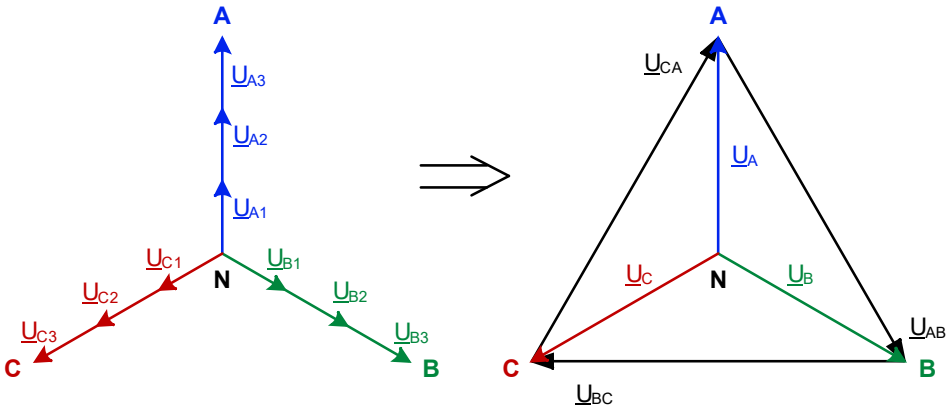



*Fig. 3-5 Three-phase AC voltage system at VFD output A, B, C*

In this connection, the following phase voltages $U_{NL}$ are formed:

- Phase A: $\mathbf{U_{NA}} = \mathbf{U_A} = U_{A1} + U_{A2} + U_{A3}$
- Phase B: $\mathbf{U_{NB}} = \mathbf{U_B} = U_{B1} + U_{B2} + U_{B3}$
- Phase C: $\mathbf{U_{NC}} = \mathbf{U_C} = U_{C1} + U_{C2} + U_{C3}$

And the corresponding line-to-line voltages $U_{LL}$:

- Phases A and B: $U_{LL} = \mathbf{U_{AB}}$
- Phases B and C: $U_{LL} = \mathbf{U_{BC}}$
- Phases C and A: $U_{LL} = \mathbf{U_{CA}}$

The following table maps the required VFD output rated voltage, and the number of the power cells and their rated voltage.

| VFD-Rated voltage [kV] | Cells per phase | Input voltage per cell [V]* | Phase voltage $U_{NL}$ [V] | Line-to-line voltage $U_{LL}$ [kV] | Levels of voltage |
|---|---|---|---|---|---|
| **2.3** | 3 | 450 | 1330 | 2.3 | 7 |
| **3.3** | 3 | 640 | 1900 | 3.3 | 7 |
| **4.16** | 4 | 600 | 2400 | 4.16 | 9 |
| **6** | 5 | 690 | 3460 | 6 | 11 |
| **6** | 6 | 640 | 3460 | 6 | 13 |
| **6.6** | 6 | 640 | 3810 | 6.6 | 13 |
| **10** | 9 | 640 | 5770 | 10 | 19 |
| **11** | 9 | 700 | 6350 | 11 | 19 |
| **13.8** | 12 | 660 | 7967 | 13.8 | 25 |

* Special design power cell rated voltage: available as non-standard (contact AuCom for further information)

*Tab. 3-1 Power cell configuration*

The three-phase output is Y-connected to obtain the medium voltage power supply required for driving the motor.

- The total number of 4160 V power cells is 12.
- The total number of 6 kV power cells is 15 or 18 (see *Voltage stacking diagram 6 kV VFD*).
- The total number of 11 kV power cells is 24 or 27 (see *Voltage stacking diagram 11 kV VFD*).

*EXAMPLE: 6KV-VFD* Five power cells providing a nominal voltage of 690 V each are connected in series per phase to obtain a phase voltage of 3450 V and a line-to-line voltage of 6 kV.

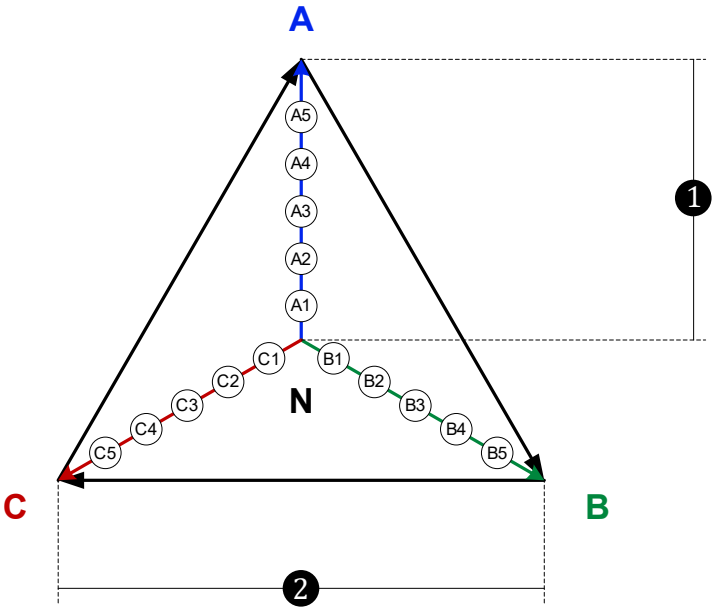



*Fig. 3-6 Voltage stacking diagram 6 kV VFD*

1. Phase voltage (3460 V)
2. Line to line voltage (6000 V)

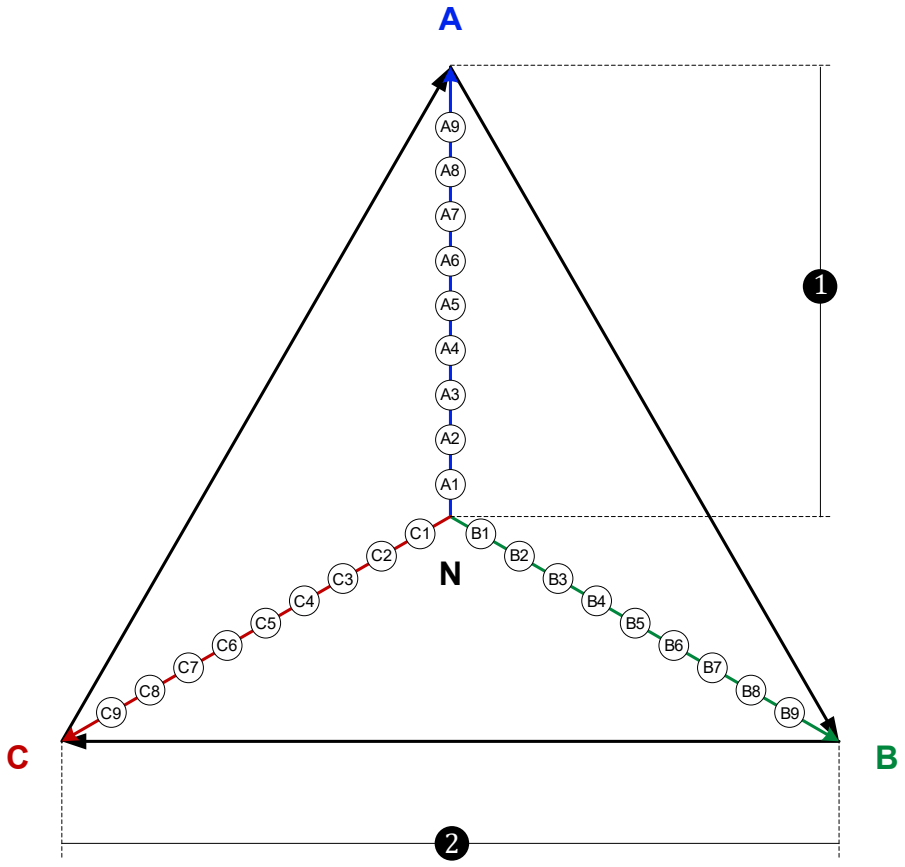



*Fig. 3-7 Voltage stacking diagram 11kV VFD*

1. Phase voltage (6350 V)
2. Line to line voltage (11000 V)

In a 6 kV VFD with five power cells connected in series, there are 11 output levels (-5 to 0 and 0 to +5).

The following figure shows – for one phase – the waveform of the output per power cell, as well as the waveform of the resulting total phase voltage (series connection of the power cells) at the VFD output.

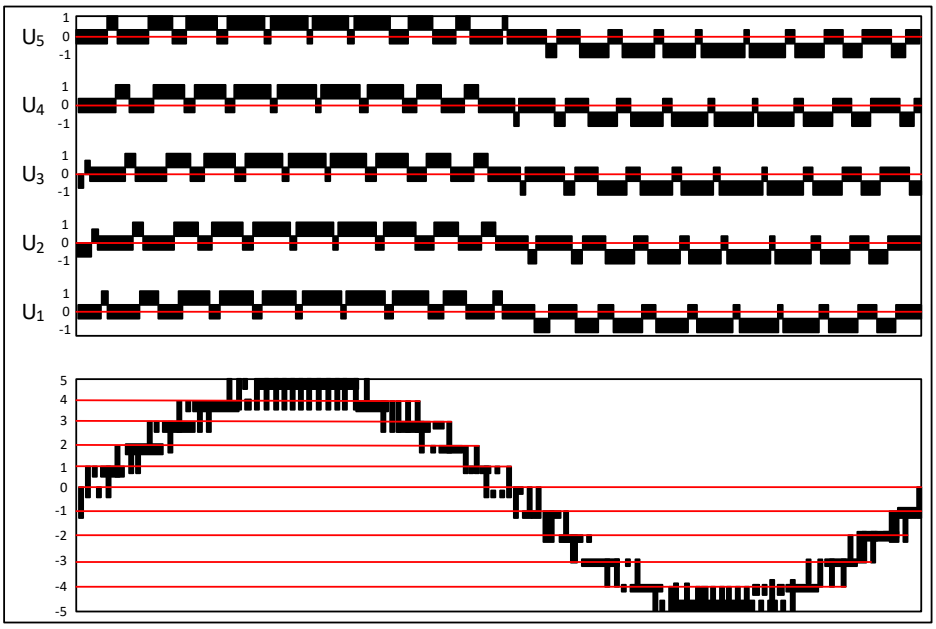



*Fig. 3-8 Formation of a phase voltage with five power cells in a 6 kV VFD*

The sinusoidal output voltage is formed by the incremental addition of the power cell output voltages using H-bridge multi-level overlapping PWM technology. As a result, the MVH 2.0 provides a nearly perfect sine wave at the motor terminals. Therefore, no special motors (increased winding isolation, or insulated bearings) are required. The MVH 2.0 is also suitable for retrofitting while retaining existing motors.

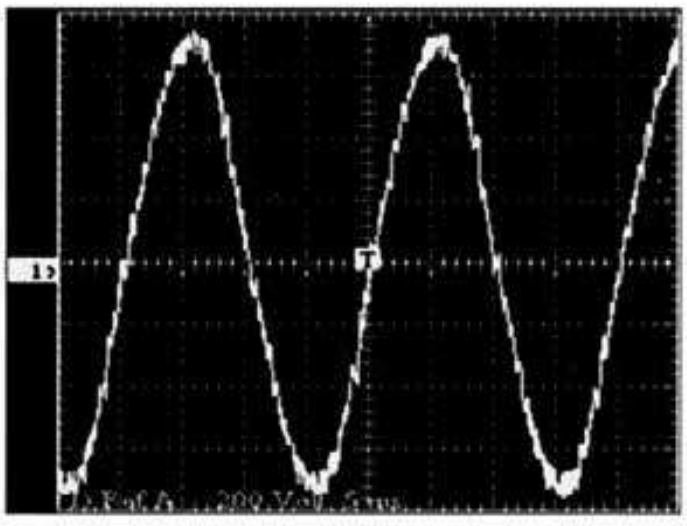


*Fig. 3-9 Waveform of the VFD output voltage*

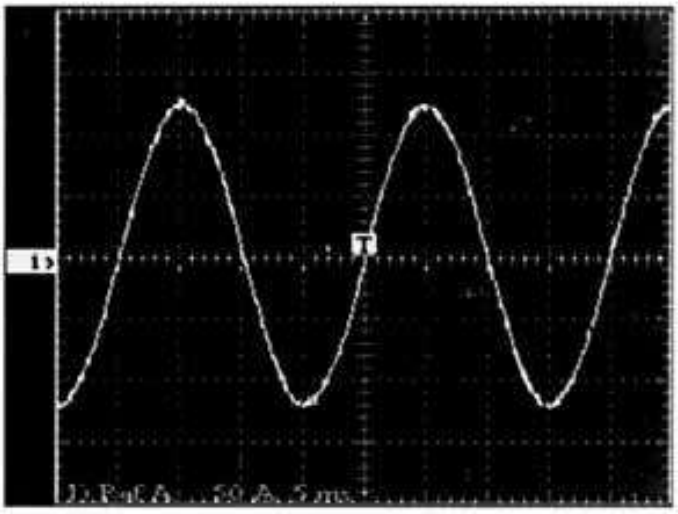


*Fig. 3-10 Waveform of the VFD output current*

## 3.2 Mechanical Structure

In the following sections, we describe the most important assemblies of the various MVH 2.0 series cabinet types, including their front, side, and rear views.

### 3.2.1 ACC – AuCom Compact Cabinet: Front Side Service Zone

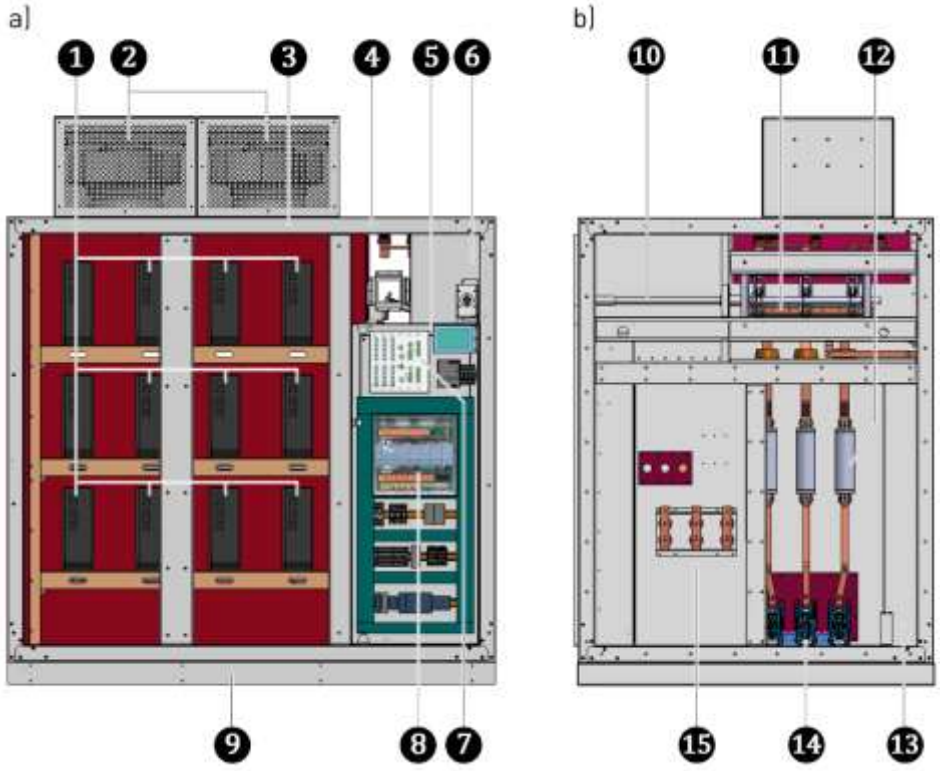



*Fig. 3-11 ACC-AuCom Compact Cabinet*
*a) Front view*
*b) Side view: VFD control/feeder panel*

1. Power cells for phases A, B and C
2. Cooling fans of the VFD cabinet
3. Frame of the combined power cell/transformer cabinet
4. VFD control/feeder panel
5. low voltage compartment (bulkheaded) for VFD control
6. Actuating access for MV disconnector/earthing switch
7. VFD control unit
8. I/O interface unit
9. Base for VFD cabinet
10. Mechanical drive shaft for MV disconnector/earthing switch
11. MV disconnector/earthing switch
12. MV fuses
13. Cable duct for customer MV supply line
14. Main contactor
15. Connection to motor feeder line

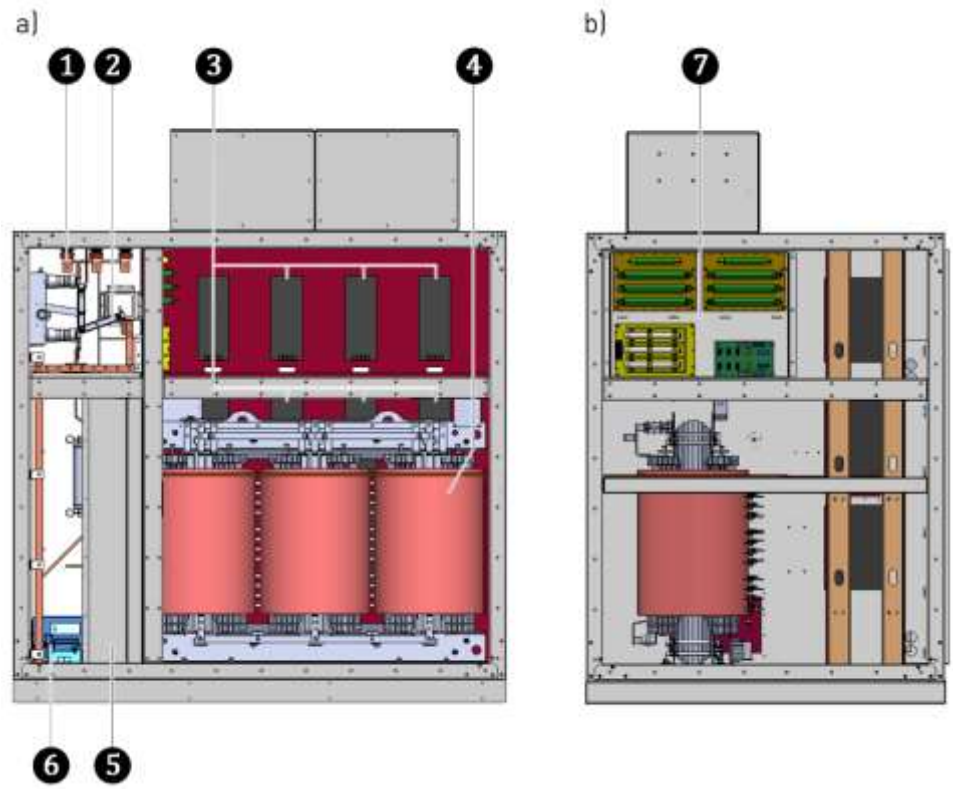



*Fig. 3-12 ACC-AuCom Compact Cabinet*
*a) Rear view*
*b) Side view: combined power cell/transformer cabinet*

1. Connection terminals for customer MV supply line
2. MV disconnector/earthing switch
3. Power cells for phases A, B and C
4. Multi-level transformer
5. Cable duct for customer MV supply line
6. Main contactor
7. Installation compartment for voltage measurement, power cell detection and precharge system resistors

### 3.2.2 AFA – AUCOM FRONT ACCESS: FRONT SIDE SERVICE ZONE

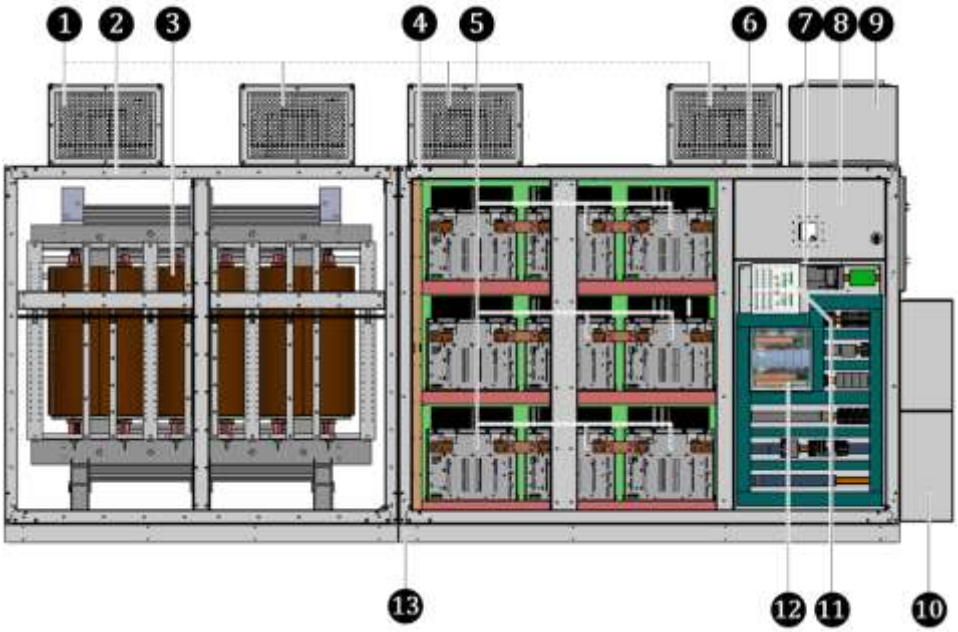



*Fig. 3-13 AFA-AuCom Front Access – Front view*

1. Cooling fans for the VFD cabinet
2. Frame of the transformer cabinet
3. Multi-level transformer
4. Frame of the power cell cabinet
5. Power cells on the front for phases A, B and C
6. VFD control/feeder panel
7. low voltage compartment (bulkheaded) for VFD control
8. Actuating access for MV disconnector/earthing switch
9. Optional cable entry: MV supply line from above (customer side)
10. Optional cable entry: Motor feeder line from above (customer side)
11. VFD control unit
12. I/O interface unit
13. Base for VFD cabinet

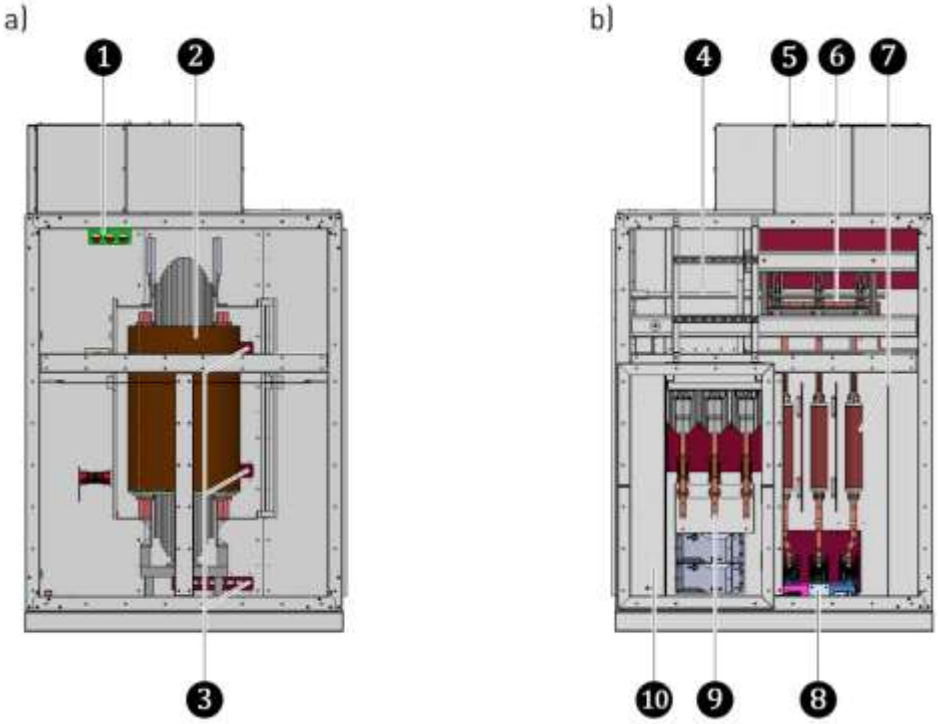



*Fig. 3-14 AFA-AuCom Front Access – Side view*
*a) Side view left: transformer cabinet*
*b) Side view right: VFD control/feeder panel*

1. Cable glands: MV transformer supply line
2. Multi-level transformer
3. Cable glands
4. Mechanical drive shaft for MV disconnector/earthing switch
5. Cable entry for MV supply line (customer side)
6. MV disconnector/earthing switch
7. MV fuses
8. Main contactor
9. Optional cable connection: MV supply line from above (customer side)
10. Optional cable connection: Motor feeder line from above (customer side)

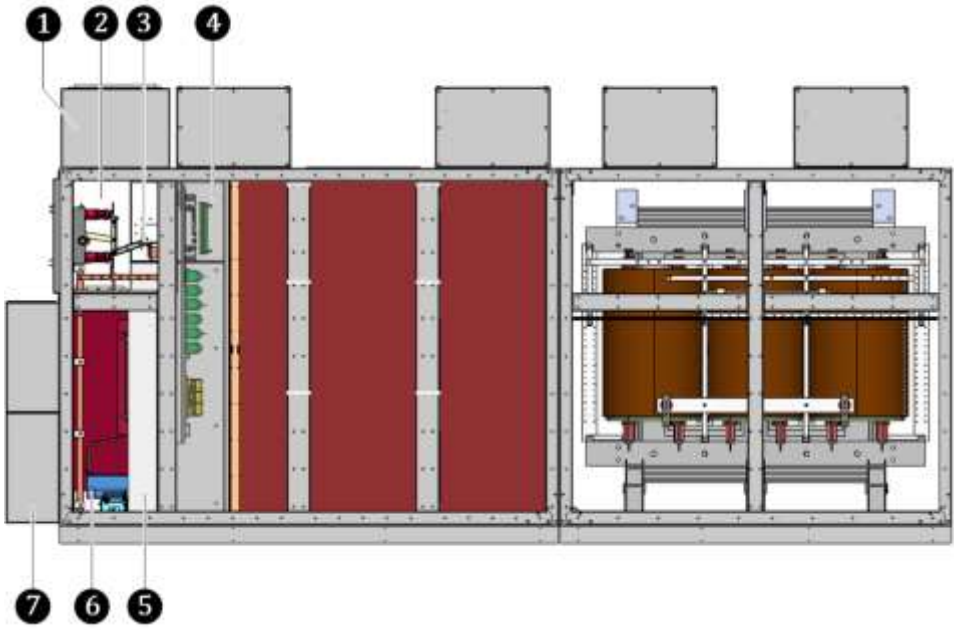



*Fig. 3-15 AFA-AuCom Front Access – Rear view*

1. Optional cable entry: MV supply line from above (customer side)
2. Cable connection for MV supply line (customer side)
3. MV disconnector/earthing switch
4. Installation compartment for voltage measurement, power cell detection and precharge system resistors
5. Cable duct for customer MV supply line
6. Main contactor
7. Optional cable entry: Motor feeder line from above (customer side)

### 3.2.3 ADA – AUCOM DOUBLE ACCESS: DOUBLE SIDE SERVICE ZONE

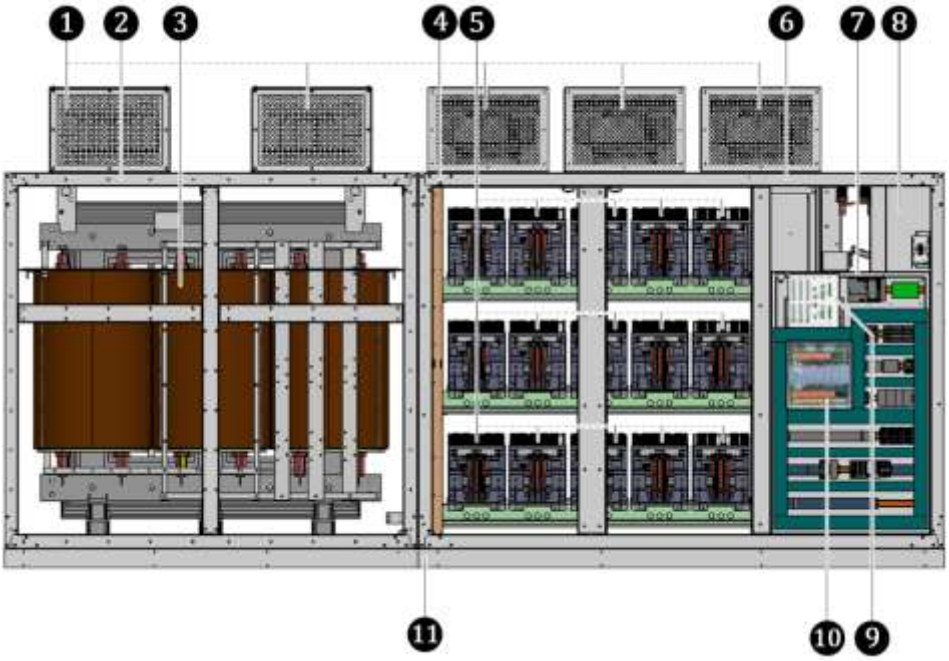



*Fig. 3-16 ADA-AuCom Double Access – Front view*

1. Cooling fans for the VFD cabinet
2. Frame of the transformer cabinet
3. Multi-level transformer
4. Frame of the power cell cabinet
5. Power cells on the front for phases A, B and C
6. VFD control/feeder panel
7. low voltage compartment (bulkheaded) for VFD control
8. Actuating access for MV disconnector/earthing switch
9. VFD control unit
10. I/O interface unit
11. Base for VFD cabinet

**NOTE**

The *ADA cabinet type can also be equipped with an*:

- optional cable entry: MV supply line from above (customer side)
- optional cable entry: Motor feeder line from above (customer side)

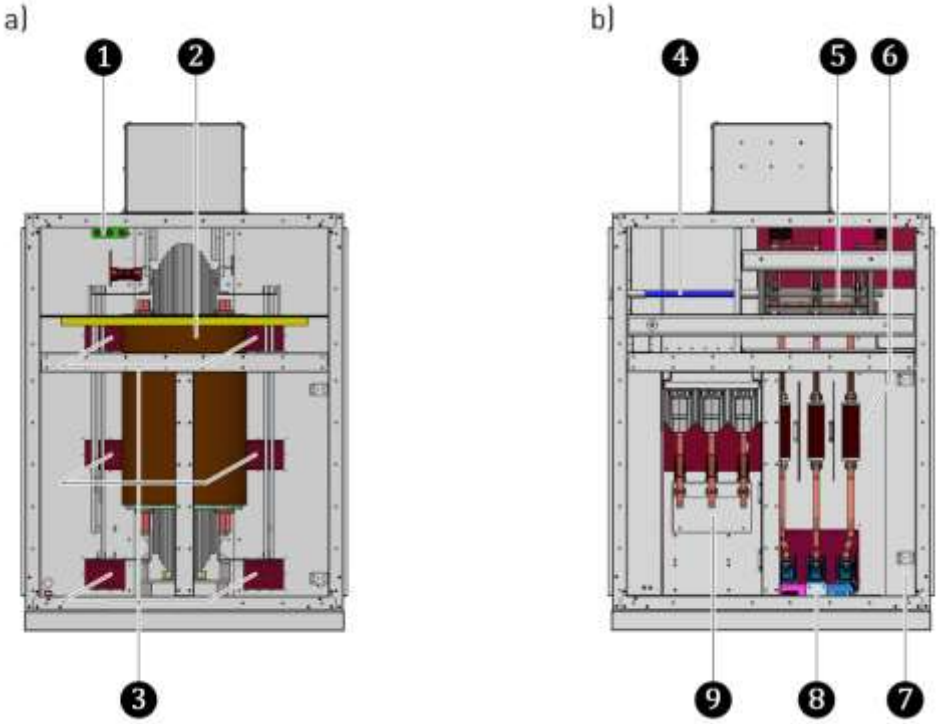



*Fig. 3-17 ADA-AuCom Double Access – Side view*
*a) Side view left: transformer cabinet*
*b) Side view right: VFD control/feeder panel*

1. Cable glands: MV transformer supply line
2. Multi-level transformer
3. Cable glands
4. Mechanical drive shaft for MV disconnector/earthing switch
5. MV disconnector/earthing switch
6. MV fuses
7. Cable duct for customer MV supply line
8. Main contactor
9. Connection motor feeder line

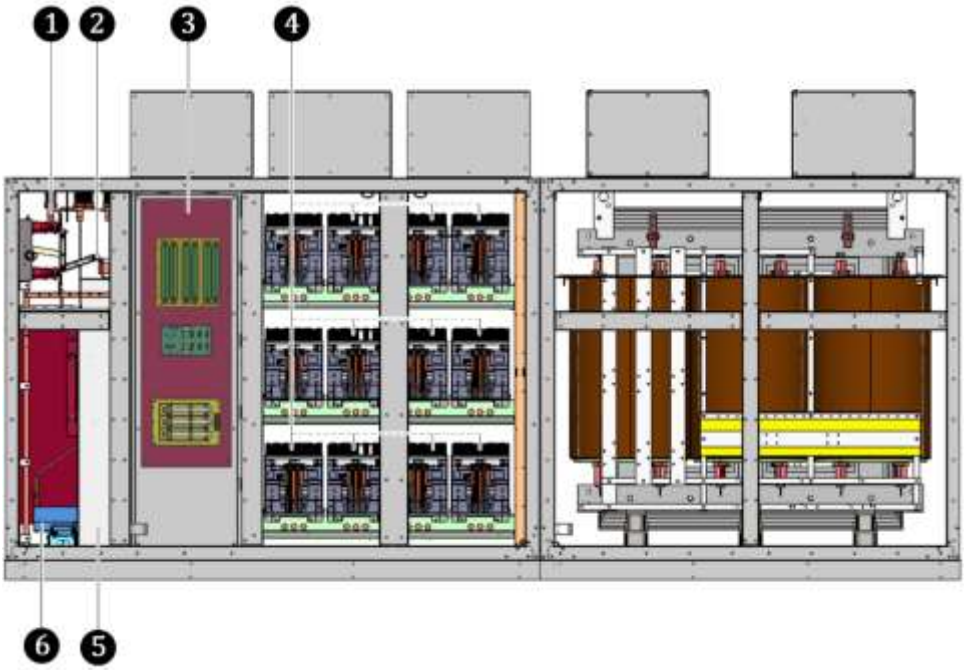



*Fig. 3-18 ADA- AuCom Double Access – Rear view*

1. Cable connection: MV supply line (customer side)
2. MV disconnector/earthing switch
3. Installation compartment for voltage measurement, power cell detection and precharge system resistors
4. Power cells on the rear for phases A, B and C
5. Cable duct for customer MV supply line
6. Main contactor

## 3.3 SAFETY AND MONITORING EQUIPMENT

### 3.3.1 EMERGENCY STOP

***SWITCH OF IN AN EMERGENCY***

In case of danger to persons or damage to system parts caused by the supply of electrical energy to the VFD, the MVH 2.0 provides an *EMERGENCY STOP* feature for your safety.

The EMERGENCY STOP feature includes the disconnection of the VFD from the medium voltage via the VFD main contactor. In parallel, the MVH 2.0 provides switch-off signals to the customer side to connect an external upstream MV main switching element. The input and output signals of the EMERGENCY STOP circuit are designed with redundancy (2-channel) in accordance with the IEC standard.

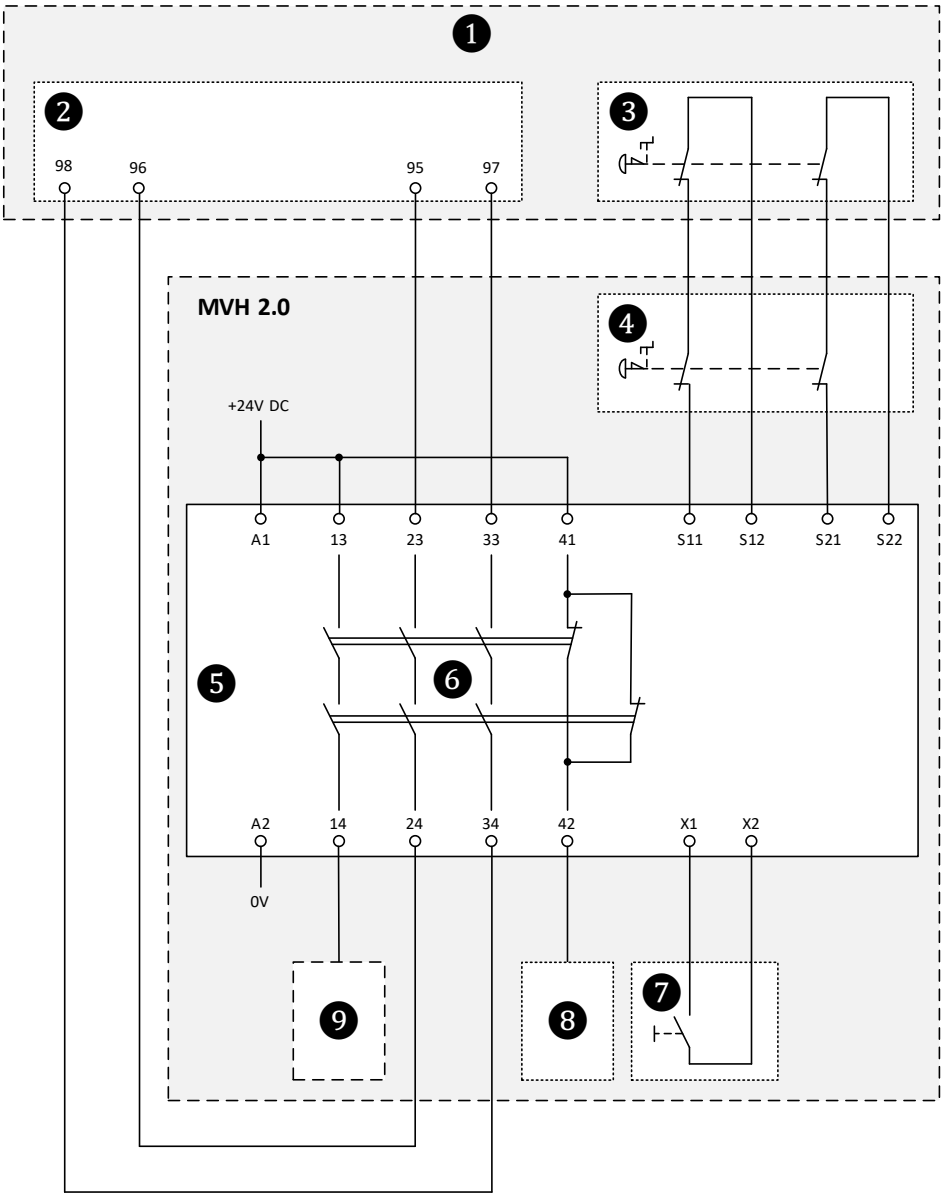



*Fig. 3-19 MVH 2.0 – Schematic diagram for the EMERGENCY STOP feature*

1. Connection terminals on the customer side
2. Terminal block on the customer side (e.g., MV circuit breaker)
3. Customer's EMERGENCY STOP button
4. VFD EMERGENCY STOP button
5. Certified safety relay of the VFD
6. Main contacts of safety relay
7. RESET door pushbutton of the VFD
8. EMERGENCY STOP signal to I/O interface unit of the VFD
9. EMERGENCY STOP signal for optional motor protection device

***EMERGENCY STOP switch- (input signals)***

The VFD *EMERGENCY STOP switch* (located on the door of the control/feeder panel) and the customer's *EMERGENCY STOP switch* are connected in series. The signal performance is of 2 channels. The signal lines of the EMERGENCY STOP signal chains lead to a *certified safety relay* which operates according to the *closed-circuit principle*.

***Safety relay***

During fault-free operation, terminals S11 and S12 as well as S21 and S22 are closed via NC contacts of the ERMERGENCY STOP switch. For this state, the safety relay is energised.

When the safety relay is energised, its six NO main contacts are closed, and its two NC main contacts are open.

In an emergency (or in case of any wire breakage within the signal circuit), the safety relay trips, and the NC main contacts close.

The output signal of the two NC main contacts (terminal 42) causes the main contactor to open via the I/O interface unit of the VFD.

***Switch-off signal for upstream MV main switching element***

The NO main contacts (input terminals 23, 33 and the output terminals 24, 34) are provided as potential free contacts (2-channel) to the terminal block on the customer side.

**NOTE**

If the VFD does not have a main contactor for switching the medium voltage, you must connect the upstream MV main switching element to the potential-free contacts of the safety relay in order to release the VFD in case of emergency!

***Switch-off signal for optional motor protection device***

The VFD can be equipped with an *optional motor protection device* which switches off the upstream MV main switching element in case of emergency. For this, a corresponding input signal for switching off the MV main switching element is also available via termial14 of the main contacts (NO).

***Reset of safety relay***

After clearing the emergency, the safety relay must be *reset* before the VFD can go into standby state. To reset the safety relay, press the *RESET-door pushbutton* on the VFD control/feeder panel.

### 3.3.2 CABINET DOOR INTERLOCKINGS

**DANGER**

Danger due to electric shock!

There is a risk of death or injury from electric shock if you come in contact with live parts in the power cell/transformer cabinet.

Dangerous residual voltage (capacitors) can still be present at the terminals of the power cells after the VFD has been switched off.

- Never open the doors of the power cell cabinet during VFD operation!
- Before opening the power cell cabinet doors, turn off the VFD operation and disconnect the VFD from the MV grid and apply the five safety rules (see *Five safety rules of electrical engineering*).
- After disconnecting the VFD from the MV grid, wait at least 10 min after the status display of the power cell has gone out before you start working in the power cell cabinet.

To avoid personal injury from electric shock when power cell cabinet doors are opened without permission during VFD operation, the VFD has an electrical safety device that switches off the VFD.

Each power cell cabinet door (front, and rear if applicable) has a key switch contact (normally open). All key switch contacts of the door handles are connected in series and the signal output leads to the digital input *Door alarm cell cabinet* (connection terminal: -XS3:10).

All doors must be closed and latched (locked) for VFD operation i.e., the key switch contacts are closed, and +24 V DC potential is supplied to the DI connection terminal (switching logic of the DI: closed-circuit principle).

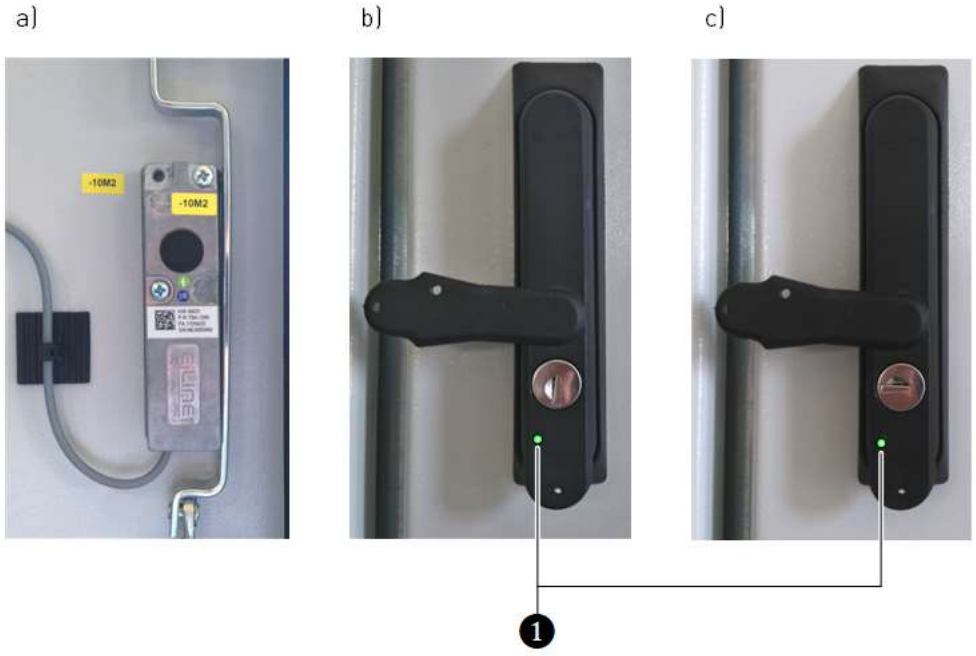



*Fig. 3-20 Cabinet door interlockings*
*a) Key switch contact (inside the door)*
*b) Door interlocked (vertical key position, closed contact)*
*c) Door unlocked (horizontal key position, open contact)*

❶ LED indicator: Door interlocking release

***DOOR INTERLOCKING RELEASE***

You can only unlock any cabinet door when the door interlocking is enabled. The release signal is only enabled by the VFD control system if the MV main supply is switched off. For this, the upstream MV main switching element must be switched off, and the disconnector/earthing switch must be in earthing position.

| LED indication | Colour code | Description |
|---|---|---|
| Door interlocking release | (OFF) | LED off: no release signal |
| | green | LED on: release signal enabled |

***DOOR INTERLOCKING FAILURE***

As soon as at least one cabinet door is unlocked *without an active release signal* (*emergency unlocking*: door interlock is unlocked with key), the digital input *Door alarm cell cabinet* is enabled.

- For parameter setting *Open cabinet door: Fault selection = Alarm*, the message *Alarm: cell cabinet door alarm* is displayed on the HMI. The VFD is *not* switched off.
- For parameter setting *Open cabinet door: Fault selection = Fault*, the message *Fault: cell cabinet door alarm* is displayed on the HMI. The VFD is switched off.

**WARNING**

Danger due to electric shock!

For parameter setting *Open cabinet door: Fault selection = Alarm*, there is a risk of death or injury from electric shock if you come in contact with live parts in the power cell cabinet.

- ➢ The VFD is always delivered with the factory setting *Open cabinet door: Fault selection = Fault.*
- ➢ We do not recommend parameter setting *Open cabinet door: Fault selection = Alarm*.

### 3.3.3 CRANK ACCESS INTERLOCK FOR DISCONNECTOR/EARTHING SWITCH

You can only switch the *disconnector/earthing* switch if the *upstream MV main switching element* is switched off.

To switch the disconnector/earthing switch, use a switching crank. Insert the crank handle into a corresponding crank access at the front of the control/feeder panel. The crank access is electro-mechanically interlocked via a separate switch and a locking plate with cross opening.

a)


b)

*Fig. 3-21 Crank access interlock*
*a) Key switch: interlocking position*
*b) Crank access interlocked*

Ensure you meet all preconditions (plant-specific) before inserting the crank handle into the crank access. You can then turn the key switch into the unlocked position. Once the key switch is in unlocked position, it releases an electro-mechanical latch, so that the locking plate can be pushed upwards. Then, you can insert the crank handle into the crank access.

a)


b)


*Fig. 3-22 Crank access interlock*
*a) Key switch: unlocking position*
*b) Crank access unlocked*

### 3.3.4 EARTHING CONCEPT OF MVH 2.0

***PROTECTIVE EARTHING AND FUNCTIONAL EARTHING***

MVH 2.0 earthing concept includes bot, the protective earthing (PE) as well as functional earthing (FE) of the VFD.

*Protective earthing (PE)* prevents the risk of injury from electric shock due to dangerous touch voltages on conductive parts of the frequency inverter that must not carry voltage. Those system parts are connected to the central earthing bar off the VFD in order to establish equipotential bonding to the common earth potential.

Functional earthing (FE) serves to comply with the requirements regarding electro-magnetic compatibility (EMC) and ensures trouble-free operation off the VFD.

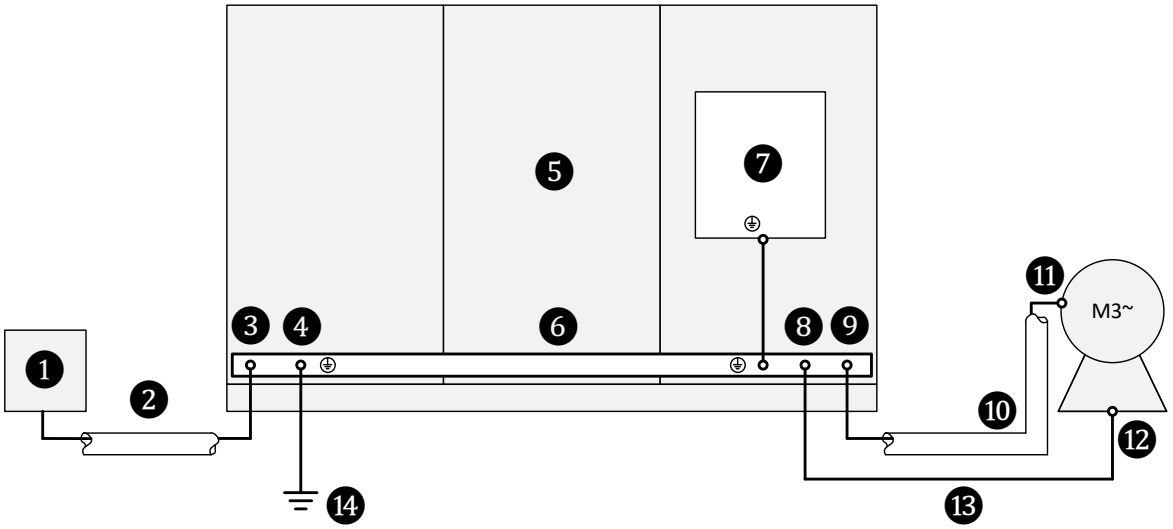



*Fig. 3-23 MVH 2.0 – Earthing principle circuit diagram*

1. MV grid (mains supply)
2. MV mains supply line
3. Earthing rail connection: shielding of the mains supply line
4. Earthing rail connection: central earthing point, customer side
5. VFD cabinet
6. Circumferential, non-enclosed VFD earthing rail
7. Base plate for functional earthing of auxiliary components
8. Earthing rail connection: separate earthing line from motor housing
9. Earthing rail connection: shielding of motor feeder line
10. Motor feeder line
11. Motor housing connection: shielding of motor feeder line
12. Motor housing connection: separate earthing line to earthing rail
13. Separate earthing line
14. Central earthing point

***CENTRAL VFD EARTHING POINT***

The VFD cabinet must be earthed at a central earthing point ⑭ via the earthing rail ⑥ at the connection point ④.

***MV MAINS SUPPLY LINE SHIELDING***

The shielding of the MV mains supply line ② must be earthed via the earthing rail ⑥ at the connection point ③.

***EARTHING OF AUXILIARY COMPONENTS***

All relevant, electrical auxiliary components must be connected to the base plate of the low voltage compartment ❼ in the control/feeder panel. The base plate is connected to the earthing rail ❻ via a fine-core earthing cable.

***MOTOR FEEDER LINE SHIELDING***

The shielding of the motor feeder line ❿ must be earthed at the VFD via the earthing rail ❻ at the connection point ❾ and connected to the motor housing ⓫ on the motor side.

***SEPARATE EARTHING LINE BETWEEN MOTOR UND VFD***

The motor housing ⓬ must be connected to the earthing rail of the VFD ❽ via a separate earthing line ⓭.

## 3.4 MULTI-LEVEL TRANSFORMER

The VFD draws its energy from the medium voltage grid via the multi-level transformer. On the one hand, the transformer is used to galvanically isolate the voltage system generated by the VFD form the feed-in grid. On the other hand, the transformer provides low voltage energy for each power cell of the VFD via its secondary windings (extended delta connection). The number of required secondary windings corresponds to the number of power cells in the VFD.

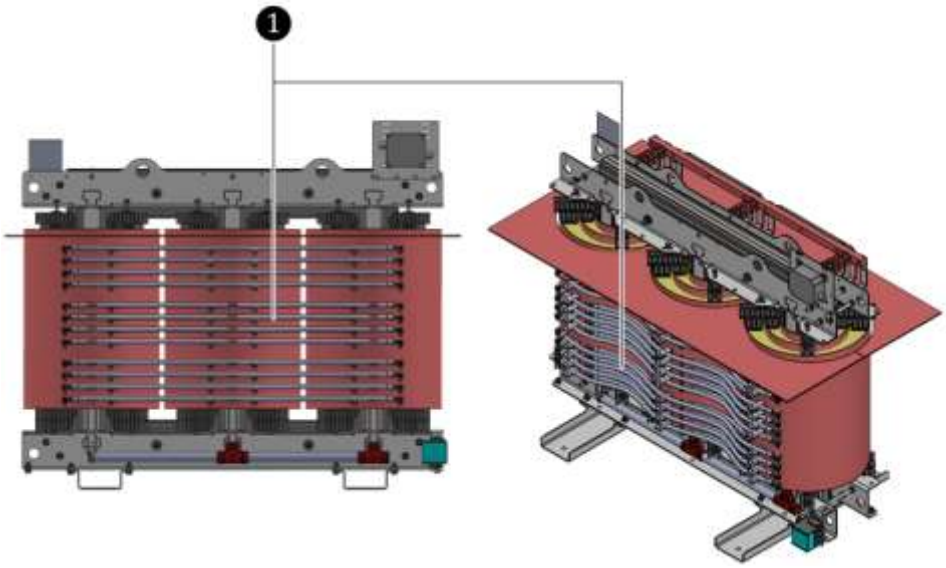



*Fig. 3-24 Example: 4,16 kV multi-level transformer*

1 Secondary windings

Another three-phase 400 V AC auxiliary winding on the transformer secondary side measures the voltage at VFD input. For power cell rated currents > 250 A, the power cells can be preloaded via the 400 V AC auxiliary winding.

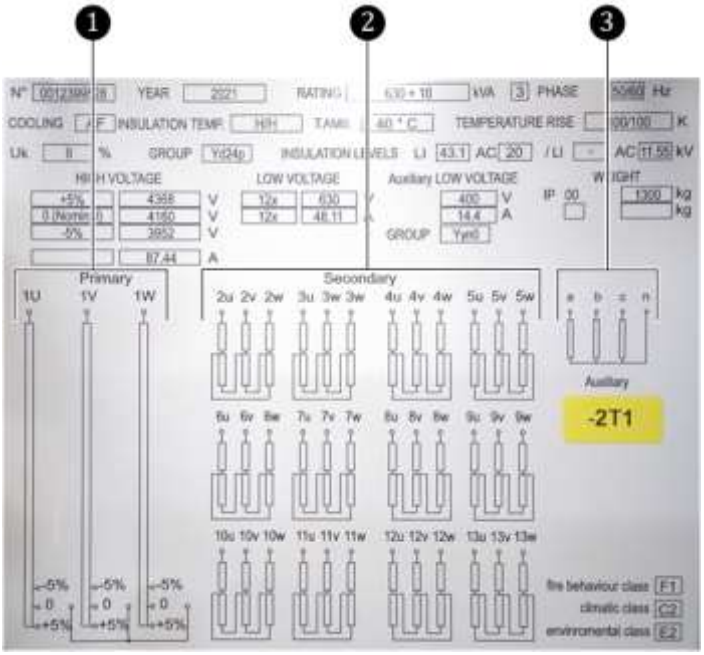



*Fig. 3-25 4.16 kV multi-level transformer – Name plate*

1. Primary winding
2. Secondary windings
3. Auxiliary winding

The main-side medium voltage is connected to terminals 1U, 1V, 1W of the multi-level transformer via the upstream MV switching element.

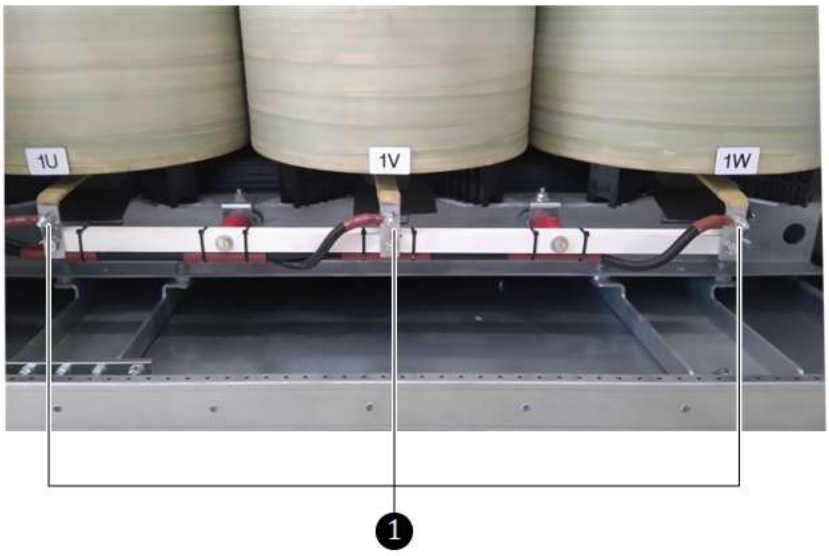



*Fig. 3-26 4,16 kV multi-level transformer – Connection to the MV mains supply*

1. Connection terminals of transformer primary winding

The current at the VFD input is measured by two current transformers in the primary winding circuit of the multi-level transformer. The primary winding is Y-connected.

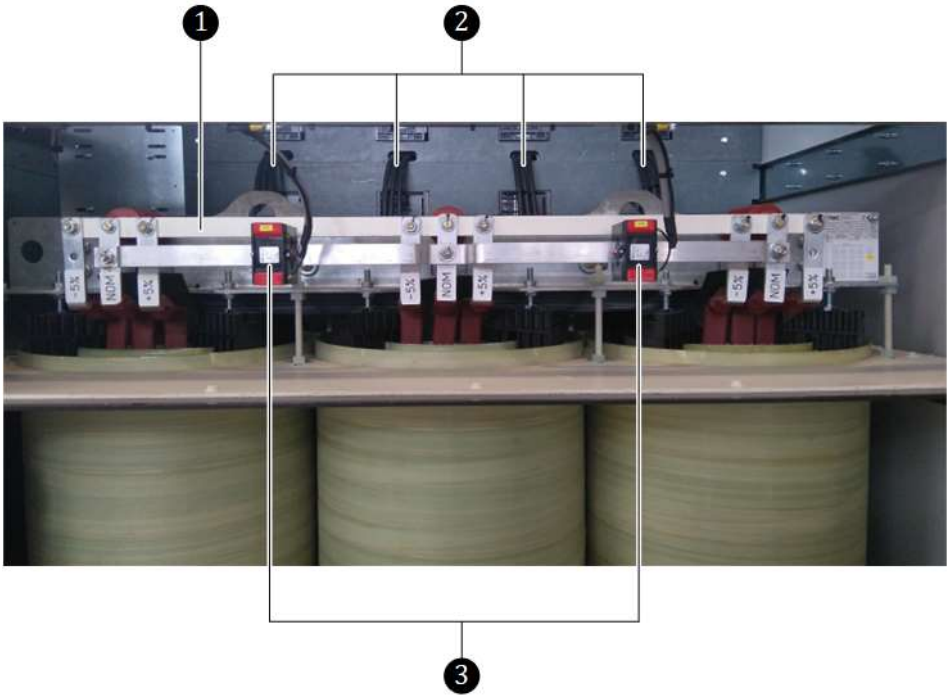



*Fig. 3-27 4,16 kV multi-level transformer – Current measurement at VFD input*

1. Transformer star point
2. Connection lines of secondary windings (R, S, T) to the power cells
3. Current transformer in the transformer primary circuit

**NOTE**

The multi-level transformer is a basic component of the tested and certified VFD. AuCom cannot assume responsibility for customer-specific modifications to the tested and approved standard version of the MVH 2.0. Any modification requires new type testing and certification.

## 3.5 VFD CONTROL SYSTEM

The MVH 2.0 control system consists of:

- a microprocessor-controlled *VFD control unit* (control and regulation) based on modular assemblies
- an *operating unit (HMI)* with touchscreen, and
- an *I/O interface unit* based on a programmable logic controller (PLC) as an integral part of the VFD system, an upper and lower terminal board for connecting signal lines for digital and analog inputs and outputs.

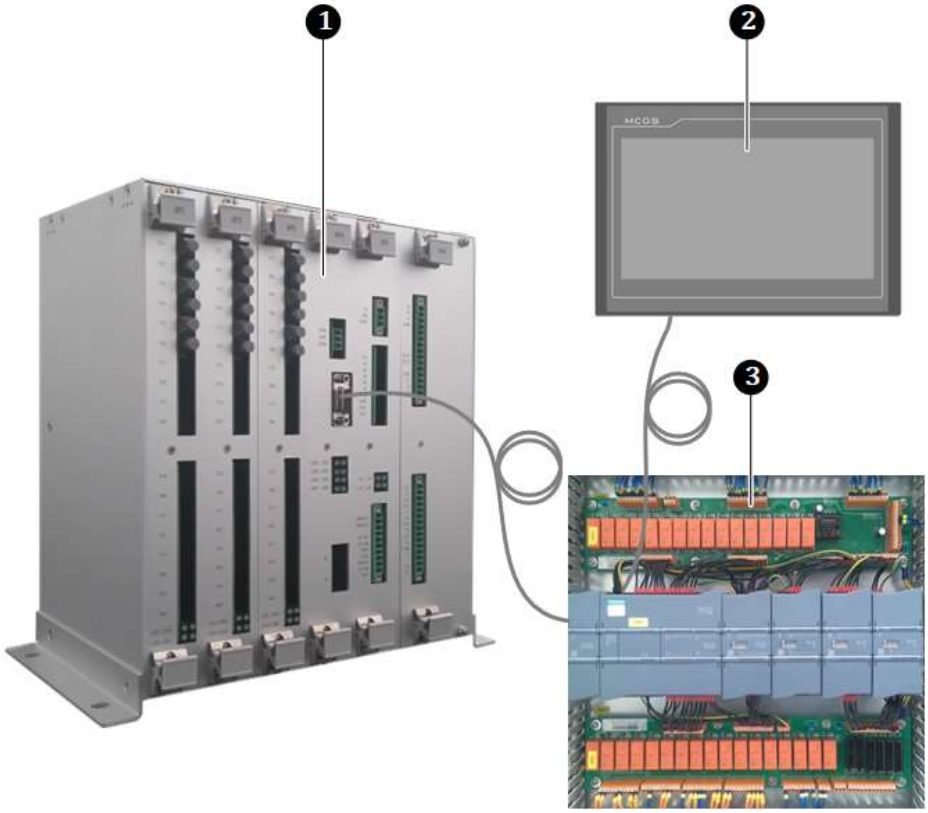



*Fig. 3-28 VFD control system*

1. VFD control unit
2. Operating unit (HMI)
3. I/O interface unit

### 3.5.1 VFD CONTROL UNIT – ASSEMBLIES

***STRUCTURE*** The VFD control unit consists of the following assemblies:

- Main processor assembly
- Fibre optic (FO) assemblies
- Power supply assembly
- Signal assembly

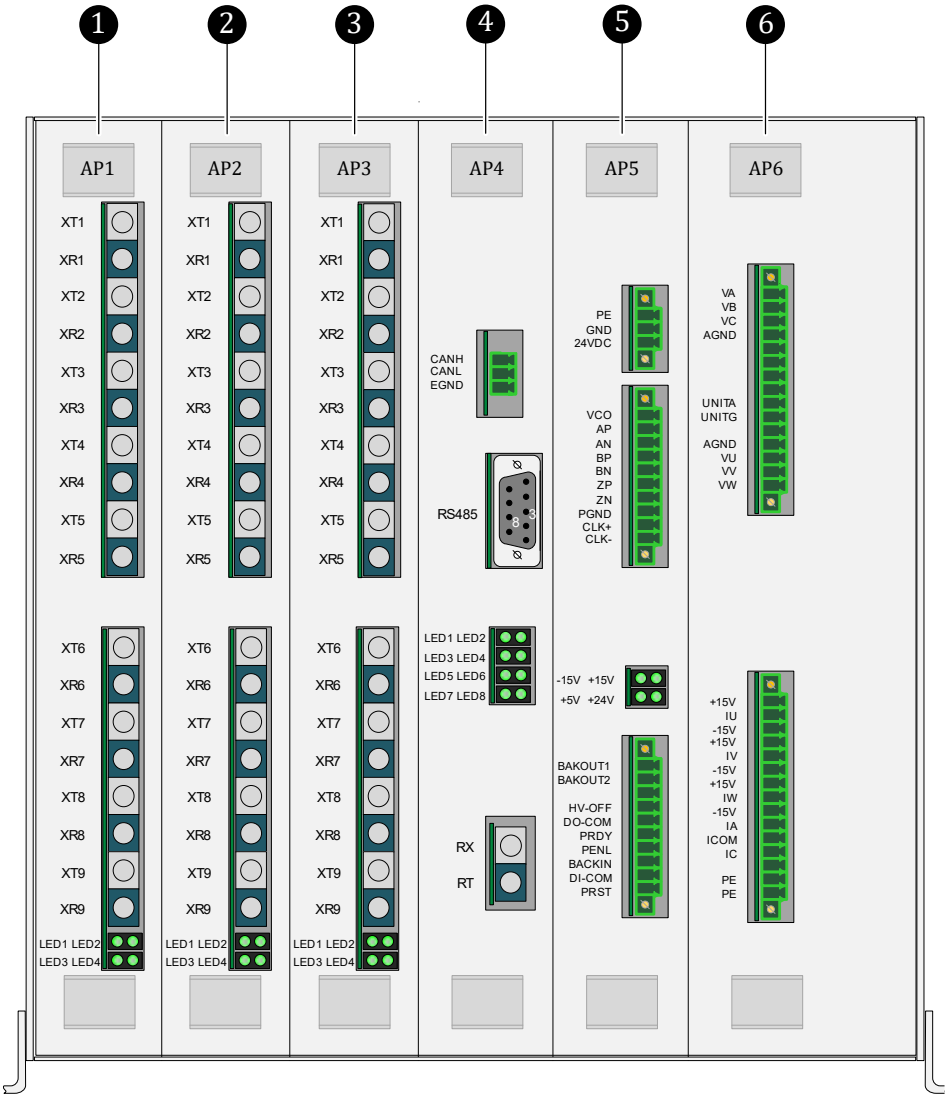



*Fig. 3-29 VFD control unit assemblies – Front view*

1. FO assembly AP1 (phase A power cell)
2. FO assembly AP2 (phase B power cell)
3. FO assembly AP3 (phase C power cell)
4. Main processor assembly AP4
5. Power supply assembly AP5
6. Signal assembly AP6

## FO BOARDS AP1 TO AP3

***FUNCTION*** The VFD control unit is equipped with a total of three FO assemblies: AP1, AP2 and AP3. The FO assemblies establishes the communication between the control unit and the power cells of the VFD.

- FO assembly AP1: Transmitting/Receiving optical signals to/from phase A power cells.
- FO assembly AP2: Transmitting/Receiving optical signals to/from phase B power cells.
- FO assembly AP3: Transmitting/Receiving optical signals to/from phase C power cells.

Each FO module communicates with all power cells of the corresponding phase of the VFD voltage system:

- Transmit (T): Pulse-width modulated (PWM) control signal to the IGBTs of the power cells.
- Receive (R): Status signals of the power cells or an error code signal in the event of a defective power cell.

*INTERFACES AND INDICATION ELEMENTS*

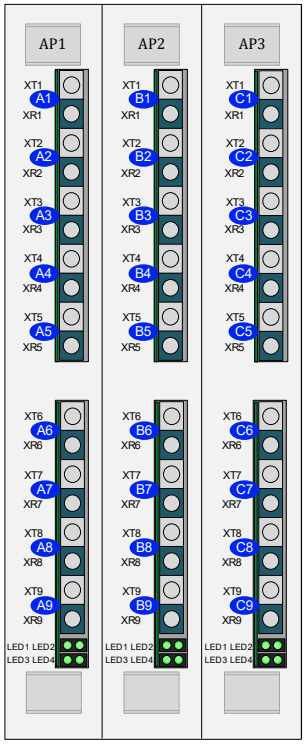



*Fig. 3-30 VFD control unit – FO boards AP1, AP2, AP3*

| FO connections AP1 (Phase A) | FO connections AP2 (Phase B) | FO connections AP3 (Phase C) | Description |
|---|---|---|---|
| A1 XT2 XR2 | B1 XT2 XR2 | C1 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 1st power cell A1, B1, C1. **Receive**: Optical signals from the 1st power cell are received. |
| A2 XT2 XR2 | B2 XT2 XR2 | C2 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 2nd power cell A1, B1, C1. **Receive**: Optical signals from the 2nd power cell are received. |
| A3 XT2 XR2 | B3 XT2 XR2 | C3 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 3rd power cell A1, B1, C1. **Receive**: Optical signals from the 3rd power cell are received. |
| A4 XT2 XR2 | B4 XT2 XR2 | C4 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 4th power cell A1, B1, C1. **Receive**: Optical signals from the 4th power cell are received. |
| A5 XT2 XR2 | B5 XT2 XR2 | C5 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 5th power cell A1, B1, C1. **Receive**: Optical signals from the 5th power cell are received. |
| A6 XT2 XR2 | B6 XT2 XR2 | C6 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 6th power cell A1, B1, C1. **Receive**: Optical signals from the 6th power cell are received. |
| A7 XT2 XR2 | B7 XT2 XR2 | C7 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 7th power cell A1, B1, C1. **Receive**: Optical signals from the 7th power cell are received. |
| A8 XT2 XR2 | B8 XT2 XR2 | C8 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 8th power cell A1, B1, C1. **Receive**: Optical signals from the 8th power cell are received. |
| A9 XT2 XR2 | B9 XT2 XR2 | C9 XT2 XR2 | **Transmit**: Optical signal are sent to the respective 9th power cell A1, B1, C1. **Receive**: Optical signals from the 9th power cell are received. |
| **LED indicators AP1** | **AP2** | **AP3** | **Description** |
| LED blocks:<br>LED: 1<br>LED: 2<br>LED: 3<br>LED: 4 | | | <br>Operating indication<br>RESET of AP1, AP2, AP3 modules<br>Power supply of the module<br>Bypass |

*Tab. 3-2 FO boards AP1, AP2, AP3 - Interfaces and LED indicators*

**NOTE**

Design of the FO modules depends on the number of power cells required in the VFD.

## MAIN CONTROL BOARD AP4

***STRUCTURE AND FUNCTION***

The *main control board* is composed of the following two parts:

- **DSP subsystem**
  The *Digital Signal Processor (DSP)* processes:
  - the motor control algorithms,
  - the power cell fault diagnosis,
  - various real-time protections, and
  - communication with interface boards.
- **FPGA subsystem**
  The *Field Programmable Gate Array (FPGA)* coordinates:
  - the real-time communication with the DSP,
  - the communication with the power cells,
  - the carrier phase shifted PWM output, and
  - other logic functions.

***INTERFACES AND INDICATION ELEMENTS***

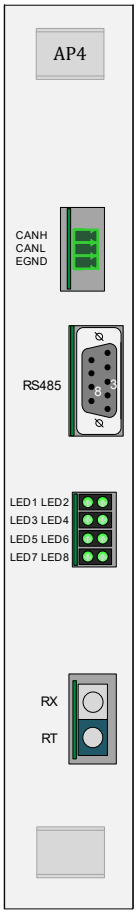



*Fig. 3-31 VFD control unit – Main control board AP4*

| Interfaces | Description |
|---|---|
| CAN bus : | Communication with PC/notebook: IBS interface, software tool: *HC Tools* |
| CANH | CAN bus -„high" level |
| CANL | CAN bus -„low" level |
| EGND | Ground and shielding |
| 9-pole SUB-D socket: | Communication with I/O interface unit (PLC): |
| PIN 3 | RS485 communication interface, RS485A: RxD/TxD „high" level |
| PIN 8 | RS485 communication interface, RS485B: RxD/TxD „low" level |
| Fibre optic (FO): | Optical communication interface for Master/Slave operation (optional: separate ordering option; not via product code!) |
| RX | Source terminal: TX terminal of AP4 assembly of Master or Slave-control unit |
| TX | Target terminal: terminal of AP4 assembly of Master or Slave-control unit |
| **LED indicators** | **Description** |
| LED-Block: | |
| LED: 1 | DSP in operation |
| LED: 2 | DSP Backup |
| LED: 3 | FPGY MV READY |
| LED: 4 | FPGA RESET |
| LED: 5 | DSP Backup |
| LED: 6 | DSP communication |
| LED: 7 | FPGA Control unit ready |
| LED: 8 | FPGA in operation |

*Tab. 3-3 Main control board AP4 – Interfaces and indicators*

## POWER SUPPLY BOARD AP5

***STRUCTURE***

In addition to generating the power used by the controller, the power board also has an I/O interface and speed encoder interface.

***FUNCTION***

- Generation of +5 V, ±15 V power for the power supply to the main control board AP4, fibre optic boards AP1, AP2, AP3, and signal board AP6
- Digital signal transmission in VFD system

For *closed loop vector control* models, it collects motor speed information fed back by the *encoder (speed sensor)*.

***INTERFACES AND INDICATION ELEMENTS***

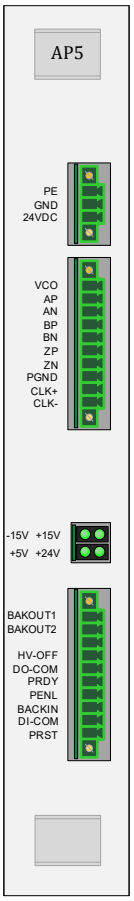



*Fig. 3-32 VFD Control unit – Power supply board AP5*

| Terminal | Description |
|---|---|
| PE | Ground |
| PGND | 24 V power supply: neg. potential |
| 24VDC | 24V power supply: pos. potential |
| VCO | Positive potential for power supply of speed sensor: +5 V or +24 V or 200 mA |
| AP | Speed sensor A+ |
| AN | Speed sensor A- |
| BP | Speed sensor B+ |
| BN | Speed sensor B- |
| ZP | Speed sensor Z+ |
| ZN | Speed sensor Z- |
| PGND | Negative potential for speed sensor power supply |
| CLK+ | Output for pos. clock signal + |
| CLK- | Output for neg. clock signal - |
| **LED indicators** | **Description** |
| LED-Block: | |
| LED: 1st line left | -15 V |
| LED: 2nd line right | +15 V |
| LED: 3rd line left | +5 V |
| LED: 4th line right | +24 V |
| **Terminal** | **Description** |
| BACKOUT1 | Spare output 1, NO contact |
| BACKOUT2 | Spare output 2, NO contact |
| HV-OFF | Output: +24 V DC signal *MV not ready* to the I/O interface unit (target terminal: -XS3:4). If medium voltage is not ready, then internal NO contact (AP5) will close (⇒ +24 V DC at terminal *HV-OFF*) |
| DO-COM | Output: Common pos. potential (+24 V DC) for digital outputs (DO) to the I/O interface unit (target terminal: -XS3:2) |
| PRDY | Output: +24 V DC signal *Control unit ready* to the I/O interface unit (target terminal: -XS3:4). If control unit is ready, then internal NO contact (AP5) will close (⇒ +24 V DC at terminal *PRDY*). |
| PENL | Input: +24 V DC signal *I/O interface unit ready from* the I/O interface unit (source terminal: -XS15:5) If I/O interface unit is ready, then external NO contact (-XS15:5,6) will close (⇒ +24 V DC at terminal *PENL*). |
| BACKIN | Spare input |
| DI-COM | Output: Common pos. potential (+24 V DC) for digital outputs (DO) to the I/O interface unit (target terminal: -XS15:6) |
| PRST | Input: +24 V DC signal *AP1, AP2, AP3 RESET* from the I/O interface unit (source terminal: -XS15:6,8) If I/O interface unit is ready, then external NO contacts (-XS15:5,6 and -XS15:7,8) will close (⇒ +24 V DC at terminal *PRST*). |

*Tab. 3-4 Power supply board AP5 – Terminals and indicators*

## SIGNAL BOARD AP6

***STRUCTURE AND FUNCTION***

The signal board AP6 collects the input/output voltage and current signals of the VFD, performs analog-to-digital conversion on the collected signals, then sends them to the main control board AP4.

***TERMINALS***

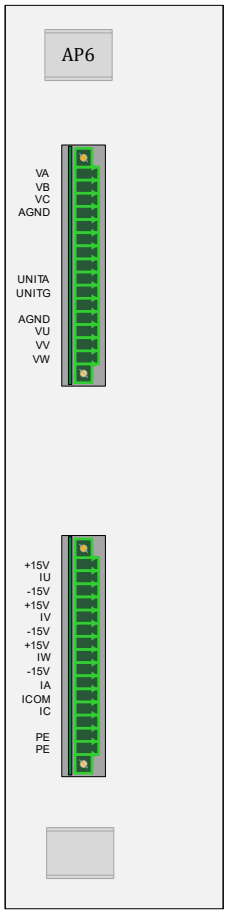



*Fig. 3-33 VFD control unit – Signal board AP6*

| Terminal | Description |
|---|---|
| VA | Phase A input voltage signal |
| VB | Phase B input voltage signal |
| VC | Phase C input voltage signal |
| AGND | Input voltage detection signal common terminal |
| UNITA | Power cell bus voltage sampling + |
| UNITG | Power cell bus voltage sampling - |
| AGND | Common terminal for output voltage detection signals |
| VU | Phase U output voltage signal |
| VV | Phase V output voltage signal |
| VW | Phase W output voltage signal |
| +15 V | Hall sensor pos. potential + |
| IU | Phase U output current signal |
| -15 V | Hall sensor neg. potential - |
| +15 V | Hall sensor pos. potential + |
| IV | Phase V output current signal |
| -15 V | Hall sensor neg. potential - |
| +15 V | Hall sensor pos. potential + |
| IW | Phase W output current signal |
| -15 V | Hall sensor neg. potential - |
| IA | Phase A input current signal (at the star point of the power cell circuit) |
| ICOM | Input current common ground |
| IC | Phase C input current signal (at the star point of the power cell circuit) |
| PE | Shield ground |
| PE | Shield ground |

*Tab. 3-5 Signal board AP6 – Terminals*

**NOTE**

The design of the signal board AP6 depends on the VFD performance characteristics.

## 3.5.2 I/O INTERFACE UNIT (PLC) FOR INPUTS AND OUTPUTS

### OVERVIEW

***STRUCTURE*** The I/O interface unit is composed of a programmable logic controller (PLC), an upper terminal board with terminal blocks for input signals, and a lower terminal board with terminal blocks for output signals. Both upper and lower terminal boards are connected to the PLC.


*Fig. 3-34 I/O interface unit*

1. Upper terminal board with terminals for input signals
2. Programmable logic controller (PLC)
3. lower terminal board with terminals for output signals

***FUNCTION*** The I/O interface unit is used for logical processing of internal signals, external I/O customer signals and feedback as well as status signals.

The I/O interface unit control logic is based on a Siemens S7-1200 PLC. It is equipped with a Siemens high speed processor. The maximum PLC cycle time is 0.15 µs. Extensive interfaces are available for fast calculation and processing of signals for the VFD control requirements, such as:

- 24 digital inputs (DI),
- 16 digital outputs (DO),
- 4 analog inputs (AI), and
- 4 analog outputs (AO).

*COMMUNICATION*

The S7-1200 SMART CPU module is equipped with an Ethernet interface as standard, supports Siemens S7 protocol, TCP/IP protocol, and effectively supports a variety of terminal connections.

For external communication, an RS485 interface with Modbus protocol is available. It provides communication to third-party devices. Other protocol types such as Modbus TCP/IP, Profinet or Profibus etc. can be provided optionally.

| interface | Description |
|---|---|
| Ethernet (LAN):<br>RJ45 | Internal communication to the operating unit (HMI)<br>S7 protocol |
| 9-pole SUB-D socket:<br>PIN 3<br>PIN 8 | Communication to the VFD control unit (Main control board AP4):<br>RS485 communication interface, RS485A: RxD/TxD „high" level<br>RS485 communication interface, RS485B: RxD/TxD „low" level |

*Tab. 3-6 I/O interface unit– Interfaces*

You can also obtain free communication via the RS485 interface using the CM01 signal module.

*FIRMWARE AND PROGRAM UPDATE*

The PLC integrates a micro-SD card slot. You can perform program update and PLC firmware upgrade using a universal micro-SD card. You don't need to return the PLC to the factory or for a factory service technician to be present for firmware upgrades.

*PRECONDITIONS REFERRING TO THE CONNECTION DIAGRAM*

The following preconditions apply to the connection diagram with regard to the represented signal contacts:

- Control voltage for the VFD control system is switched on
- Set VFD operating mode: *VFD mode = **Test***
- All boards AP1, AP2, AP3, AP4, AP5 and AP6 on the VFD control unit are operational
- *External VFD release* is active
- The door contacts of the transformer cabinet and cell cabinet are NO contacts, and all doors are closed and locked ⇒ contacts (NO) are closed
- Medium voltage (MV) is not switched on (MV main switching element is switched off)

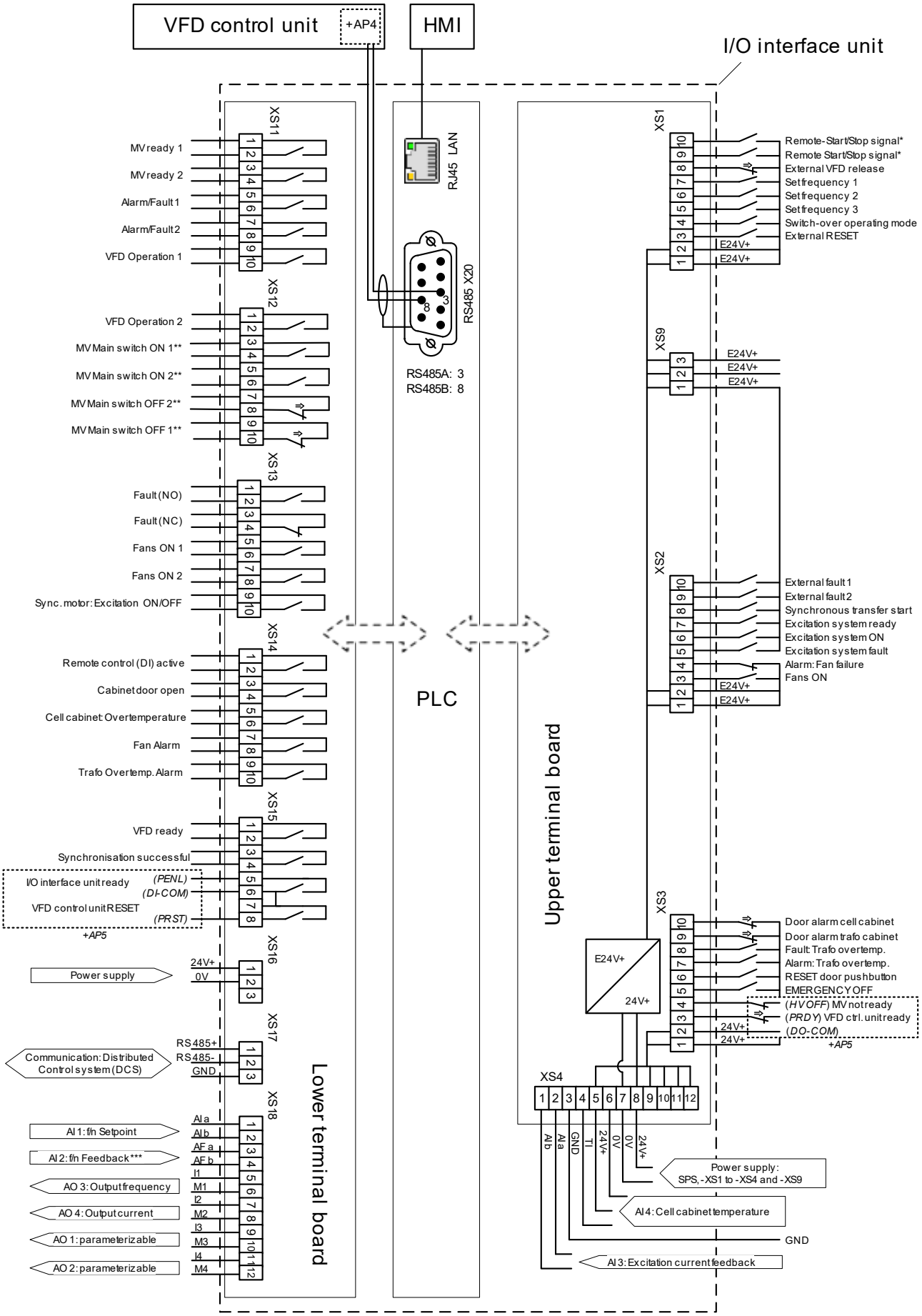



*Fig. 3-35 I/O interface unit – connection diagram*

*Legend for the above figure*:
⇒ : actuated contact
E24V+ : decoupled supply voltage
* : Function and operation of these digital inputs depends on settings of parameters *Reverse release* and *Remote START/STOP: DI mode*
** : Active control signals are performed redundantly according to IEC standard
*** : Speed sensor

## UPPER TERMINAL BOARD

The interface signal of the upper terminal strip blocks XS1, XS2, XS3, XS4 and XS9 are composed of external remote input groups ❶, signals in the VFD cabinet, and excitation feedback signals. The 24 V+ power supply ❻ is fed internally by the VFD. The E24 V+ voltage is then generated by a DC/DC module to the supply voltage, and to the remote signal section ❶, ❸ and ❹ of the circuit. The remote signals are galvanically decoupled from the PLC by relays.

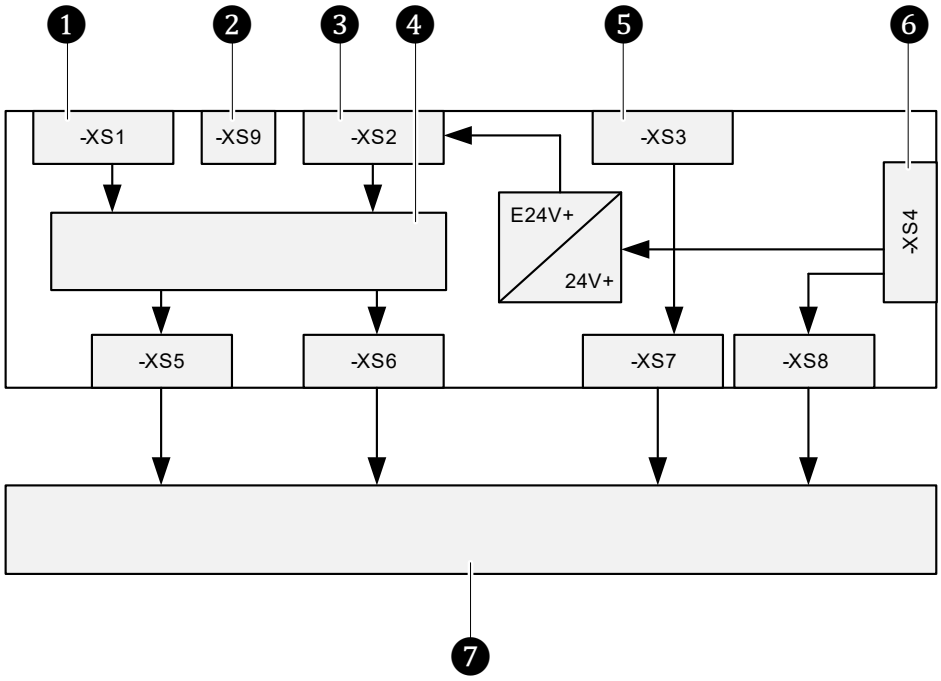



*Fig. 3-36 I/O interface unit– upper terminal board and PLC*

❶ External control signal (Remote)
❷ Common terminal E24 V+
❸ External status and fault signals
❹ Galvanic decoupling (relays)
❺ Internal signals from VFD system
❻ Common terminal 1, power supply, temperature recording, and excitation feedback
❼ Programmable logic controller (PLC)

The upper terminal strips are connected to digital input signals for the *Remote control mode (DI)* and the VFD status messages. Furthermore, an analogue input (0/4 to 20 mA) is available for *excitation current feedback* as well as another analogue input for recording the *cell cabinet temperature*. The load impedance of the analog inputs must not exceed 500 Ω.

Operating mode *remote control (DI)* supports two different types of signals: *level signals* and *pulse signals*. You can select the signal type mode via parameter *Remote START/STOP: DI mode*.

**NOTE**

- Digital input signals must be potential-free. If several digital inputs are used, you can use the E24 V potential as root.
- Signal for DI *External RESET* as the same function as the operating unit (HMI) *RESET* button. During fault-free VFD operation, a reset has no effect on the system operation, and does *not* cause the VFD to switch off.
- After clearing a fault, you must reset the control system to return the VFD to the standby state.

Below are the terminals for *digital inputs (DI)* on the upper terminal strip blocks:

| Terminal block | Terminal No. | DI name | DI switching logic/ Signal mode | Description of DI function |
|---|---|---|---|---|
| *-XS1* | 10 | *Remote-Start/Stop signal* | Open-circuit principle/ Level or pulse signal (set via parameter) | DI is only effective for parameter setting: *Operating mode = Remote control (DI).*<br>Two different signal modes are available as setting options for parameter *Remote START/STOP: DI mode*:<br>• Setting ***Level signal***:<br>DI active (signal contact closed):<br>⇒ **Motor starts forward,** if set frequency > 0 Hz<br>⇒ **Motor starts in reverse,** if:<br>• *Parameter setting: Release: VFD reverse = Enabled* and<br>• set frequency < 0 Hz (negative setpoint) and<br>• DI *Remote Start/Stop signal* (terminals: -XS1:1,9) is additionally enabled.<br>DI inactive (signal contact open):<br>⇒ **Motor stops (forward)**<br>• Setting: ***Impulse signal***:<br>DI active (signal contact must be closed for at least 500 ms):<br>⇒ **Motor starts forward** (set frequency > 0 Hz) or in **reverse** (set frequency < 0 Hz) |
| | 9 | *Remote-Start/Stop signal* | Open-circuit principle/ Level or pulse signal (set via parameter) | DI is only effective for parameter setting: *Operating mode = Remote control (DI).*<br>Two different signal modes are available as setting options for parameter *Remote START/STOP: DI mode*:<br>• Setting ***Level signal***:<br>DI active (signal contact closed):<br>⇒ **Motor starts in reverse,** if:<br>• set frequency < 0 Hz and<br>• if DI *Remote Start/Stop signal* (terminals: -XS1:1,10) is already enabled.<br>DI inactive (signal contact open):<br>⇒ **Motor stops (reverse)** regardless of the state of DI *Remote Start/Stop signal* (terminals: -XS1:1,10)<br>• Setting ***Impulse mode***:<br>DI active (signal contact must be closed for at least 500 ms):<br>⇒ **Motor stops** |
| | 8 | *External VFD release* | Open-circuit principle/ | DI active (signal contact closed): |

| Terminal block | Terminal No. | DI name | DI switching logic/ Signal mode | Description of DI function |
|---|---|---|---|---|
| | | | Level signal | ⇒ The VFD output is **released** (e.g., the start command for the motor can be sent). The signal contact must be closed for VFD operation.<br>DI inactive (signal contact open):<br>⇒ The VFD output is **blocked** (e.g., the start command for the motor cannot be sent).<br>NOTE: Digital outputs (DO) *MV Main switch ON 1* and *MV Main switch ON 2* remain switched on, independent of the signal status of DI *External VFD release.* |
| | 7 | *Set frequency 1* | Open-circuit principle/ Level signal | DIs are only effective for parameter setting: *Setpoint mode = Setpoint via DI)*<br>The setpoint frequency for the VFD output is set via the three DIs.<br>Frequency setpoint setting is done according to a coding of the binary states (DI active/inactive) of the three DIs as well as *Speed section 3* or *Speed section 7* set in parameter *Setpoint via DI*. |
| | 6 | *Set frequency 2* | Open-circuit principle/ Level signal | |
| | 5 | *Set frequency 3* | Open-circuit principle/ Level signal | |
| | 4 | *Switch-over operating mode* | Open-circuit principle/ Level signal | DI is only effective for parameter setting *Release: Switch-over (DI) operating mode =Enable.*<br>DI active (signal contact closed):<br>⇒ Operating mode: **Remote control (DI)**<br>DI inactive (signal contact open):<br>⇒ Operating mode: **Local control (HMI)** |
| | 3 | *External RESET* | Open-circuit principle/ Pulse signal | This function corresponds to the function of the *RESET* button of the HMI.<br>DI active (signal contact closed):<br>⇒ **All active fault messages** are **reset**, provided their causes have been resolved.<br>DI inactive (signal contact open):<br>⇒ **no function** |
| *-XS2* | 10 | *External fault 1* | Open-circuit principle/ Level signal | This function corresponds to the function of the *EMERGENCY STOP push button* on the cabinet door of the VFD control panel.<br>DI active (signal contact closed):<br>⇒ MV mains supply is **switched off** (VFD main contactor)<br>DI inactive (signal contact open):<br>⇒ **no function** |
| | 9 | *External fault 2* | Open-circuit principle, Level signal | The *External fault 2* function corresponds to the function of the *EMERGENCY STOP push button* on the cabinet door of the VFD control panel.<br>DI active (signal contact closed):<br>⇒ MV mains supply is **switched off** (VFD main contactor)<br>DI inactive (signal contact open):<br>⇒ **no function** |
| | 8 | *Synchronous transfer start* | Open-circuit principle, Level signal | DI is only effective for parameter setting *Transfer release: VFD<->Grid = Enable.*<br>DI active (signal contact closed):<br>⇒ Synchronous transfer process **starts**<br>DI inactive (signal contact open):<br>⇒ **no function** |
| | 7 | *Excitation system ready* | Open-circuit principle, Level signal | Status signal from *external excitation system* (synchronous motors only).<br>DI active (signal contact closed):<br>⇒ The external excitation system is **ready to start** the excitation process |

| Terminal block | Terminal No. | DI name | DI switching logic/ Signal mode | Description of DI function |
|---|---|---|---|---|
| | | | | DI inactive (signal contact open):<br>⇒ The external excitation system is **not** ready to start the excitation process |
| | 6 | *Excitation system ON* | Open-circuit principle, Level signal | Feedback signal from *external excitation system* (synchronous motors only).<br>DI active (signal contact closed):<br>⇒ the external excitation field is **in operation**<br>DI inactive (signal contact open):<br>⇒ the external excitation field is **not** in operation |
| | 5 | *Excitation system fault* | Open-circuit principle, Level signal | Fault signal from *external excitation system* (synchronous motors only).<br>DI active (signal contact closed):<br>⇒ **Fault** in the external exciter field<br>DI inactive (signal contact open):<br>⇒ **No** fault in the external exciter field |
| | 4 | *Alarm: Fan failure* | Open-circuit principle/ Level signal | Indication signal that all power circuit breakers and temperature switches of the fans are switched on.<br>DI active (signal contact closed):<br>⇒ **all circuit breakers** of the fans are **closed**<br>DI inactive (signal contact open):<br>⇒ **at least one** circuit-breaker has **tripped** |
| | 3 | *Fans ON* | Open-circuit principle/ Level signal | Feedback that all fans are switched on.<br>DI active (signal contact open):<br>⇒ **all** auxiliary contacts of the fans' contactors are **closed**<br>DI inactive (signal contact closed):<br>⇒ **at least one** auxiliary contact of the fans' contactors is **open** |
| *-XS3* | 10 | *Door alarm cell cabinet* | Open-circuit principle/ Level signal | Each power cell cabinet door has a door key switch whose signal contact (NO contact) is closed when the door is closed and locked. All door switch contacts are connected in series.<br>DI active (signal contact closed):<br>⇒ **all power cell cabinet doors are closed and locked**<br>DI inactive (signal contact open):<br>⇒ **at least one** power cell cabinet door is **unlocked**<br>⇒ for setting the parameters: *Open cabinet door: Selection Alarm/Fault = Fault*, the fault message *Fault: Door alarm cell cabinet* is issued and the VFD **switches off**!<br>⇒ for setting the parameters: *Open cabinet door: Selection Alarm/Fault = Alarm* the message *Alarm: Door alarm cell cabinet* is issued; but the VFD **remains in operation.** |
| | 9 | *Door alarm trafo cabinet* | Open-circuit principle/ Level signal | Each transformer cabinet door has a door key switch whose signal contact (NO contact) is closed when the door is closed and locked. All door switch contacts are connected in series.<br>DI active (signal contact closed):<br>⇒ **all transformer cabinet doors are closed and locked**<br>DI inactive (signal contact open):<br>⇒ **at least one** transformer cabinet door is **unlocked**<br>⇒ for setting the parameters: *Open cabinet door: Selection Alarm/Fault = Fault*, the |

| Terminal block | Terminal No. | DI name | DI switching logic/ Signal mode | Description of DI function |
|---|---|---|---|---|
| | | | | message *Fault: Door alarm transformer cabinet* is issued and the VFD **switches off**!<br>⇒ for setting the parameters: *Open cabinet door: Selection Alarm/Fault = Alarm* the message *Alarm: Door alarm transformer cabinet* is issued; but the VFD **remains in operation.**<br>NOTE: For transformer cabinets *without* doors, this DI must be wired with +24 V DC. |
| | 8 | *Fault: Trafo overtemp.* | Open-circuit principle/ Level signal | This DI is only be used in conjunction with an *external temperature monitoring relay*.<br>DI active (signal contact closed):<br>⇒ **at least one** of the three transformer temperature sensors (PT100) reports an **overtemperature:** $\vartheta \geq 150$ °C<br>⇒ the VFD **switches off!**<br>DI inactive (signal contact open):<br>⇒ **none** of the three transformer temperature sensors (PT100) reports an overtemperature**:** **$\vartheta < 150$ °C**<br>NOTE: If *no sensor* is used, terminal 8 must remain unconnected (open). |
| | 7 | *Alarm: Trafo overtemp.* | Open-circuit principle/ Level signal | This DI is only used in conjunction with an *external temperature monitoring relay*.<br>DI active (signal contact closed):<br>⇒ **at least one** of the three transformer temperature sensors (PT100) reports an **overtemperature:** $\vartheta \geq 95$ °C<br>⇒ VFD **remains** in operation<br>DI inactive (signal contact open):<br>⇒ **none** of the three transformer temperature sensors (PT100) reports an overtemperature**:** $\vartheta < 95$ °C<br>NOTE: If no sensor is used, terminal 7 must remain unconnected (open). |
| | 6 | *RESET Door-Push button* | Open-circuit principle/ Level signal | DI active (signal contact closed):<br>⇒ **All** error messages are reset, provided that their causes have been resolved<br>⇒ The EMERGENCY STOP safety relay is **reset** when the cause of EMERGENCY STOP has been **resolved** and the EMERGENCY STOP signalling chain (2-channel) is **closed** again.<br>⇒ The VFD control unit is reset.<br>DI inactive (signal contact open):<br>⇒ **no function** |
| | 5 | *EMERGENCY OFF* | Open-circuit principle/ Level signal | The EMERGENCY STOP function is used to switch off the medium voltage via an upstream main switching element when an EMERGENCY STOP switch is actuated.<br>DI active (signal contact closed):<br>⇒ An EMERGENCY STOP switch was actuated and the medium voltage was switched off via the upstream main switching element.<br>DI inactive (signal contact open):<br>⇒ **no function** |
| | 4 | *MV not ready* | Open-circuit principle / Level signal | Source terminal: *Power supply module AP5*, terminal: *HV-OFF* |

| Terminal block | Terminal No. | DI name | DI switching logic/ Signal mode | Description of DI function |
|---|---|---|---|---|
| | | | | DI active (*AP5*: internal signal contact **closed**, *HV-OFF*: +24 V DC):<br>⇒ **MV not ready,** medium voltage is **not** connected<br>DI inactive (*AP5*: internal signal contact **open**, *HV-OFF*: 0 V):<br>⇒ **MV ready,** medium voltage is **connected** |
| | 3 | *VFD ctrl. unit ready* | Open-circuit principle/ Level signal | Source terminal: *Power supply module AP5*, terminal: *PRDY*<br>DI active (AP5: internal signal contact **closed**, *PRDY*: +24 V DC):<br>⇒ VFD control unit is **ready**<br>DI inactive (AP5: internal signal contact **open**, *PRDY*: 0 V):<br>⇒ VFD control unit is **not ready** |

*Tab. 3-7 Upper terminal board – Terminals (DI)*

Below are the terminals for *analog inputs (AI)* on the upper terminal strip blocks:

| Terminal block | Terminal No. | AI name | AI specification | Description of AI function |
|---|---|---|---|---|
| *-XS4* | 2 | *Excitation feedback current* | AI/current: 0/4 ... 20 mA | You can set the measuring range of transfer characteristics for the current excitation current with parameters:<br>*AI 3 (Feedback excit. current): Meas.range start* and<br>*AI 3 (Feedback excit. current): Meas.range end*<br>Meas.range start ≙ 0 A<br>Meas.range end ≙ Parameter *Motor: Rated excitation current*<br>Accuracy: 1.5 %. |
| | 4<br>5<br>6 | *Cell cabinet temperature* | AI/PT-100 sensor | Cell cabinet's temperature monitoring sensor |
| | 7<br>8 | *Power supply PLC, -XS1 to -XS4 and -XS9* | 24V+<br>0V | 24 V+ power supply for internal PLC:<br>+24 V DC<br>Common potential |
| *-XS9* | 1<br>2<br>3 | *Power supply for external* | E24V+<br>E24V+<br>E24V+ | Power supply for further external signals<br>pos. potential of power supply<br>pos. potential of power supply<br>pos. potential of power supply |

*Tab. 3-8 Upper terminal board – Terminals (AI)*

## LOWER TERMINAL BOARD

The lower terminal block is used to connect:

- the VFD status output signals,
- the upstream MV switching element,
- the analog inputs and outputs,
- signal lines of main control board AP5, and
- a fieldbus system (DCS) to the communication interface RS485 (Modbus).

Terminals -XS11, -XS12 and -XS13 are rated up to 250 V AC / V DC and 8 A continuous current. If a higher current or voltage value is required, use coupling relays to increase the output power.

The analog inputs (AI) must be routed and connected with shielded cables, input impedance ≥ 250 Ω, max. input current 30 mA (max. input voltage 15 V).

The digital output *Synchronisation successful* only applies for the *Synchronous transfer* function.

**NOTE**

Digital outputs *MV Main switch ON 1/2* and *MV Main switch OFF 1/2* are foreseen to release/interlock the upstream MV switching element.

- The ON signals are NO contacts with which the circuit of the upstream main switch is switched on.
- The OFF signals are NO contacts with which the circuit of the upstream main switch is switched off.
- For safety reasons, the ON and OFF signals are redundant (2-channel).
- Connection is made via the customer terminal block.

Below are the terminals for *digital outputs (DO)* on the lower terminal strip blocks:

| Terminal block | Terminal No. | DO name | Specification | DO operating conditions |
|---|---|---|---|---|
| *-XS11* | 1<br>2 | *MV ready 1* | 8 A, 250 V AC | Relay contacts (NO) **close**<br>• when DI *MV not ready (HV-OFF)* is inactive.<br>Relay contacts (NO) **open**<br>• when DI *MV not ready (HV-OFF)* is active. |
| | 3<br>4 | *MV ready 2* | 8 A, 250 V AC | |
| | 5<br>6 | *Alarm/Fault 1* | 8 A, 250 V AC | **Alarms**:<br>Relay contacts (NO) **close** and **open cyclically** (1 s cycle: 0.5 s ON / 0.5 s OFF)<br>• once at least **one** Alarm is **active**.<br>Relay contacts (NO) **open**<br>• once the Alarm is **inactive**.<br>**Faults**:<br>Relay contacts (NO) **close**<br>• once at least **one** Fault is **active**.<br>Relay contacts (NO) **open**<br>• once **no** Fault is **active** and **all** *Fault notifications* are **reset**<br>(HMI: button *RESET* or digital input: *External RESET* or *RESET command* via DCS-communication). |
| | 7<br>8 | *Alarm/Fault 2* | 8 A, 250 V AC | |
| | 9<br>10 | *VFD Operation 1* | 8 A, 250 V AC | For parameter setting ***VFD mode = Operation*** applies:<br>Relay contacts (NO) **close**, once the following criteria are met:<br>• DI *MV not ready (HV-OFF)* is inactive and<br>• there is **no active Fault** and<br>• DI *EMERGENCY-OFF* is **inactive** and |
| *-XS12* | 1<br>2 | *VFD Operation 2* | 8 A, 250 V AC | |

| Terminal block | Terminal No. | DO name | Specification | DO operating conditions |
|---|---|---|---|---|
| | | | | • all power cells show power cell status ***Normal*** and<br>• all power cells show cell bypass unit status ***Normal*** and<br>• the VFD is put in operation by a START command.<br><br>Relay contacts (NO) **open**<br>• as soon as the VFD switches off due to at least one of the above criteria or<br>• the motor is switched off by a STOP command.<br><br><u>For parameter setting ***VFD mode = Test*** applies</u>:<br>Relay contacts (NO) **close**, once the following criteria are met:<br>• there is **no active Fault** and<br>• DI *EMERGENCY-OFF* is **inactive** and<br>• the VFD is put in operation by a START command.<br><br>Relay contacts (NO) **open**<br>• as soon as the VFD switches off due to at least one of the above criteria or<br>• the motor is switched off by a STOP command. |
| | 3<br>4 | *MV Main switch ON 1* | 8 A, 250 V AC | <u>For parameter setting ***VFD mode = Operation*** applies</u>:<br>Relay contacts (NO) **close**, once the following criteria are met:<br>• there is **no active Fault** and<br>• DI *EMERGENCY-OFF* is **inactive** and<br>• all power cells show power cell status ***Normal*** and<br>• all power cells show cell bypass unit status ***Normal***<br><br>Relay contacts (NO) **open**<br>• if **none** of the above criteria **are met**.<br><br><u>For parameter setting ***VFD mode = Test*** applies</u>:<br>Relay contacts (NO) **close** once the following criteria are met:<br>• there is **no active Fault** and<br>• DI *EMERGENCY-OFF* is **inactive**<br>Relay contacts (NO) **open**<br>• as soon as **none** of the above criteria are met. |
| | 5<br>6 | *MV Main switch ON 2* | 8 A, 250 V AC | |
| | 7<br>8 | *MV Main switch OFF 1* | 8 A, 250 V AC | Relay contacts (NO) **close**<br>• as soon as *VFD mode = **Test*** is set or<br>• when *VFD mode = **Operation*** is set and **at least one** Fault is **active**.<br><br>Relay contacts (NO) **open**<br>• when *VFD mode = **Operation*** is set and **no** Fault is active |
| | 9<br>10 | *MV Main switch OFF 2* | 8 A, 250 V AC | |
| *-XS13* | 1<br>2 | *Fault (NO)* | 8 A, 250 V AC | Relay contact (NO) **closes**<br>• once a *Fault* is **active**.<br><br>Relay contact (NO) **opens**<br>• once no *Fault* is active and<br>• all Fault notifications are reset<br>(HMI: button *RESET* or digital input: *External RESET* or *RESET command* via DCS-communication). |
| | 3<br>4 | *Fault (NC)* | 8 A, 250 V AC | Relay contact (NC) **opens**<br>• once a Fault is **active**.<br><br>Relay contact (NC) **closes**<br>• once **no** Fault is **active** and<br>• **all** *Fault notifications* are **reset**<br>(HMI: button *RESET* or digital input: *External RESET* or *RESET command* via DCS-communication). |

| Terminal block | Terminal No. | DO name | Specification | DO operating conditions |
|---|---|---|---|---|
| | 5<br>6 | *Fan ON 1* | 8 A, 250 V AC | Relay contacts (NO) **close**<br>• if *VFD mode* = ***Operation*** is set and DI *Fans ON* (-XS2:3) is **active** while the VFD is in operation, or<br>• if *VFD mode* = ***Test*** is set and fans are manually **switched on** using the **START** button in *Functions parameters 3* menu |
| | 7<br>8 | *Fan ON 2* | 8 A, 250 V AC | Relay contacts (NO) **open**<br>• if *VFD mode* = ***Operation*** is set and DI *Fans ON* (-XS2:3) is **inactive** while the VFD is in operation, or<br>• if *VFD mode* = ***Test*** is set and fans are manually **switched off** using the **STOP** button in *Functions parameters 3* menu |
| | 9<br>10 | *Sync. motor: Excitation ON/OFF* | 16 A,<br>250 V AC | *ON command* to the *external exciter panel* to switch on excitation (synchronous motors only).<br>Relay contact (NO) **closes**<br>• depending on the settings in the *Excitation system* menu. |
| *-XS14* | 1<br>2 | *Remote control (DI) active* | 16 A,<br>250 V AC | This DO is only effective for parameter setting ***Release: Switch-over (DI) operating mode= Enable***:<br>Relay contact (NO) **closes**<br>• if DI *Switch-over operating mode* is **active**.<br>Relay contact (NO) **opens**<br>• If DI *Switch-over operating mode* is **inactive**. |
| | 3<br>4 | *Cabinet door open* | 16 A,<br>250 V AC | Relay contact (NO) **closes**<br>• At least **one** cabinet door of the transformer or cell cabinet is **unlatched/opened** (DI *Door alarm cell cabinet* or DI *Door alarm trafo cabinet* is **active)**<br>Relay contact (NO) **opens**<br>• **all** cabinet doors of the transformer or cell cabinet are **closed and latched** (DI *Door alarm cell cabinet* or DI *Door alarm trafo cabinet* is in**active)** |
| | 5<br>6 | *Cell cabinet overtempt. Alarm* | 16 A,<br>250 V AC | Relay contact (NO) **closes**<br>• if the sensor for **temperature** monitoring in the **power cell** cabinet (AI: -XS4:4,5,6) reports **an overtemperature** ($\vartheta \geq 55$ °C).<br>Relay contact (NO) **opens**<br>• if the sensor for **temperature** monitoring in the **power cell** cabinet (AI: -XS4:4,5,6) reports **no** overtemperature ($\vartheta < 55$ °C). |
| | 7<br>8 | *Fan Alarm* | 16 A,<br>250 V AC | Relay contact (NO) **closes**<br>• if at least **one** of the fans reports a **malfunction** (DI *Alarm: Fan failure* is **active**)<br>Relay contact (NO) **opens**<br>• provided that **all** fans are **fault-free** (DI *Alarm: Fan failure* is in**active**). |
| | 9<br>10 | *Trafo overtemp. Alarm* | 16 A,<br>250 V AC | This DO is only to be used in cooperation with an **external temperature monitoring relay**.<br>Relay contact (NO) **closes**<br>• if at least one of the three sensors for transformer temperature monitoring reports an **overtemperature** ($\vartheta \geq 95$ °C) (DI *Alarm: Trafo overtemp.* is **active**)<br>Relay contact (NO) **opens**<br>• provided that all three sensors for transformer temperature monitoring reports **no** overtemperature ($\vartheta < 95$ °C) (DI *Alarm: Trafo overtemp.* is **inactive**) |
| *Terminal* | 1<br>2 | *VFD ready* | 16 A,<br>250 V AC | For parameter setting ***VFD mode = Operation*** applies:<br>Relay contact (NO) **closes**<br>• provided that **all** self-check procedures of the VFD control system have been **successfully completed** and<br>• medium voltage is **switched on** |

| Terminal block | Terminal No. | DO name | Specification | DO operating conditions |
|---|---|---|---|---|
| | | | | Relay contact (NO) **opens**<br>• if medium voltage is **switched off** (intended control command) or<br>• any *Fault* or *Alarm* is **active**<br><br>For parameter setting ***VFD mode = Test*** applies:<br>Relay contact (NO) **closes**<br>• provided that **all** self-check procedures of the VFD control system have been **successfully completed** and<br>• medium voltage is **switched off**<br><br>Relay contact (NO) **opens**<br>• if medium voltage is **switched on by accident** or<br>• any *Fault* or *Alarm* is **active**<br><br>NOTE: Digital output (DO) *VFD ready* corresponds to the LED indicator *VFD ready* on the operating unit (HMI). |
| | 3<br>4 | *Synchronization successful* | 16 A,<br>250 V AC | Synchronisation process for the fct. *Synchronous transfer*:<br>Relay contact (NO) **closes**<br>• provided that the *VFD output voltage* **is synchronized with** the *MV mains voltage* (measured phase angle difference $\Delta\varphi$ is **within** the set value of parameter *Synchronization: Max. permitted* $\Delta\varphi$, and **same value** of the corresponding phase voltages)<br><br>Relay contact (NO) **opens**<br>• once the synchronicity conditions are **no longer fulfilled** |
| | 5<br>6 | *I/O interface unit ready* | 16 A,<br>250 V AC | Relay contact (NO) **closes**<br>• if the PLC of the I/O interface unit is ready for operation<br>PENL<br>DI-COM |
| | 7<br>6<br>8 | *VFD control unit RESET* | 16 A,<br>250 V AC | Relay contact (NO) **closes**<br>• if the VFD control unit detects any internal fault<br>n.a.<br>DI-COM<br>PRST |

*Tab. 3-9 Lower terminal board – Terminals (DI, DO)*

Below are the terminals for *analog inputs and outputs (AI, AO)* on the lower terminal strip blocks:

| Terminal block | Terminal No. | AI or AO name | AI or AO specification | Description of AI or AO function |
|---|---|---|---|---|
| *-XS16* | 1<br>2<br>3 | *Power supply* | +24 V DC<br>0 V<br>n.a. | Supply voltage for lower terminal blocks |
| *-XS17* | 1<br>2<br>3 | *Communication: Distributed control system (DCS)* | RS485+<br>RS485-<br>GND | Communication interface for DCS<br>RS485A: RxD/TxD „high" level<br>RS485B: RxD/TxD „low" level<br>Ground and shielding |
| *-XS18* | 1<br>2 | *AI 1: f/n Setpoint* | Analog input (AI):<br>Current: 0/4 – 20 mA | You can set the measuring range of transfer characteristics for the ***frequency setpoint*** with the parameters:<br>*AI 1 (f/n Setpoint): Meas.range start* und<br>*AI 1 (f/n Setpoint): Meas.range end*<br>Meas. scale start ≙ 0 Hz<br>Meas. scale end ≙ Parameter: *Maximum frequency*<br>Accuracy: 1.5 %. |
| | 3<br>4 | *AI 2: f/n Feedback* | Analog input (AI):<br>Current: 0/4 ... 20 mA | You can set the measuring range of the transfer characteristics for the ***frequency feedback*** can be set with the parameters:<br>*AI 2 (f/n Feedback): Meas.range start a*nd<br>*AI 2 (f/n Feedback): Meas.range end*<br>Meas. scale start ≙ 0 Hz<br>Meas. scale end ≙ 100 %<br>Accuracy:1.5 %. |
| | 5<br>6 | *AO 3: Output frequency* | Analog output (AI):<br>Current: 4 ... 20 mA | Transfer measured variable: ***VFD output frequency***<br>Meas. range start ≙ 4 mA<br>Meas. range end ≙ 20 mA<br>Meas. scale start ≙ 0 Hz<br>Meas. scale end ≙ parameter: *Maximum frequency*<br>Burden: max. 500 Ω,<br>10-bit A/D sampling,<br>Resolution: 0.1 %,<br>Accuracy: 1.0 % |
| | 7<br>8 | *AO 4: Output current* | Analog output (AI):<br>Current: 4 ... 20 mA | Transfer measured variable: ***VFD output phase current***<br>Meas. range start ≙ 4 mA<br>Meas. range end ≙ 20 mA<br>Meas. scale start ≙ 0 A<br>Meas. scale end ≙ 150 % of parameter *Rated output current* [A]<br>Burden: max. 500 Ω,<br>10-bit A/D sampling,<br>Resolution: 0.1 %,<br>Accuracy: 1.0 % |
| | 9<br>10 | *AO 1: parameterizable* | Analog output (AI):<br>Current: 0/4 ... 20 mA | The analog output can be configured for one of the following different measured variables:<br>• ***Output frequency***<br>Meas. range start ≙ 4 mA<br>Meas. range end ≙ 20 mA<br>Meas. scale start ≙ 0 Hz<br>Meas. scale end ≙ parameter *Maximum frequency*<br>• ***Output current***<br>Meas. range start ≙ 4 mA |

| Terminal block | Terminal No. | AI or AO name | AI or AO specification | Description of AI or AO function |
|---|---|---|---|---|
| | | | | Meas. range end ≙ 20 mA<br>Meas. scale start ≙ 0 A<br>Meas. scale end ≙ 150 % of parameter *Rated output current* [A]<br>• ***Cell cabinet temperature***<br>Meas. range start ≙ 4 mA<br>Meas. range end ≙ 20 mA<br>Meas. scale start ≙ 0 °C<br>Meas. scale end ≙ 100 °C<br>• ***Excitation current*** (only sync. motors)<br>The measuring range of the transfer characteristic for the setpoint excitation current can be set with the parameters:<br>*AO 1(2) (Setpoint): Meas.range start* and *AO 1(2) (Setpoint): Meas.range end*<br>Meas. scale start ≙ 0 Hz<br>Meas. scale end ≙ parameter *Motor: Rated excitation current*<br>***Output power***<br>Meas. range start ≙ 4 mA<br>Meas. range end ≙ 20 mA<br>Meas. scale start ≙ 0 A<br>Meas. scale end ≙ 150 % of rated *VFD output power* [kW]<br>• ***Output power factor***<br>Meas. range start ≙ 4 mA<br>Meas. range end ≙ 20 mA<br>Meas. scale start ≙ 0<br>Meas. scale end ≙ 1<br>***Output voltage***<br>Meas. range start ≙ 4 mA<br>Meas. range end ≙ 20 mA<br>Meas. scale start ≙ 0V<br>Meas. scale end ≙ 150 % of parameter *Rated output voltage* [V]<br>Burden: max. 500 Ω,<br>10-bit A/D sampling,<br>Resolution: 0.1 %,<br>Accuracy: 1.0 % |
| | 11<br>12 | *AO 2: parameterizable* | Analog output (AI):<br>Current: 0/4 ... 20 mA | See description of *AO 1: parameterizable* above |

*Tab. 3-10 Lower terminal board – Terminals (AI, AO)*

### 3.5.3 OPERATING UNIT HMI (TOUCHSCREEN)

*STRUCTURE*

To operate the VFD locally (on site), the VFD provides an operating unit (HMI). The HMI is installed in the cabinet door on the VFD control/feeder panel.

The HMI is equipped with a resistive touchscreen, terminals for connecting the power supply and various interfaces for communication with the peripherals and the VFD control system.

A sealing lip between the HMI front panel and the control panel ensures the required IP protection level.

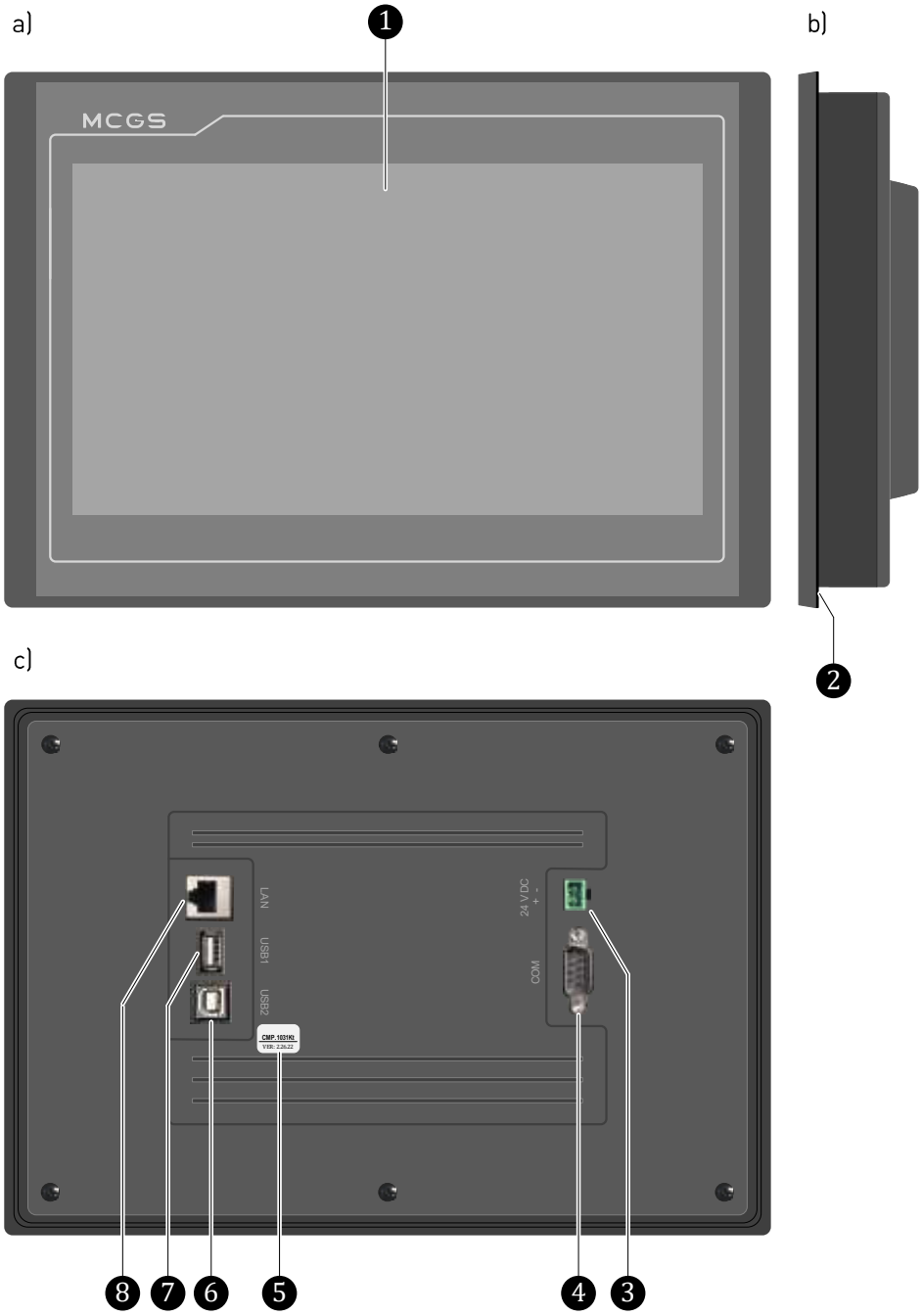



*Fig. 3-37 Operating unit HMI (Touchscreen)*
*a) Front view*
*b) Side view*
*c) Rear view*

1. Touchscreen with transparent, removable protective film
2. Sealing lip between HMI and control panel
3. HMI power supply 24 V DC
4. (COM: D-SUB 9-pole; plug: not used)
5. HMI hardware version
6. (USB2: not used)
7. USB1
8. LAN: RJ45 interface for communication with I/O interface unit (PLC)

***FUNCTIONS***

Using the graphic touchscreen you can:

- Read, update, and save data recordings (*trend recorder, event recorder*)
- Set different user levels (*user login*)
- Change and save parameter settings
- In operating mode *Local control (HMI)*: manually start and stop the motor under operating conditions (menu *VFD Monitor*)
- In test mode: manually start and stop the motor and test the peripherals without connection to the medium voltage (menu *VFD Monitor*)
- *Pre-charging system*: manually start and stop the charging process for the power cells
- *Excitation system* (optional, only for synchronous motors): manually start and stop excitation of synchronous motors

***CONNECTION, INDICATION ELEMENT AND INTERFACES***

| Terminal | Description |
|---|---|
| 24 V DC:<br>+<br>- | HMI power supply:<br>pos. potential<br>neg. potential |
| **Indication element** | **Description** |
| Display | Graphic display, resistive touchscreen; display array (W x H): 222 x 125 (mm) |
| **Interfaces** | **Description** |
| USB1: | Interface for memory medium, e.g., data export<br>type A, 2.0; socket |
| Ethernet (LAN):<br>RJ45 | Communication with I/O interface unit (PLC)<br>S7 protocol, TCP/IP |

*Tab. 3-11 Terminals, indication element and interfaces of the operating unit (HMI)*

## 3.6 POWER CELL

The *power cells* in the VFD are basic components for generating the voltage system at the VFD output. The following sections explain the mechanical and electrical structure of the power cells.

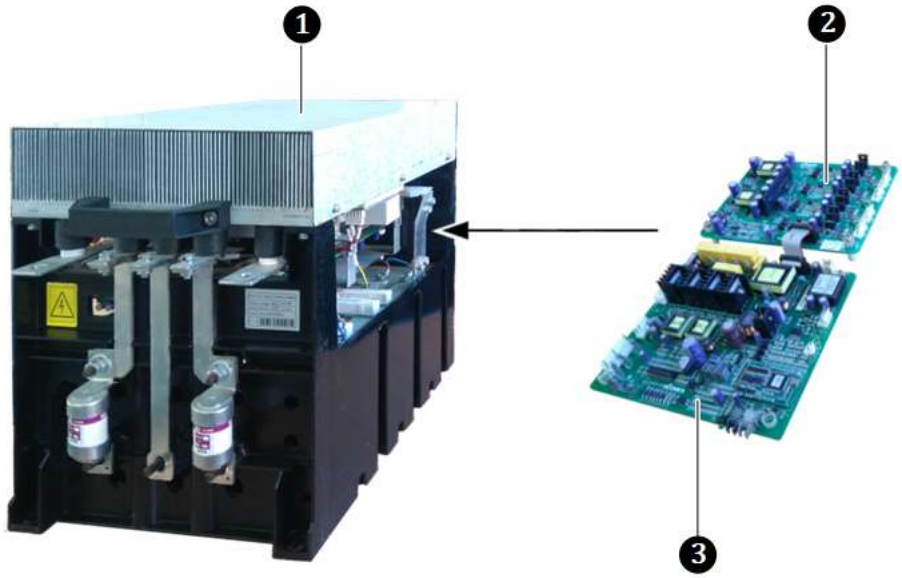



*Fig. 3-38 Typical power cell*

1. Power cell
2. Power cell gate drive board
3. Power cell control board

### 3.6.1 POWER CELL COMPONENTS

***POWER CELL COMPONENTS - FRONT SIDE***

The power cells are installed in the power cell cabinet and fastened to the mounting rail with screws and bolts. The following illustrations show the typical components of a power cell.

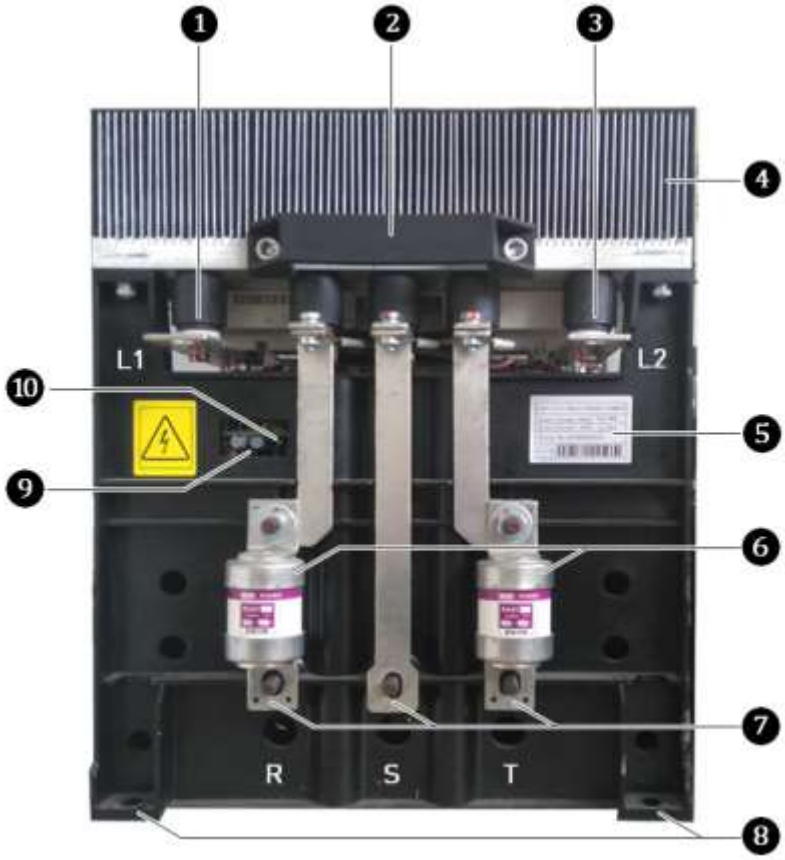



*Fig. 3-39 Power cell 690 V – Typical front view*

1. Power cell output (terminal: L1)
2. Front mounting handle
3. Power cell output (terminal: L2)
4. Heat sink
5. Power cell name plate
6. Fuses
7. Power cell input (terminals: R, S, T)
8. Front mounting points
9. Fibre optic (FO) interface to the VFD control unit
10. Voltage status indicator (green LED)

### POWER CELL COMPONENTS – REAR SIDE


*Fig. 3-40 Power cell 690 V – Typical rear view*

1. Rear mounting handle
2. Test interface (manufacturer only!)
3. Rear mounting points

The cells in the cabinet have identical electrical and mechanical parameters and are interchangeable. The power cell's three-phase input is connected to the secondary winding of the multi-level transformer. The power cell's single-phase output is provided by terminals L1 and L2.

**WARNING**

Danger due to electric shock!

Dangerous residual voltage is still present at the input terminals R, S, T on the power cell, even after the VFD has been switched off.

To mitigate risks of injury from electric shock if you come in contact with live parts on the power cell:

- Switch off the medium voltage feed through upstream main switching element.
- Apply the five safety rules (see *Five safety rules of electrical engineering*).
- Wait at least 10 min after the power cell status indicator has gone out before starting any work on the power cells.

### POWER CELL DISASSEMBLY

After removing the mounting screws, input cables at terminals R, S, T, output copper bars, and fibre optic connectors and the guide rail, the cell is completely separated from the cell cabinet and can be removed from the guide rail. The procedure for re-installing the cell is the reverse of disassembling.

### 3.6.2 POWER CELL ELECTRICAL OPERATING PRINCIPLE

The figure below illustrates the electrical topology of a power cell.

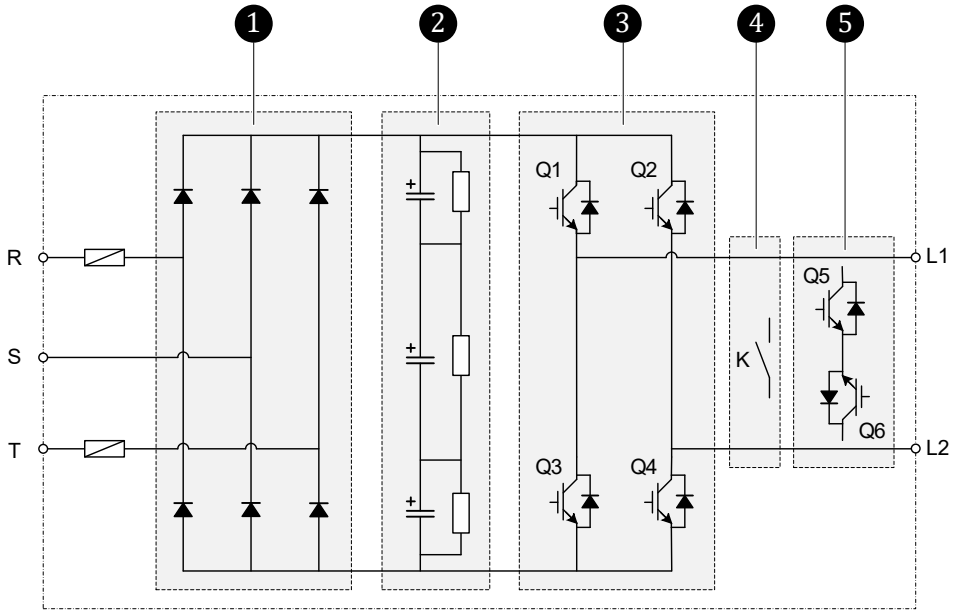



*Fig. 3-41 Electrical schematic diagram of a power cell*

1. Rectifier
2. DC bus
3. Inverter
4. Optional power cell bypass: contactor
5. Optional power cell bypass: IGBTs

***POWER CELL INPUT: R, S, T*** The input terminals R, S, T are connected to a three-phase secondary winding of the multi-level transformer.

***RECTIFIER*** Three-phase full-bridge rectification is used to supply power to the internal DC bus, and to the output of the H-bridge VFD circuit. The parallel-connected diodes of the three-phase full-bridge rectifier allow the current to flow in only one direction at a time, producing a coarse-wave DC output.

***DC BUS*** Then, this current flows into the so-called DC link, in which a filter circuit consisting of capacitors and resistors generates an even and constant DC voltage. For this purpose, the capacitors release electrons during the gap time and thus smooth out the residual ripple of the voltage.

***INVERTER*** The resulting smoothed DC current then enters the inverter, which consists of four electronic switches (power IGBTs) in an H-bridge circuit. The power IGBTs Q1 to Q4 are controlled in pairs and temporarily via a control signal to switch the current flow on and off cyclically. The selection of the IGBTs to be controlled determines the current paths and the duration of the controlled IGBTs determines the duration of the current flow in the various current paths. In this way, an AC voltage is generated from the DC voltage of the DC bus.

***CONTROL SIGNALS FOR IGBTS*** The power cell receives the optical control signals (FO) from the control unit for switching the IGBTs Q1 to Q4 in the inverter on and off. A single-phase voltage in the form of pulse width modulated (PWM) voltage pulses is provided at the output of the inverter (connections L1 and L2).

The voltage pulse at the inverter output of a power cell can assume the following states:

1. When Q1 and Q4 are switched on, the power cell voltage is equal to the DC bus voltage.
2. When Q2 and Q3 are switched on, the power cell output voltage is equal to the *negative* DC bus voltage.

***POWER CELL OUTPUT: L1, L2***

A correspondingly high clocking of the control signals produces a square-wave voltage at the output of the power cell.

***POWER CELL BYPASS***

With the parameter settings options *Power cell bypass: type = Contactor bypass* or *Power cell bypass: type = IGBT bypass*, the power cell bypass function is automatically activated.

If a power cell is defective, its status is shown in the *status bar* of the HMI.

If a power cell fails, its output (Q1 to Q4) is disabled and the IGBT bypass or the contactor bypass K is switched on. This ensures continuous operation of the VFD.

At the same time, the *xx power cell bypass alarm* is displayed in the yellow error bar, in the lower right corner of the touchscreen. *xx* corresponds to the number of this power cell.

***CONTROL BOARD AND GATE DRIVE BOARD***

Each power cell has an independent control board and a gate drive board:

- The *control board* is physically connected to the VFD control unit via fibre optic cables. This means that these units are galvanically separated from each other.
- The *gate drive board* is used to control the IGBTs.

## 3.6.3 POWER CELL CONTROL BOARD

The following figure shows the operating principle of the power cell control board.

*Fig. 3-42 Power cell control board*

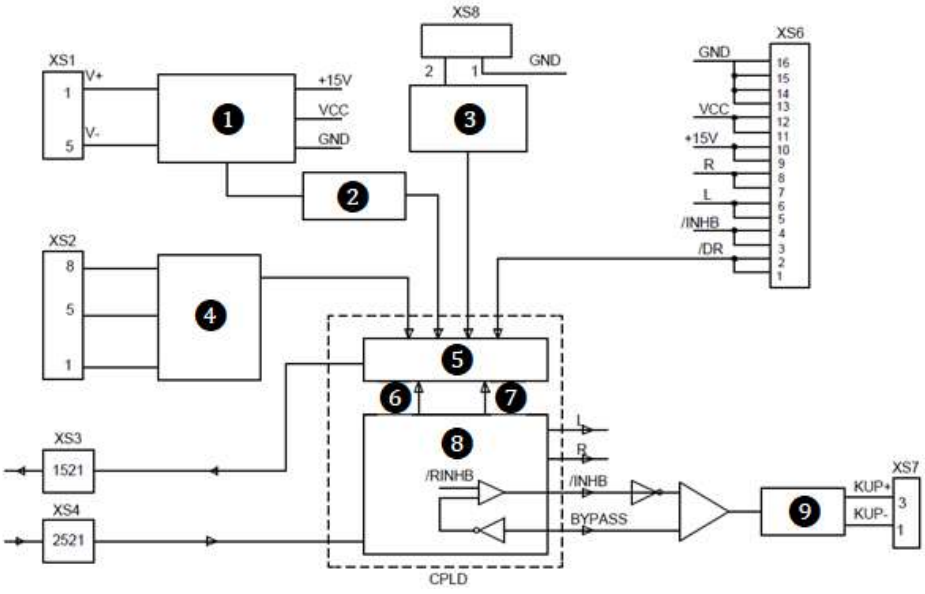



*Fig. 3-43 Power cell control board principle diagram*

| | |
|---|---|
| ❶ | Power supply |
| ❷ | Overvoltage detection (limit value: 1150 V) |
| ❸ | Overtemperature detection |
| ❹ | Loss of phase detection |
| ❺ | Error coding logic |
| ❻ | Power supply failure |
| ❼ | Fibre optic (FO) failure |
| ❽ | Receive decoding |
| ❾ | Bypass drive |
| XS 1 | DC voltage input |
| XS 2 | AC voltage output (max. 690 V AC) |
| XS 3 | FO interface TX: signals to send (light grey) |
| XS 4 | FO interface RX: signals to receive (blue-grey) |
| XS 8 | NC contact |

***CONTROL SIGNALS***

The power cell control board receives the signal from the main controller through the fibre optics (-XS4). After receiving and decoding, the data is used to control:

- the cell IGBTs,
- the bypass IGBT, or
- the contactor bypass.

***POWER CELL FAULT DETECTION***

The power cell *control board* has a variety of *cell fault detection circuits* such as:

- overtemperature detection
- phase loss detection
- DC bus overvoltage detection (limit value: 1150 V)
- fibre optic (FO) failure detection
- drive failure detection,
- integrated cell bypass failure detection.

After the fault signal is encoded by the controller, it is sent back to the main controller via fibre optic cable (XS3) to provide status feedback.

***POWER SUPPLY***

The power supply of the cell control board is taken from the DC bus (through XS1) in the main power cell circuit. The power supply is galvanically isolated and stepped down, and the required local control power is obtained.

***VOLTAGE STATUS INDICATOR OF THE POWER CELL***

After disconnection from the mains, the voltage status display (green LED) on the power cell control module only goes out after approx. 10 minutes.

### 3.6.4 POWER CELL GATE DRIVE BOARD

*Fig. 3-44 Power cell gate drive board*

The following figure shows the operating principle of the power cell control board:

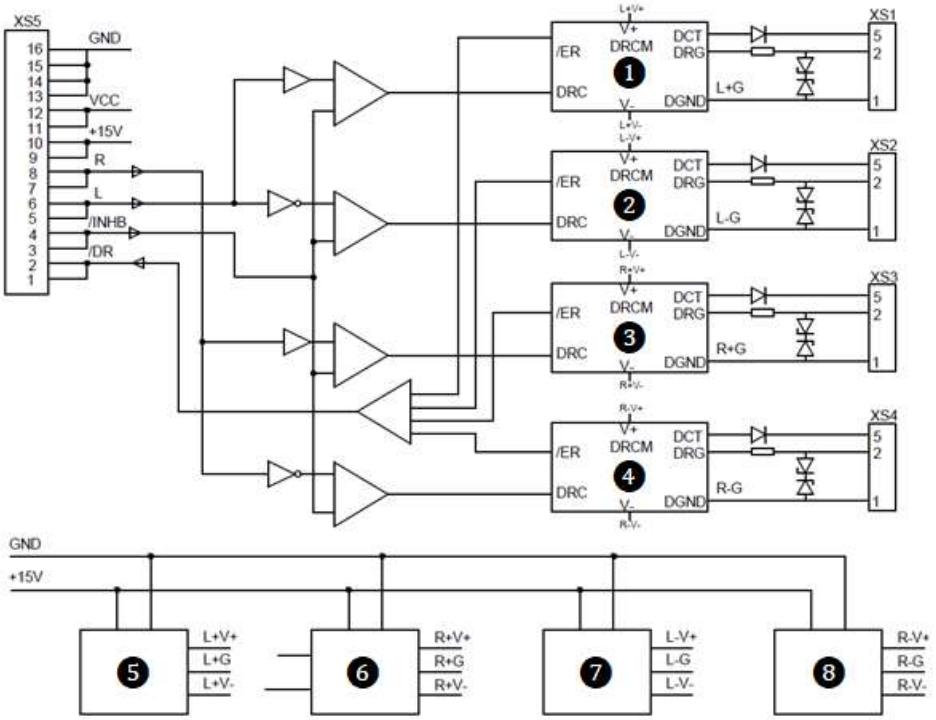



*Fig. 3-45 Power cell gate drive board principle diagram*

1. DRCM: Drive control module for IGBT Q1
2. DRCM: Drive control module for IGBT Q2
3. DRCM: Drive control module for IGBT Q3
4. DRCM: Drive control module for IGBT Q4
5. Isolated power supply for DRCM Q1
6. Isolated power supply for DRCM Q2
7. Isolated power supply for DRCM Q3
8. Isolated power supply for DRCM Q4

***IGBT SIGNALS TO CONTROL THE INVERTER CIRCUIT***

The power cell gate drive board generates all four IGBT drive signals and in case of an *IGBT drive fault*, the notification is sent back to the cell control board. Then, the control module sends an error message to the control unit, which initiates the corresponding measures.

The power cell gate drive is connected to the control board terminal XS6 via terminal XS5. The specific signals are defined as follows:

*IGBT control:*

- control signal „L": controls the two IGBTs (Q1, Q2) of the left bridge arm,
- control signal „R": controls the two IGBTs (Q3, Q4) of the right bridge arm, and the drive signals of Q1, Q2 and Q3, Q4 interlock.

*IGBT error:*

- blocking signal „/ INHB": IGBT disable signal,
- feedback signal „/ DR": IGBT fault signal, which is fed back to the cell control board for cell protection.

***POWER SUPPLY***

The gate drive board is supplied by the control board. The +15 V voltage supply is divided into four separate voltage supplies to control the four IGBTs.

# 4 OPERATING AND DISPLAY

## 4.1 OVERVIEW

All components used for the operation, display and setting of the VFD are detailed in the following sections.


*Fig. 4-1 Operating and display components*

1. Operating unit (HMI) with touchscreen
2. Operating indicators for the switch positions of the main contactor and the disconnector/earthing switch
3. Fault indicator for a VFD trip triggered by a fault event
4. *RESET door pushbutton* used to reset fault messages
5. *EMERGENCY STOP* switch for manual shutdown of the VFD in case of emergency
6. Key switch to enable crank access for the disconnector/earthing switch

## 4.2 ALARM INDICATIONS

The VFD reports faults of low severity as alarm events. Alarms do not switch off the VFD operation. Depending on the chosen operating mode, *alarm messages* are signalled as follows:

- *Local control (HMI)*: When an *alarm event* is active, the alarm message is displayed in plain text in the right array of the lower status bar, on a *yellow* background.
  For instance, *Alarm: Transformer overtemperature*:

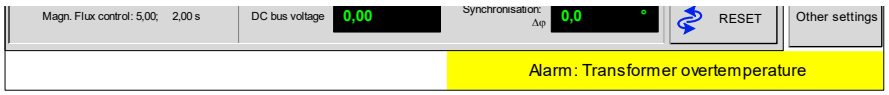



*Fig. 4-2 Operating unit (HMI): Indication of an alarm event*

- *Remote control (DCS)*: The VFD sends data points for the alarm message to the master computer of the distributed control system (DCS).
- *Remote control (DI)*: Activation of corresponding digital outputs (AO) of the I/O interface unit for active alarms that are either reported via digital inputs (DI) of the I/O interface unit or generated by the VFD control unit.

**CHAPTER REFERENCE**

➢ To determine the causes of active alarm events and resolve them, see chapter "7.1.1 Alarm Messages".

## 4.3 CONTROL AND DISPLAY COMPONENTS

### 4.3.1 EMERGENCY STOP SWITCH

In case of faults or in situations that do not lead to an automatic shutdown of the VFD, you can press the EMERGENCY STOP switch on the door of the control panel. This switches off the upstream main switching element (e.g., main contactor or circuit breaker) and interrupts the MV mains supply for the VFD.

*Fig. 4-3 EMERGENCY STOP switch to interrupt MV mains supply*

To actuate the EMERGENCY STOP switch, press down the red switch button until it engages and locks mechanically. For unlocking (*EMERGENCY STOP* release), turn the red switch knob to the right (clockwise) until you feel a stop, then release it. The switch button comes back to its original position.

### 4.3.2 DISCONNECTOR/EARTHING SWITCH: KEY SWITCH, CRANK ACCESS, AND CRANK HANDLE

The *Disconnector/Earthing switch* is switched on and off manually by means of a switch crank. First enable crank access by unlocking the 'Disconnector Operating Handle Access

Shutter Release'. Then, insert the crank handle into the crank access at the front of the control/input panel.

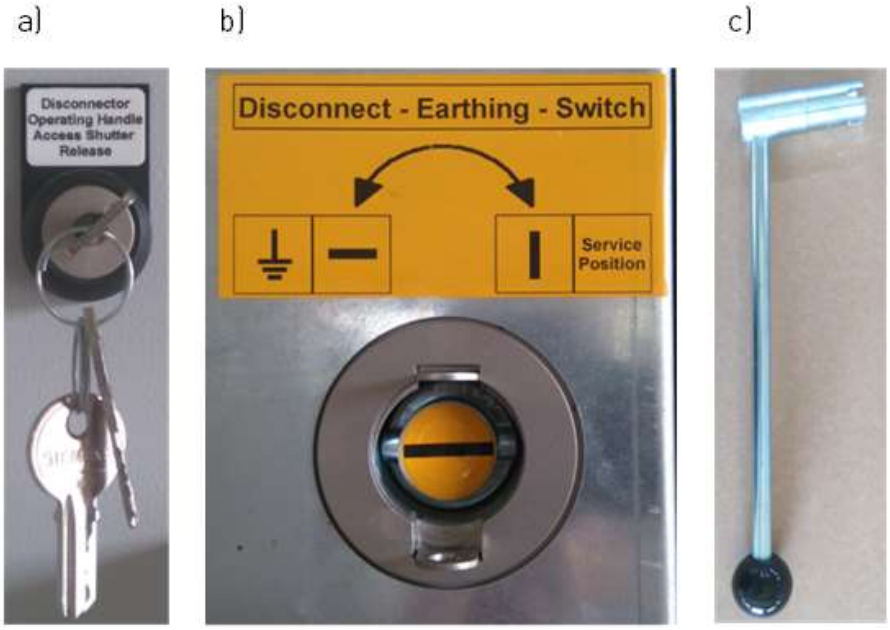



*Fig. 4-4 Operating elements for disconnector/earthing switch*
*a) Key switch to enable crank access*
*b) unlocked crank access*
*c) crank handle*

The switch positions of the *Disconnector/Earthing switch* are indicated by the two indicator lights *Disconnector Open (Earthed)* and *Disconnector Closed (Live)*:

- *Disconnector Open (Earthed)*: Disconnector/Earthing switch open (earthed, separation section open)
- *Disconnector Closed (Live)*: Disconnector/Earthing switch closed (separation section closed)


*Fig. 4-5 Status indicators for Disconnector/Earthing switch*

### 4.3.3 MV MAIN SWITCH ELEMENT (MEDIUM VOLTAGE)

The main contactor or MV circuit breaker is switched on automatically if no fault/alarm messages are active.

The switch positions of the main switching element are indicated by the two indicator lights *Main Contactor Open* and *Main Contactor Closed*:

- *Main Contactor Open:* MV switched off
- *Main Contactor Closed:* MV switched on


*Fig. 4-6 Status indictors for main switch element*

### 4.3.4 START/STOP BUTTONS ON THE HMI

You can switch the motor on and off manually in the *Local control (HMI)* operating mode using the START and STOP buttons on the screen. The buttons are in the *VFD monitor* menu.

***TEST MODE:*** The buttons start and stop the simulated forward/reverse operation of the virtual motor without connecting the medium voltage.

***OPERATION MODE:***

- The START button switches *on* the VFD operation
- The STOP button: switches *off* the VFD operation

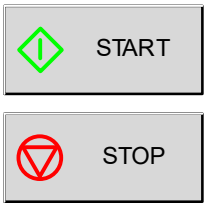



*Fig. 4-7 Operating unit (HMI): enabled START/STOP buttons*

If you set *Operating mode* to *Remote control (DCS)* or *Remote control (DI)*, the START/STOP buttons on the HMI are disabled. The buttons appear in dark grey.

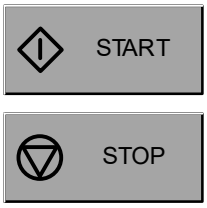



*Fig. 4-8 Operating unit (HMI): disabled START/STOP buttons*

### 4.3.5 RESET COMPONENTS

Depending on the operating mode you selected, resetting of fault messages is performed as follows:

- *Local control (HMI)*: Press the *RESET* button on the touchscreen.


*Fig. 4-9 Operating mode = Local control (HMI): RESET button*

- *Remote control (DCS)*: Send the *RESET* command via the distributed control system (DCS).
- *Remote control (DI):* Use the digital input *External RESET* (terminal -XS1:3).

- For all *Operating modes*: Parallel to the reset options of the individual operating modes, you can reset *fault messages*, reset the *VFD control unit* and reset the *EMERGENCY STOP safety relay* using the *RESET door pushbutton* on the door of the control/feeder panel:


*Fig. 4-10 RESET-Door-push button*

For this purpose, the make contact of the *RESET door pushbutton* is routed to the digital input *RESET door pushbutton* (DI: -XS3:6) of the I/O interface unit.

### 4.3.6 FAULT INDICATIONS

The VFD reports serious fault events (called *faults*) that *switch off* the VFD operation. Depending on the operating mode you selected, *fault messages* are signalled as follows:

- *TRIP* indicator on the *door of the control/feeder panel*:
  In the event of an active *fault* and a subsequent shutdown (trip) of the VFD, the *TRIP* indicator light is automatically switched on (orange). The indicator light is switched off as soon as the cause of the fault has been resolved and the *fault* has been reset by a RESET function (e.g., using the *RESET door pushbutton*).


*Fig. 4-11 TRIP indicator light*

**NOTE**

If the TRIP indicator light flashes, it indicates an active *alarm event*. However, *alarms* do not trigger a shutdown of the VFD.

*Local control (HMI)*: When a *fault event* is active, the fault message is displayed in plain text on the left array of the lower status bar on a *red* background. For instance, *Fault: Door alarm cell cabinet*:


*Fig. 4-12 Operating unit (HMI): Indication of a fault event*

- *Remote control (DCS)*: The VFD sends data points for fault message to the master computer of the distributed control system (DCS).

- *Remote control (DI)*: The corresponding digital outputs (AO) of the I/O interface unit for the active fault are activated and are either reported via digital inputs (DI) of the I/O interface unit or generated by the VFD control unit.

**CHAPTER REFERENCE**

➢ To determine the causes of active fault events and to resolve them, see chapter "7.1.2 Fault Messages".

### 4.3.7 OPERATING UNIT (HMI)

To operate the VFD via the HMI's touchscreen, use the buttons, sliders, selection filters, or number and keyboard blocks on the screen.

**CHAPTER REFERENCE**

➢ For detailed information on the various display and control components as well as their functions and setting options, see chapters „General Operating Instructions" and „4.6 Main Menu (HMI)".

## 4.4 OPERATING MODES AND VFD MODES

| Operating mode | Purpose | Precondition |
|---|---|---|
| Local control (HMI) | • Local control of the VFD either in *Operating* mode or *Test* mode<br>• *Manual START/STOP of the motor* | • Parameter setting: *Operating mode = Local control (HMI)* |
| Remote control (DCS) | • Remote control of the VFD via a Distributed Control System (DCS) as central operating station | • Parameter setting: *Operating mode = Remote control (DCS)*<br>• Fieldbus system with communication protocols such as: Modbus Profibus or Profinet |
| Remote control (DI) | • Remote control of the VFD via an external motor control station | • Parameter setting: *Operating mode = Remote control (DI)*<br>• conventional wiring (copper signal lines) of the motor control station with the VFD (digital inputs and outputs) |
| **VFD mode** | **Purpose** | **Precondition** |
| Test | • Simulation operation of the VFD without connected medium voltage | • Medium voltage must be switched off and<br>• Parameter setting: *VFD mode = Test* |
| Operation | • VFD operation with real application, connected to medium voltage | • Parameter setting: *VFD mode = Operation* |

*Tab. 4-1 Operating modes and VFD modes of MVH 2.0*

## 4.5 GENERAL OPERATING INSTRUCTIONS

### 4.5.1 SWITCHING THE VFD ON AND OFF (STANDBY)

To operate the VFD in real application (start/stop and motor control), you must first switch on the VFD to gain the *ready-to-start* (standby) state.

Once the VFD operation is complete (motor STOP), you can switch off the VFD to exit the *Ready-to-start* (standby) state.

**NOTICE**

After stopping the motor, make sure that the fan power supply is still available.

The following instructions describe the procedures required to switch the VFD on and off in relation to the *Ready-to-start* (standby) state.

*SWITCH ON THE VFD FOR READY-TO-START STATE*

**INSTRUCTION – Switching on the VFD for *ready-to-start* (standby) state**

*START* *USER LEVEL:* **Standard**

**STEP 1:** Inspect the VFD visually system for any external damage or abnormalities.

**STEP 2:** Unlock the *EMERGENCY STOP* signal chain (unlock both the *EMERGENCY STOP* switch on the VFD control/feeder cabinet and the customer's *EMERGENCY STOP* switch).

**STEP 3:** Check that all doors of the VFD cabinet are closed and locked.

**STEP 4:** Switch on the LV circuit breaker in the control/feeder panel to enable power supply for:

- VFD control unit
- I/O interface unit (PLC)
- operating unit (HMI)
- heating
- fans

**STEP 5:** The VFD control system performs the following (self-)checks:

- internal communication check: checks the VFD control system (control unit, I/O interface unit and operating unit (HMI)).
- status check of the medium voltage (MV ready)
- status check of the power cells
- cell bypass units check (depending on the power cell type)
- checks for any active alarms/faults

**STEP 6:** Determine and eliminate the cause(s) of any malfunction, if applicable.

**STEP 7:** Check all parameter settings for compliance with the application and correct as necessary.

**STEP 8:** Using the HMI, ensure that parameter *VFD mode* is set to *Operation.*

**STEP 9:** Unlock electrically (key switch *Disconnector Operating Handle Access Shutter Release*) and mechanically the crank access.

**STEP 10:** Insert the crank handle into the crank access and switch on the disconnector/earthing switch.

**STEP 11:** Check status indicators for *Main Contactor* and *Disconnector/Earthing switch* and correct the following switch positions if necessary:

- *Disconnector Closed (Live)* = ON (status indicator is *green*)
- *Disconnector Open (Earthed)* = OFF (status indicator is *off*)
- *Main Contactor Closed* = ON (status indicator is *off*)
- *Main Contactor Open* = OFF (status indicator is *green*)

**STEP 12:** Remove the crank handle and lock the crank access mechanically and electrically.

**STEP 13:** Check the *VFD ready* status indication on the operating unit display:

- *VFD ready* = ON (virtual status LED is *grün*)

⇒ The VFD is now ready to send the START command to the motor and to start VFD operation, depending on the operating mode used.

*END*

*SWITCH OFF THE VFD TO EXIT READY TO START STATE*

## INSTRUCTION – Switching off the VFD to exit *ready to start* (standby) state

*START*

*USER LEVEL:* **Standard**

**STEP 1:** Send a STOP command.

**STEP 2:** After motor shutdown, check the motor has reached a standstill.

**STEP 3:** Lock the *EMERGENCY STOP* signal chain (press the *EMERGENCY STOP* switch on the VFD control/feeder cabinet).

**STEP 4:** Check the medium voltage disconnection as follows:

- The status indicators for the *Main contactor* must clearly show the *OFF position* for this switchgear unit:
  - *Main Contactor Closed* = OFF (status indicator is *off*)
  - *Main Contactor Open* = ON (status indicator is *green*)
- Check the measured values for the input voltage in the menu VFD monitor on the operating unit (HMI).

**STEP 5:** Unlock electrically (key switch: *Disconnector Operating Handle Access Shutter Release*) and mechanically the crank access.

**STEP 6:** Insert the crank handle into the crank access and switch off the disconnector/earthing switch.

**STEP 7:** Check the Disconnector/Earthing switch OFF position as follows:

- The status indicators for the *Disconnector/Earthing switch* must clearly show the *OFF position* on this switchgear unit:
  - *Disconnector Closed (Live)* = OFF (status indicator is *off*)
  - *Disconnector Open (Earthed)* = ON (status indicator is *green*)
- Visually inspect the switch position through the viewing window next to the crank access

**STEP 8:** Electrically and mechanically lock the crank access.

**STEP 9:** Switch off the LV circuit breaker in the control/feeder panel to disable power supply for:

- VFD control unit
- I/O interface unit (PLC)

- operating unit (HMI)
- heating
- fans

⇒ VFD *Ready-to-start state* is now disabled.

***END***

### 4.5.2 START PAGE AND STANDBY PAGE

After switching on the VFD, the *VFD Monitor* menu is displayed as the *start page*. If the touchscreen is inactive (not touched) for a settable time, the display switches to the *standby page* (if this was set via parameter). If the standby page is *deactivated*, the display always shows the *last menu page called up*.

#### START PAGE

The *start page* shows the main menu *VFD Monitor*, which displays general information for monitoring the VFD operation. The start page is divided into *six sections*.

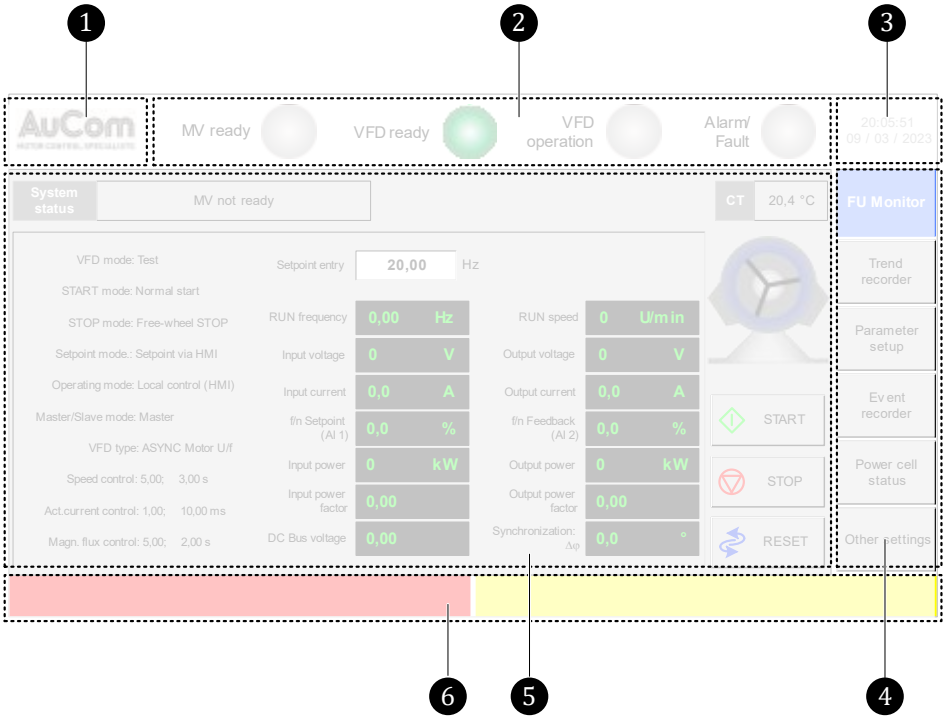



*Fig. 4-13 HMI start page: VFD Monitor menu*

1. Manufacturer's logo
2. Status displays: medium voltage (MV) standby, VFD standby, VFD operating status and alarm/fault status.
3. System date and time
4. Main menu bar (first menu level)
5. VFD operational information
6. Information status bar: Display of alarm/fault messages

***STATUS INDICATIONS***

- ***MV ready* (MV mains supply indication)**:
  The indicator turns *red* when the mains voltage for the VFD is switched on.
- ***VFD ready* (VFD standby indication)**:
  The indicator turns *green* when the VFD system is ready for operation.
- ***VFD Operation* (VFD run indication)**:
  The indicator turns *green* when the VFD is in operation.
- ***Alarm/Fault* (active issue indication)**:
  - the indicator turns *red* when a *fault message* is active
  - the indicator *flashes red* when an *alarm message* is active

***SYSTEM DATE AND TIME*** Displays current date and time

***MAIN MENU*** Buttons to select the various main menus on the first menu level

***VFD OPERATIONAL INFORMATION*** Main display area, including display of main parameter settings, measured values, VFD operating status, VFD start/stop control, etc.

***ALARM/FAULT INDICATOR*** When a fault is active, the *left* array of the information status bar changes to a *red* background and the fault message is displayed.

When an alarm is active, the *right* array of the information status bar changes to a yellow background and the alarm message is displayed.

### STANDBY PAGE

If the touchscreen doesn't detect any activity after a preset time delay, the HMI display defaults to the *standby page*.

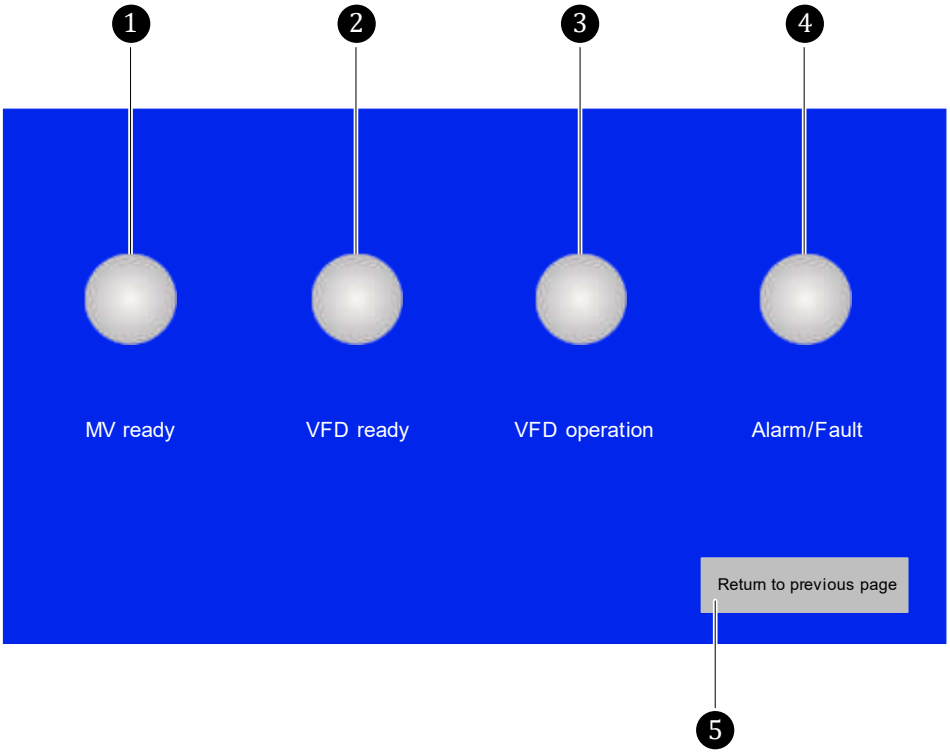



*Fig. 4-14 HMI Display: Standby page (all status indicators switched off)*

1. MV ready status indicator
2. VFD ready status indicator
3. VFD operation status indicator
4. Alarm/Fault status indicator
5. Navigation button to return to the previously accessed menu page

You can set the display for the standby page in the menu *Other settings/User center/**System settings***.

*MV READY*

**Medium voltage (MV) supply status indication**

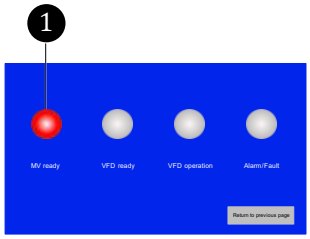



*Fig. 4-15 MV switched on*

- If medium voltage is switched on, the LED is red.
- If medium voltage is switched off, the LED is grey.

*VFD READY*

**VFD Ready-to-start (standby) status indicator**

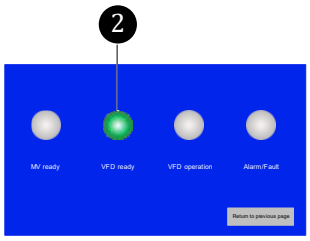



*Fig. 4-16 VFD ready for operation*

- If the VFD is ready for operation, the LED is green.
- If the VFD is not ready for operation, the LED is grey.

*VFD OPERATION*

**Indication of VFD operation status (motor is operated by the VFD)**

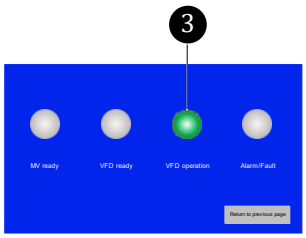



*Fig. 4-17 VFD in operation*

- If the VFD is in operation, the LED is green.
- If the VFD is not in operation, the LED is grey.

*ALARM/FAULT*

**Indication of active disturbance event**

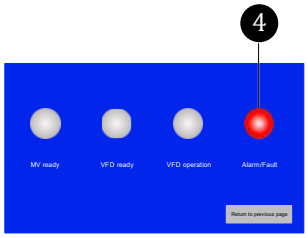



*Fig. 4-18 Active Alarm or Fault*

- At least one Alarm/Fault event is active:
  - If an active *fault* event is present, LED is red.
  - If an active *alarm* event is present, LED flashes red.
- When no active alarm/fault is present, LED is grey.

### 4.5.3 MENU STRUCTURE

The software menu of the VFD control unit is divided into menu levels.

The following figure shows the *menu structure* in the display of the operating unit (HMI).

| Menu level 1 | Menu level 2 | Menu level 3 |
|---|---|---|
| VFD Monitor | | |
| Trend recorder | | |
| Parameter setup | | |
| | Change user level | |
| | | Inverter parameters 1 |
| | | Inverter parameters 2 |
| | | Motor parameters 1 |
| | | Motor parameters 2 |
| | | Function parameters 1 |
| | | Function parameters 2 |
| | | Function parameters 3 |
| Event recorder | | |
| | Settings | |
| Power cell status | | |
| Other settings | | |
| | Other systems | |
| | | Monitoring: Water cooling transformer cabinet |
| | | Monitoring: Water cooling cell cabinet |
| | | Monitoring: Cell bypass units |
| | | Temperature monitoring |
| | Precharge system | |
| | Excitation system<br>Exitation monitor<br>Excitation options<br>Excitation parameters | |
| | Operating hours | |
| | SW versions | |
| | User center | |
| | | System settings |
| | | Change password |
| | | User login |

*Tab. 4-2 Menu structure of the operating unit (HMI)*

### 4.5.4 MENU NAVIGATION

You can operate and set the VFD using the touchscreen. You can:

- enter or exit a main menu or submenu (navigating between menus on the same menu level or different menu levels)
- call up different menu pages within a menu (navigation on the same menu level)

The touchscreen uses virtual buttons, which can be used as:

- *Direct selection keys* or
- *Navigation keys*

***DIRECT SELECTION KEYS***

To navigate between menus and menu levels:

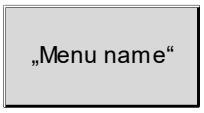



*Fig. 4-19 Menu direct access*

- Press the menu button of your choice to gain direct access to this menu.


*Fig. 4-20 Opened menu*

- Once a menu button is pressed, it highlighted in blue and white text.


*Fig. 4-21 Menu level - Return*

- Returns to previous menu level


*Fig. 4-22 Previous menu page-Return*

- Returns to the previously accessed menu page

*Fig. 4-23 Close menu and return*

- Returns to the next higher menu level by closing a (sub) menu

***NAVIGATION KEYS***

To navigate between menu pages on the same menu level:


*Fig. 4-24 Scrolling menu pages*

- You can scroll through the menu pages. The numbers in the center indicate the current page number/total page number.

### 4.5.5 USER LEVELS

The MVH 2.0 has different user levels (access levels) which differ in the authorisation to operate the VFD and/or to change parameter settings.

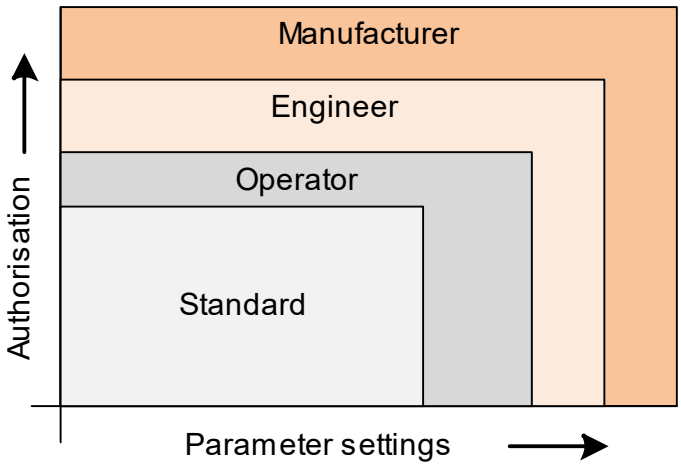



*Fig. 4-25 User levels – Access levels for parameter settings*

After switching on the VFD control system, the user level *Standard* applies:

1. ***Standard***
   For operators performing basic tasks, no password required

The other user levels are password-protected and only allow authorised personnel to make further changes to parameter settings:

2. ***Operator***
   Operators with advanced application skills
3. ***Engineer***
   Commissioning and operating personnel with advanced knowledge of equipment and applications
4. ***Manufacturer***
   AuCom MCS GmbH & Co.KG

**NOTE**

- You can select *Operator* and *Engineer user level* via the touchscreen, then enter the password when prompted.
- If user level *Manufacturer* is required, contact AuCom MCS GmbH & Co.KG.

The following table shows the *access level* required for each menu.

| User level | Menu level 1 | Menu level 2 | Menu level 3 |
|---|---|---|---|
| Standard | VFD Monitor | | |
| Standard, Operator, Engineer | Trend recorder | | |
| Standard | Parameter setup | | |
| Operator, Engineer | | Change user level | |
| Engineer | | | Inverter parameters 1 |
| Engineer | | | Inverter parameters 2 |
| Engineer | | | Motor parameters 1 |
| Engineer | | | Motor parameters 2 |
| Operator, Engineer | | | Function parameters 1 |
| Operator, Engineer | | | Function parameters 2 |
| Operator, Engineer | | | Function parameters 3 |
| Standard | Event recorder | | |
| Standard | Power cell status | | |
| Standard | Other settings | | |
| Standard | | Other systems | |
| Standard | | | Monitoring: Water cooling transformer cabinet |
| Standard | | | Monitoring: Water cooling cell cabinet |
| Standard | | | Monitoring: Cell bypass units |
| Standard | | | Temperature monitoring |
| Standard | | Precharge system | |
| Standard, Operator, Engineer | | Excitation system | |
| Standard | | Excitation monitor | |
| Engineer | | Excitation options | |
| Standard, Operator, Engineer | | Excitation parameters | |
| Standard | | Operating hours | |
| Standard | | SW versions | |
| Standard | | User center | |
| Standard | | | System settings |
| Operator, Engineer | | | Change password |
| Operator, Engineer | | | User Login |

*Tab. 4-3 HMI user levels - Menu access*

## Changing the user level

Depending on the user's access level, a corresponding *password entry* is required to change the user level.

| Username | Authorisation | Password (6 digits) |
|---|---|---|
| *Standard* | very low | none |
| *Operator* | low | 123456 |
| *Engineer* | high | 300048 |
| *Manufacturer* | highest | - |

*Tab. 4-4 User levels - Authorisation*

You can change the user level can be done either via:

- the menu *Other settings/User center/**User Login***, or
- the ***Parameter setup*** main menu.

**NOTE**

If there is no operation of the touchscreen within 10 minutes after activating a password-protected user level, screen defaults back to the *Standard* user level.

The following instructions show the procedure for *changing the user level* via the *User center* menu using the example of the *Engineer* user level.

### INSTRUCTION – Activating the Engineer user level (example)

***START*** ***USER LEVEL: Engineer***

***ENTER "OTHER SETTINGS" MAIN MENU***

**STEP 1:** Tap *Other settings* button.

- Main menu *Other settings* opens.
- At the same time, the *User center* menu opens.

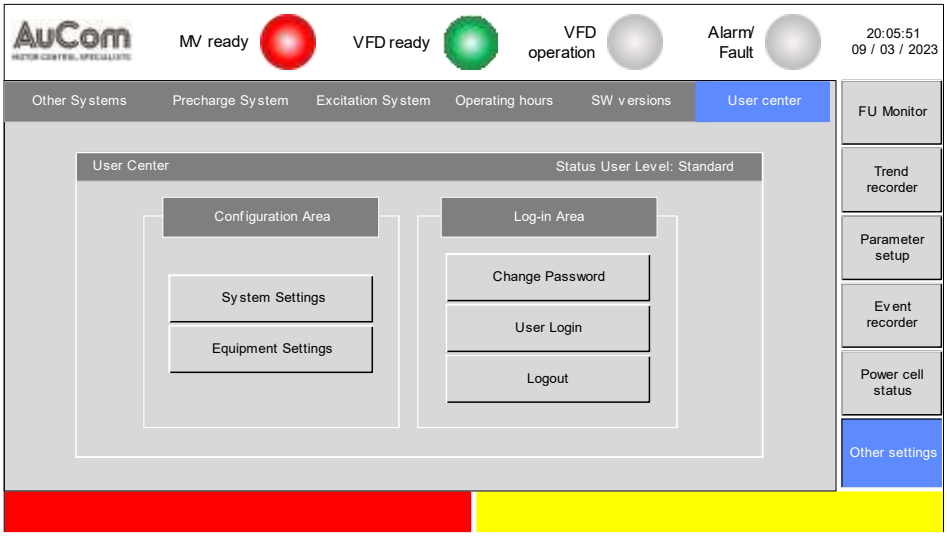



*Fig. 4-26 Menu „User center"*

***ENTER „CHANGE USER LEVEL" SCREEN***

**STEP 2:** Tap the *User Login* button.

- The screen *Change user level* is displayed with the request to enter the currently valid password for the *Engineer* user level.
- The dropdown menu shows *Operator* as the last selected user:

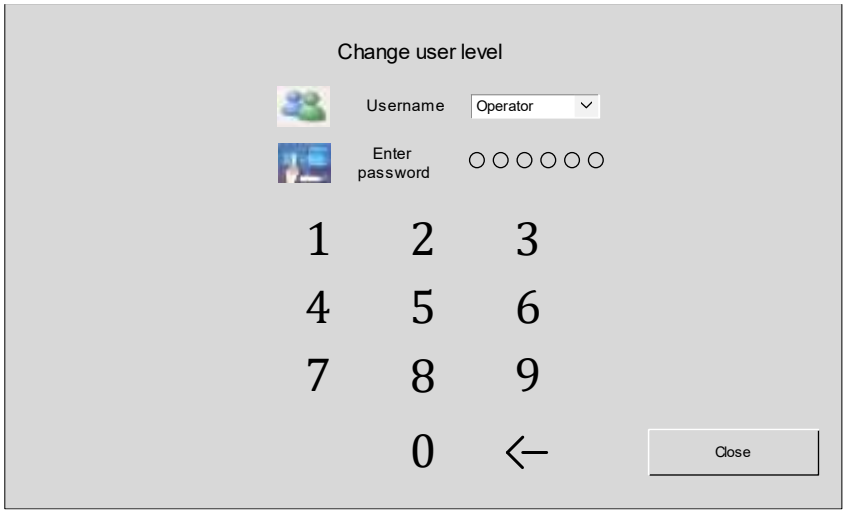



*Fig. 4-27 Password entry screen*

***SELECT USERNAME*** **STEP 3:** Tap to open the dropdown menu.

➢ Open dropdown menu shows the available usernames:

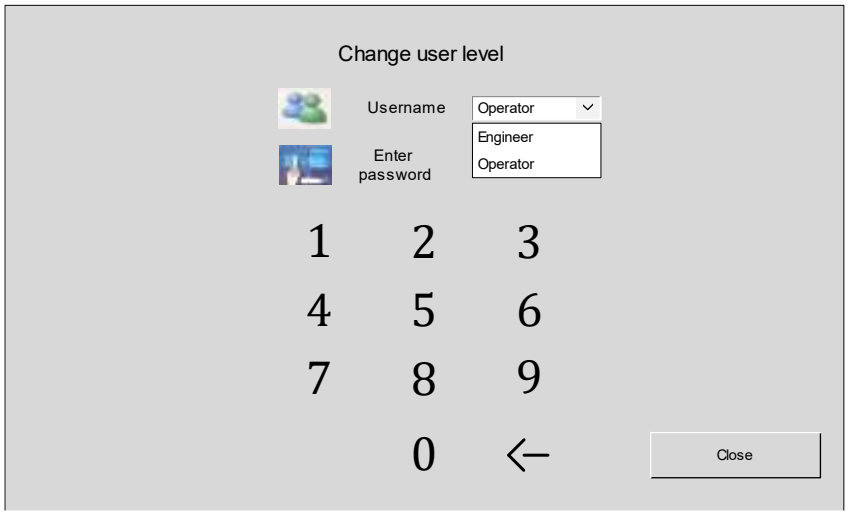



*Fig. 4-28 Username – Open dropdown menu*

***SELECT USERNAME „ENGINEER"*** **STEP 4:** Select *Engineer*.

➢ The dropdown menu shows *Engineer* as the currently selected user:

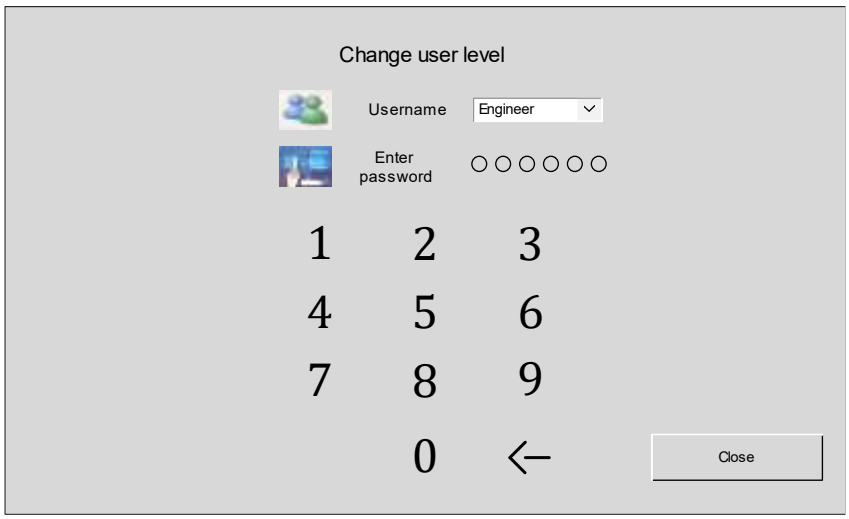



*Fig. 4-29 Selected username: Engineer*

*ENTER PASSWORD*

**STEP 5:** Enter the valid password for the *Engineer* user level using the numeric keypad.

- As you enter each individual digit of the password, the circles above the numeric keypad are highlighted in blue.

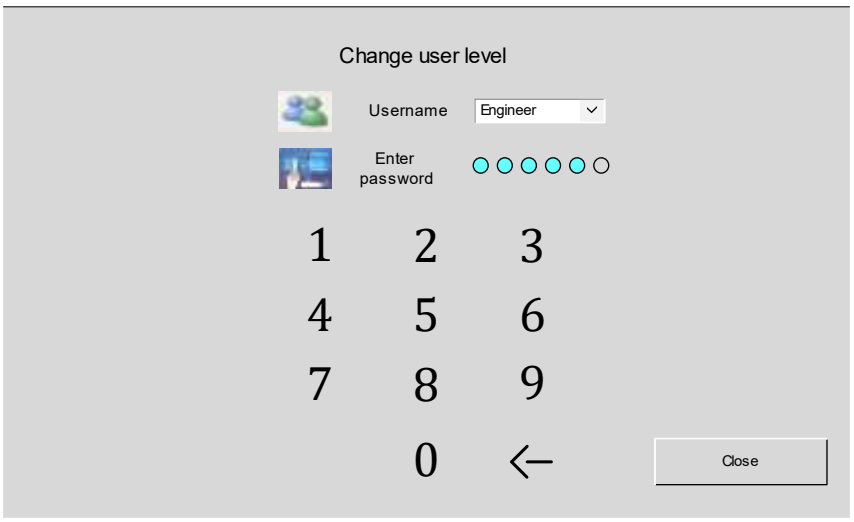



*Fig. 4-30 Entered password digits*

- The *screen* closes automatically when the *last* password digit is entered.
- The *status* of the valid *Engineer* user level is displayed in the *User center* menu.

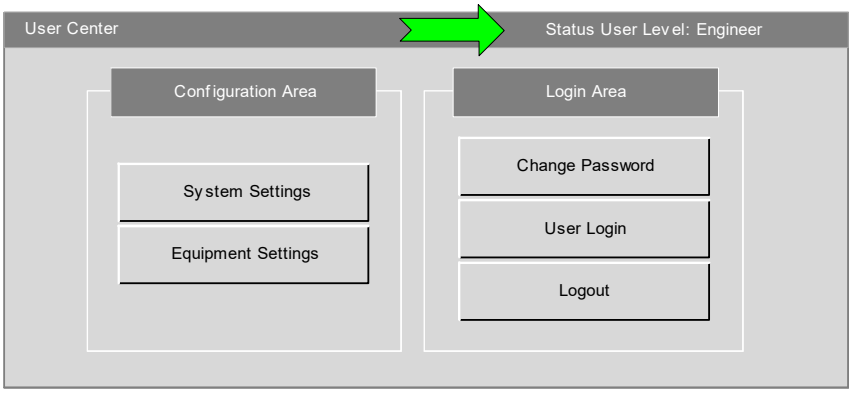



*Fig. 4-31 Status User level: Engineer*

**NOTE**

You can also open the *Change user level* screen directly via the *Parameter setup* main menu.

- After entering the password and closing the screen, the *Inverter parameters 1* menu opens automatically.

*END*

### 4.5.6 CHANGING PARAMETER SETTINGS (GENERAL)

For correct and safe operation of the VFD, the control must be adapted to the general conditions of the various applications. This is done by setting the *parameters* or *parameter groups* on the HMI.

You can set the MVH 2.0 parameters using:

- a dropdown menu (to select an option)
- a (numeric) keypad (to set a value)
- a direct button (to toggle between two settings)

In the following, the *three types* of parameter setting are explained with the help of *example instructions*.

#### PARAMETER SETTING VIA *DROPDOWN MENU* (TO SET AN OPTION)

#### INSTRUCTION (example) – Setting the *Start mode* parameter

***START*** ***USER LEVEL:*** Engineer

**NOTE**

The changed parameter setting is *not yet saved* in the VFD control unit and therefore has no influence on the functions of the VFD!

➢ To *save* the change of a *parameter setting*, all parameters must be downloaded from the HMI to the VFD control unit.

***ENABLE „ENGINEER" USER LEVEL***

**CHAPTER REFERENCE**

➢ To activate the *Engineer* user level, follow the instructions in chapter „4.5.5 User Levels".

**STEP 1:** To activate the *Engineer* user level, follow the steps described in chapter „4.5.5 User Levels".

***ENTER "PARAMETERS" MAIN MENU***

**STEP 2:** Tap *Parameter setup* main menu button.

➢ The display shows the *START mode* parameter with its current setting *Normal start* on the first of the seven menu pages:

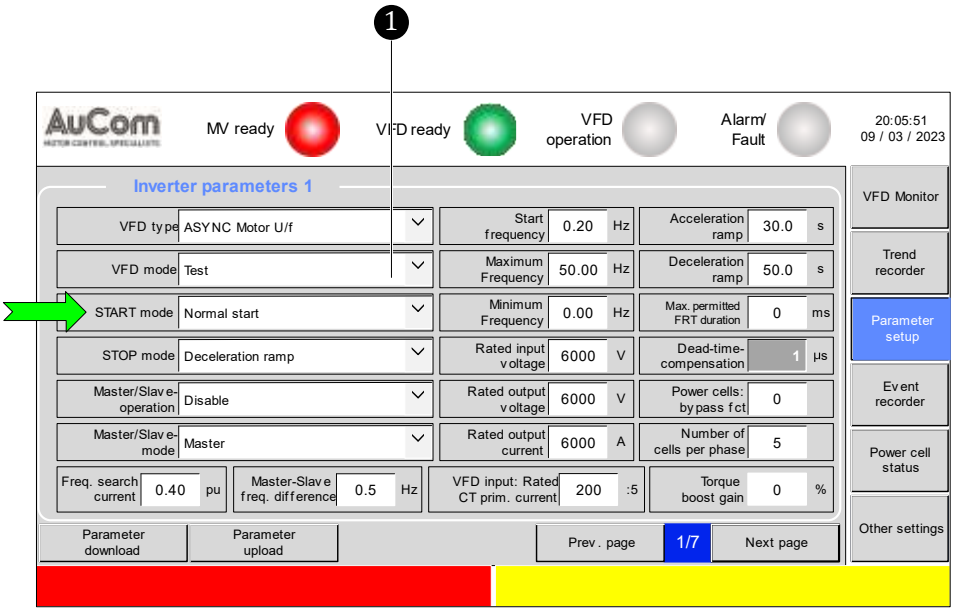



*Fig. 4-32 Inverter parameters 1 – Parameter „START mode"*

1 Dropdown menu for setting the options for the START mode parameter

***ENTER DROPDOWN MENU FOR „START MODE" PARAMETER***

**STEP 3:** Tap to the dropdown menu.

➢ The dropdown menu shows its setting options.

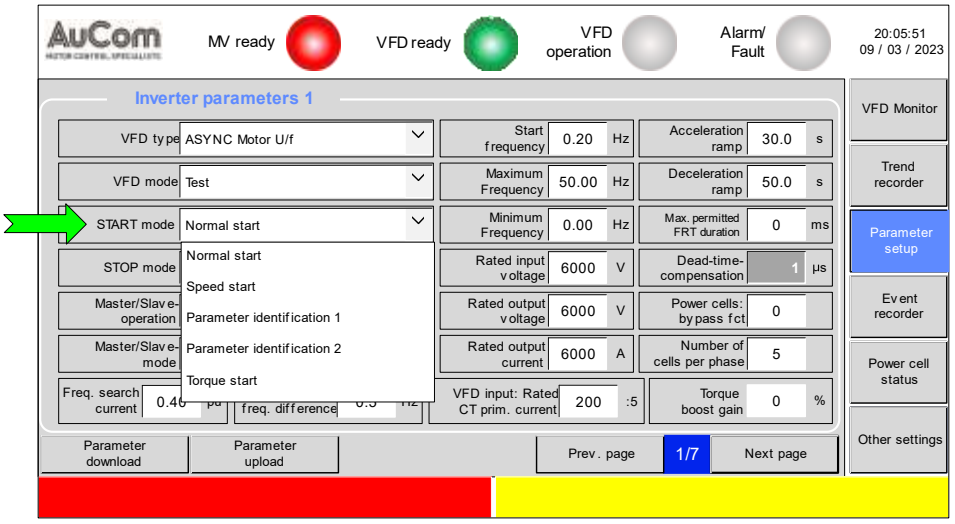



*Fig. 4-33 Dropdown list*

***SELECT SETTING OPTION***

**STEP 4:** Select an option, e.g., *Speed start.*

➢ The dropdown menu now shows *Speed start* as the currently selected setting option:

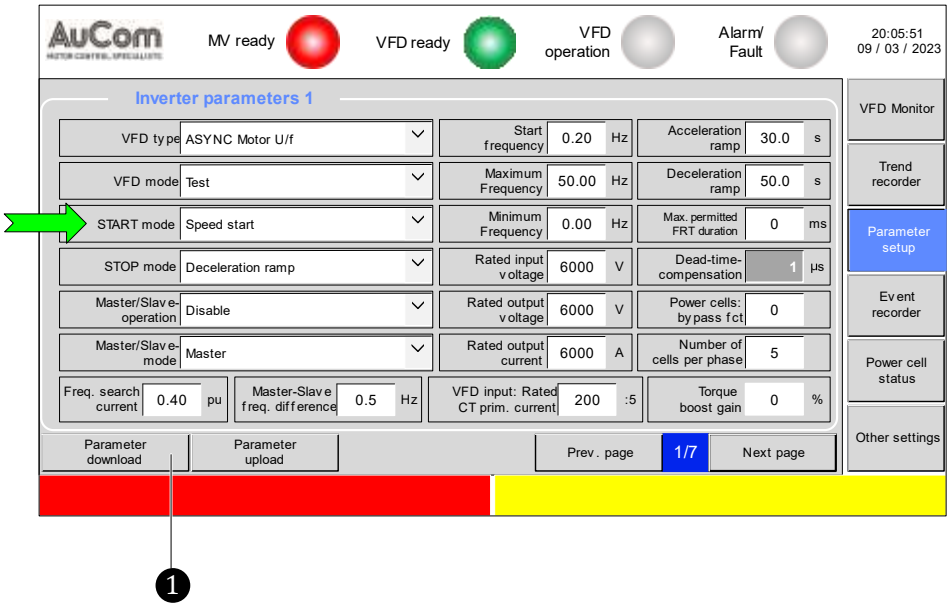



*Fig. 4-34 Selected setting option: Speed start*

1 Button for saving the parameter settings

***SAVE CHANGES*** **STEP 5:** Tap Parameter download button.

➢ If the storage is *successful*, the following message appears in the display for approx. 1.5 s:


*Fig. 4-35 Parameter changes saved successfully*

***EXIT „ENGINEER" USER LEVEL*** **STEP 6:** Tap *Logout* button in the *User center* menu.

➢ The *Standard* user level is active again.

***END***

## PARAMETER SETTING VIA (NUMERIC) KEYPAD (TO SET A VALUE)

### INSTRUCTION (example) – Setting the *System date* and *time*

**START** *USER LEVEL:* Standard

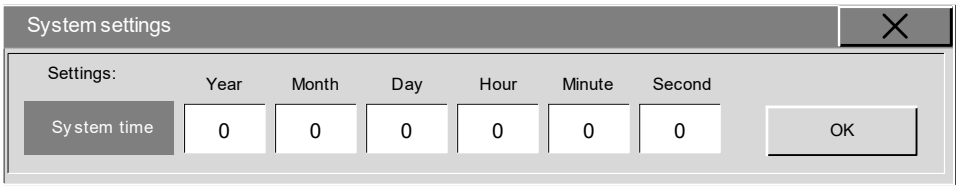



*Fig. 4-36 System time parameter group*

***SELECT „YEAR" PARAMETER***

**STEP 1:** Tap the white field next to the parameter *Year* to set the current year.


*Fig. 4-37 Numeric keypad*

- A numeric keypad for parameter setting is displayed.
- The *setting range* indicates the minimum and maximum value, respectively *Min: 2000* and *Max: 2050* as shown on the second line of the numeric keypad.

***SET THE YEAR***

**STEP 2:** Tap the corresponding digits for the desired year, one digit at a time, on the numeric keypad.


*Fig. 4-38 Numeric keypad: set the year*

- The year entered appears in the white field above the keypad.

***CONFIRM THE "YEAR" ENTERED***

**STEP 3:** Tap OK on the numeric keypad.

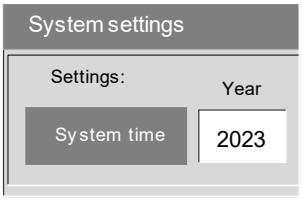



*Fig. 4-39 Field „Year"*

- The updated year appears in the field *Year*.

***ENTERING THE OTHER "SYSTEM SETTINGS" PARAMETERS***

**STEP 4:** Set the *Month*, *Day*, *Hour*, *Minute* and *Second* in the same way as you set the Year.

- Updated *dates* and time appear in the white fields of the *System time*:

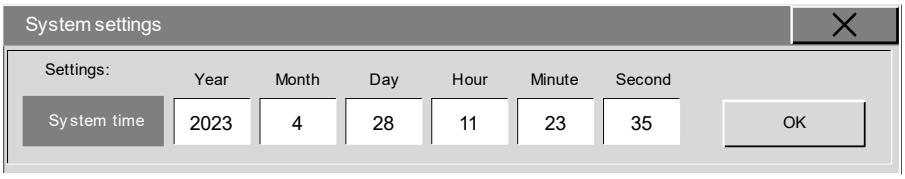



*Fig. 4-40 System time –Settings completed*

***SAVING PARAMETER SETTINGS***

**STEP 5:** Tap OK in the *System settings* menu.

➢ The *updated system* time appears in the *upper right corner* of the HMI display.

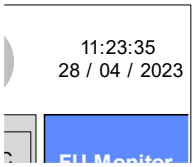



*Fig. 4-41 Updated "System time"*

***END***

## PARAMETER SETTING VIA DIRECT BUTTON (TO TOGGLE BETWEEN TWO SETTINGS)

### INSTRUCTION (example) – Enable/Disable *Standby page*

***START*** ***USER LEVEL:*** **Standard**

***ENTER "SYSTEM SETTINGS" MENU***

**STEP 1:** Tap the *System settings* button in the *User center* menu.

➢ The grey *enable* button indicates that the *Standby page* is *deactivated.*

➢ The field to the *left* of the *enable* button represents the *Standby page.*

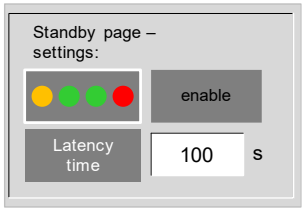



*Fig. 4-42 Standby page – current settings*

***ENABLE "STANDBY PAGE"***

**STEP 2:** Tap the *enable* button

➢ The green *disable* button indicates that the *Standby page* is *activated.*

➢ The parameter *Latency time* defines the time after which the display will automatically show the *Standby page*. The counter for the *Latency time* starts immediately after the last touch of the touchscreen. The setting range for the *Latency time* is 120 ... 1600 s.

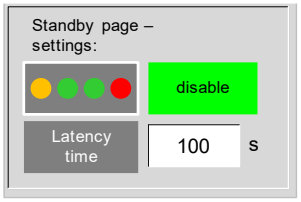



*Fig. 4-43 Standby page enabled*

**CHAPTER REFERENCE**

➢ To change the *Latency time* refer to the example instructions in chapter „4.5.6 Changing Parameter Settings (General)".

### *DISABLE "STANDBY PAGE"*

**STEP 3:** Tap the *disable* button

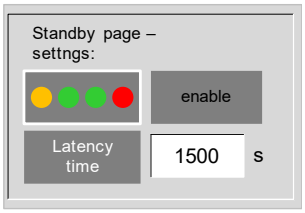



*Fig. 4-44 Standby page disabled*

➢ The grey *enable* button indicates that the *Standby page* is *deactivated* again (and can be *activated* by taping on it).

***END***

## 4.5.7 SELECTING THE MENU LANGUAGE

You can display the HMI menu in the following languages:

- German
- English
- Russian
- French
- Spanish
- Chinese

Changing the menu language does *not* require a password and can be done during VFD operation. To change the menu language, navigate to *Other settings*|*User center*|***System settings*** and select the language of your choice from the dropdown menu.

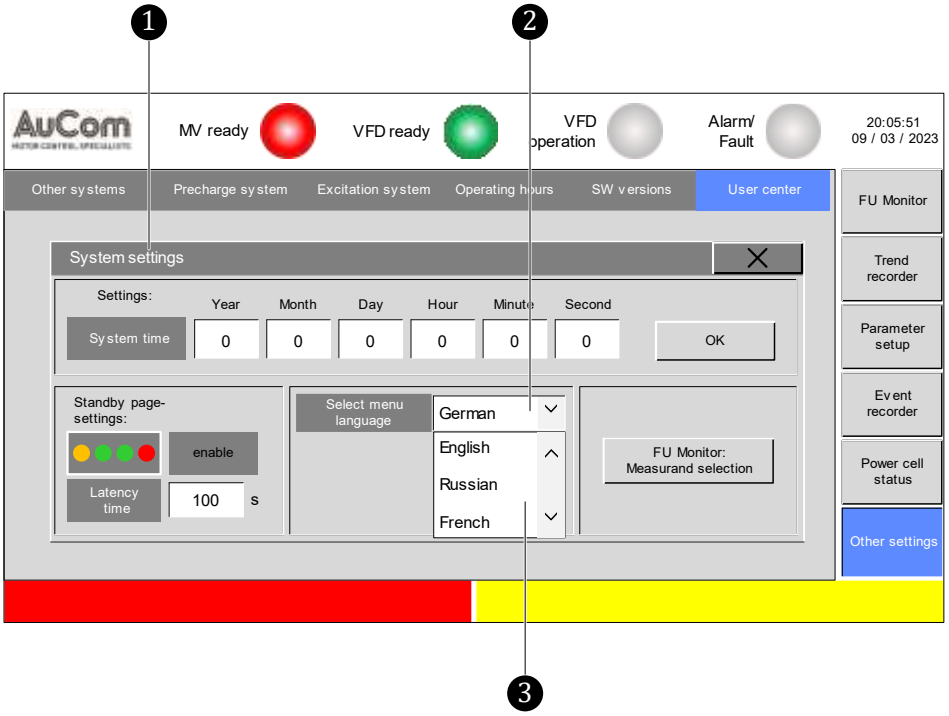



*Fig. 4-45 „System settings" menu – Selection of HMI menu language*

1. *System settings* menu
2. Selected menu language
3. Dropdown menu for available menu languages

As soon as you select the desired language from the list, all menu texts are displayed in this language.

**NOTE**

Setting the menu language only affects the HMI display. You don't need to save this setting in the VFD control unit.

## 4.6 MAIN MENU (HMI)

### 4.6.1 MAIN MENU: VFD MONITOR

The start page of the HMI displays the *VFD Monitor* menu. This menu shows the system status, the most important parameter settings, and the current operating measured values of the VFD as well as the buttons for operating the VFD.

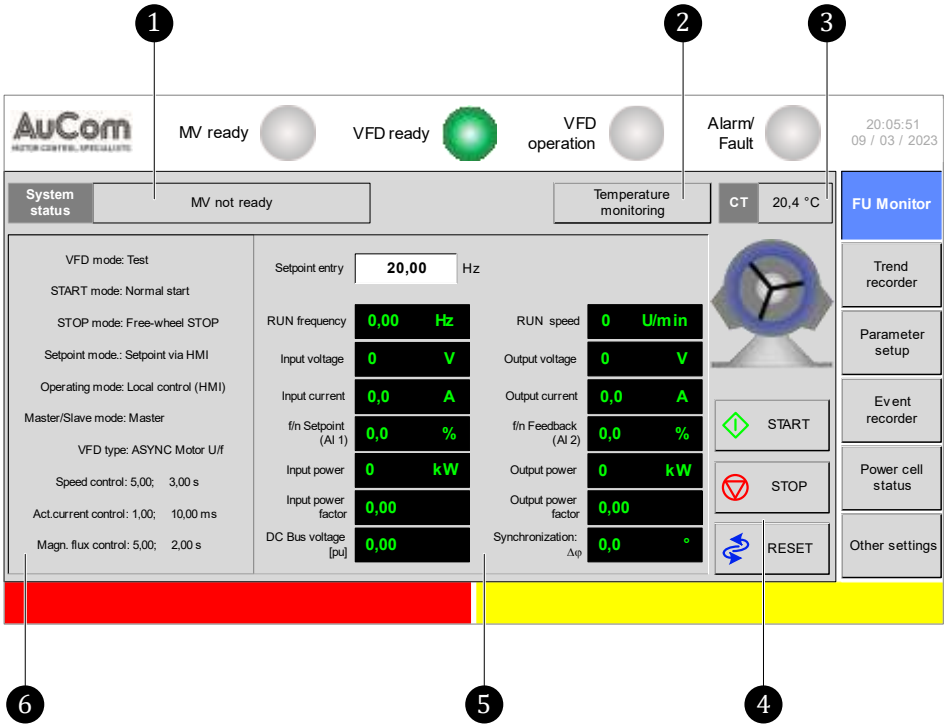



*Fig. 4-46 Main menu – VFD Monitor*

1. VFD system status messages
2. Button for calling up menus, e.g., *Temperature monitoring*
3. Display of temperature in power cell cabinet
4. Manual operation: START/STOP control; RESET of fault messages
5. Manual input of the *start frequency* and display of the *operating measured values*
6. VFD main parameter settings

***SYSTEM STATUS: MESSAGES***

The information area System status shows the current message about the status of the VFD system.

***OPTIONAL SHORTCUT BUTTONS***

If set via parameter or programmed, further menus can be called up directly from the start page of the VFD monitor. A corresponding button appears in the *VFD Monitor*.

***BUTTON "TEMPERATURE MONITORING"***

The *Temperature monitoring* button only appears with the parameter setting *FU Monitor: Shortcut button = Yes* in the *Temperature monitoring/**Settings*** menu.

Tap the *Temperature monitoring* button to open the *Temperature monitoring* menu. The current readings of the existing temperature sensors are displayed on the *Measured values* menu page.

### MANUAL VFD OPERATION

For the *Operating mode = Local control (HMI)*, you can start and stop the motor manually via the touchscreen. The START and STOP buttons are available for both *VFD mode = Operation* and *VFD mode = Test*.

You can be reset alarm/fault messages manually using the *RESET* button. For a successful reset, you must first resolve the cause of the issue.

### SETPOINT ENTRY

To enter the *frequency* at which the motor is to be operated, tap the field next to *Setpoint entry*, then enter the value via the numeric keypad.

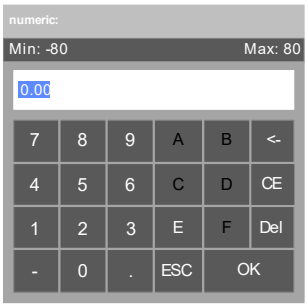



*Fig. 4-47 Numeric keypad – frequency setpoint entry*

- A setting range of 0 ... 80 Hz applies to the *forward* running of the motor.
- A setting range of 0 ... -80 Hz applies to the *reverse* running of the motor.

Tap OK to confirm. The numeric keypad closes automatically and the new setpoint frequency is approached with the set ramps.

**NOTE**

If the *set frequency* is *0 Hz*, the motor will *not* start!

### MEASURED OPERATING VALUES

During VFD operation, the *VFD Monitor* displays the following *momentary* operating values:

| Measured variable | Description |
|---|---|
| RUN frequency [Hz] | Motor operating frequency |
| RUN speed [rpm] | Motor speed |
| Input voltage [V] | Voltage at VFD input (MV) |
| Output voltage [V] | Voltage at VFD output (MV) |
| Input current [A] | Current in the VFD input (MV)<br>(Current transformers to the star point of the primary side of the multi-level transformer) |
| Output current [A] | Current in the VFD output (MV) |
| f/n Setpoint (AI 1) [%] | f/n setpoint via the *Analog input AI 1* |
| f/n Feedback (AI 2) [%] | f/n feedback via the *Analog input AI 2* |
| Input power [kW] | Active power at VFD input (MV) |
| Output power [kW] | Active power at VFD output (MV) |
| Input power factor | Power factor at VFD input (MV) |
| Output power factor | Power factor at VFD output (MV) |
| DC bus voltage [pu] | • DC bus voltage of the power cells per phase (A1, B1, C1) referred to the rated value of the DC bus voltage of the power cells:<br>$U_{DC}[pu] = [(U_{DC,A1} + U_{DC,B1} + U_{DC,C1}) / 3] / U_{DC,rated}$<br>• Measured value display in the per-unit system |
| Synchronisation: $\Delta\varphi$ | Phase angle difference between the phase voltages at the VFD input and VFD output.<br>Display of the measured value only during the synchronisation process |

*Tab. 4-5 VFD Monitor: measured operating values*

### DISPLAY OF THE MAIN VFD PARAMETER SETTINGS

The settings of the following parameters provide an overview of the most important system settings of the VFD:

| Parameter name | Description |
|---|---|
| *VFD mode* | VFD working mode: *Operation* or *Test* |
| *START mode* | Motor start-up mode |
| *STOP mode* | Motor stop mode |
| *Setpoint mode* | Source for setting the frequency setpoint |
| *Operating mode* | Mode for operating the VFD |
| *Master/Slave mode* | (Master or Slave) function of the VFD in double or multi-frequency inverter operation |
| *VFD type* | VFD control method for the corresponding motor type |
| *Speed control* | PI-controller: Proportional gain factor and integration time [s] |
| *Act.current control* | PI-controller: Proportional gain factor and integration time [ms] |
| *Magn. flux control* | PI-controller: Proportional gain factor and integration time [s] |

*Tab. 4-6 VFD Monitor: overview of the main VFD parameter settings*

**CHAPTER REFERENCE**

- Chapter „4.6.3 Main Menu: Parameter Setup" describes the above *parameters* and their *setting options* in detail.

## 4.6.2 MAIN MENU: TREND RECORDER

Trend curves show the development of measured variables of the VFD over time. The trend curves are displayed as:

- real-time curve, or
- curve history.

The *rms values* are given for the measured variables *output current* and *output voltage*.

### REAL-TIME CURVE

If you tap the *Refresh* button, the display shows the curves of the VFD measured variables operating frequency, output current and output voltage in real time. The measured values are sampled cyclically (100 ms) and the curves are updated.

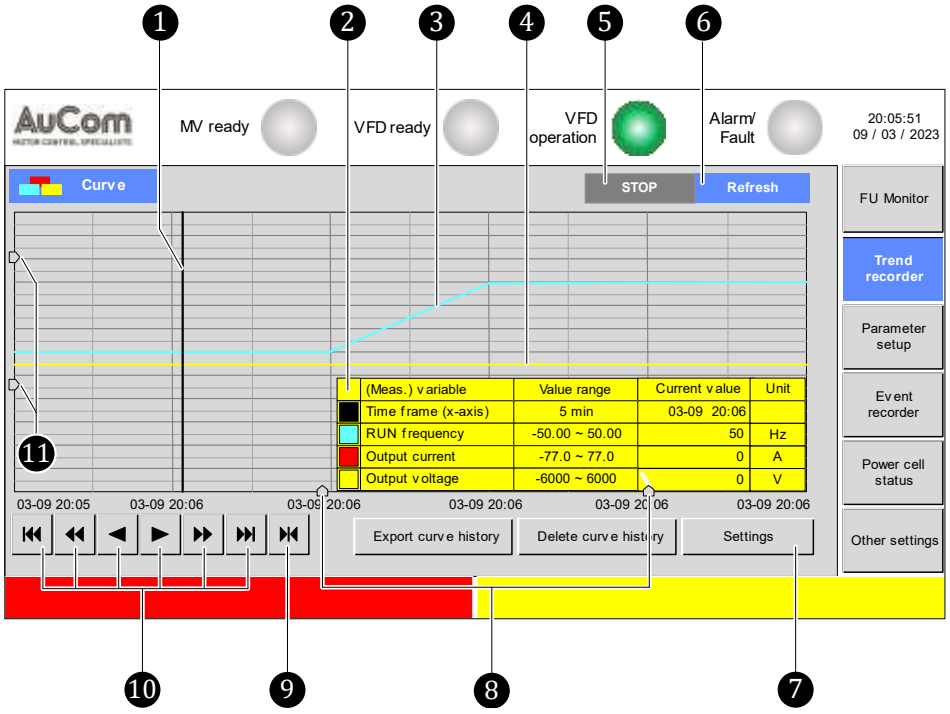



*Fig. 4-48 Main menu – Trend recorder: real-time curves*

1. Sliding marker for snapshot display of measured values
2. Information window representing the recorded measured values
3. Trend curve: motor frequency
4. Trend curve: VFD output voltage
5. STOP button to stop the time progression
6. *Refresh* button to continue the time history
7. Access to parameter menu to set the trend curve display
8. Sliders for zoom along X-axis
9. Parameterisation mask to define the dynamic, real-time display range (x-axis)
10. Buttons for fast-forwarding and rewinding the data recording (x-axis)
11. Sliders for zoom along Y-axis

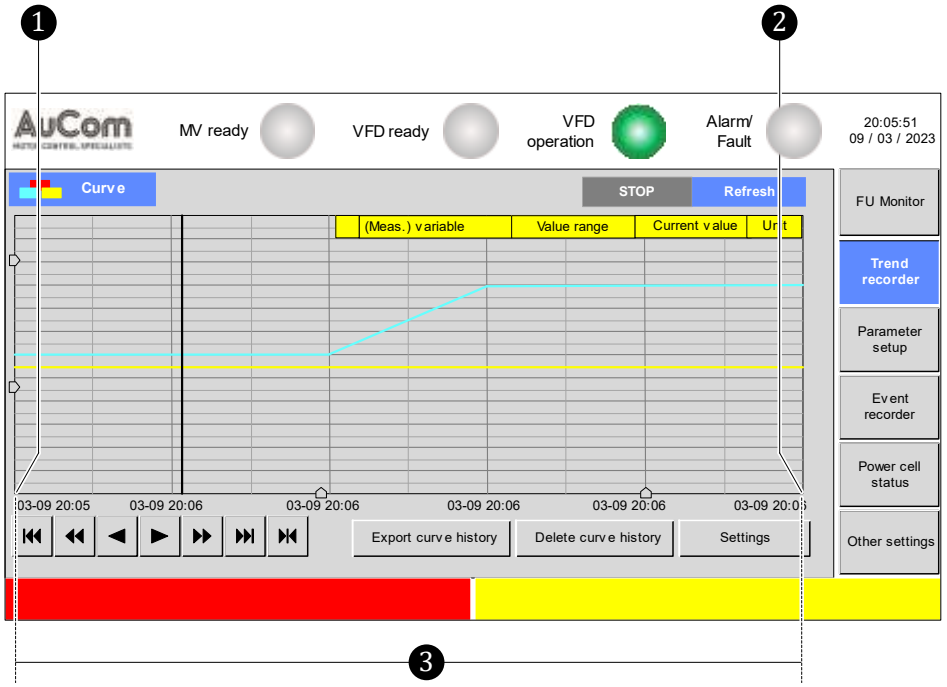



*Fig. 4-49 Scaling of the displayed time frame (x-axis)*

1. Start time of the displayed time frame
2. End time of the displayed time frame
3. Time frame for displaying the trend curves

***SLIDING MARKER AND INFORMATION WINDOW***

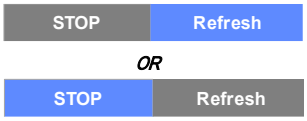
When you tap on the diagram area, a vertical black line appears as a sliding marker on the time axis (x-axis). At the same time the information window opens, providing the following information:

- scaling of the time axis (*Value range*),
- time selected with the slide marker (*Current value*),
- scaling of the measuring ranges (*Value range*), and
- measured values (*Current value*) valid for the selected time for the *RUN frequency* (frequency at the VFD output), the *Output current* and the *Output voltage* of the VFD.

***TREND CURVES***

In the diagram area, the time curves of the measured variables at the VFD output are displayed as *trend curves*.

***BUTTONS***




When you tap on the corresponding button, the display of the real-time curves can be *paused* or *continued*. The active button has a blue background.

- Activating the *Refresh* button:
  The trend curves displayed are *real-time curves* and run from left to right as time progresses. The current time is at the right end of the time axis. In this display, for example, the current trend curves can be observed in real time during the various operating phases.
- Activating the STOP button
  The dynamic real-time trend curves are stopped. The trend curves on the diagram area are "frozen" and thus represent a *curve history*. With the slider, you can now read the individual measured values at any time of the trend curves (snapshot).

***BUTTON***


Tap on the *Settings* button to open the *Settings* menu. This menu is divided into three sections:

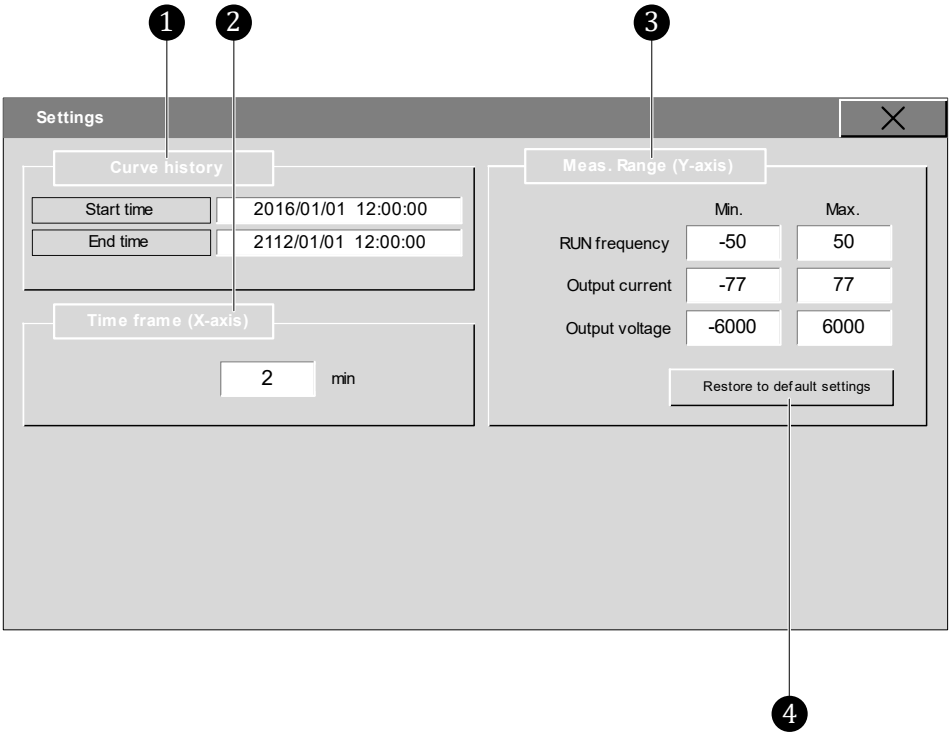



*Fig. 4-50 Trend recorder – „Settings" menu*

1. *Settings* menu: setting the start and end time for recording the curve history
2. *X-axis settings*: scaling of the displayed time frame
3. *Y-axis settings*: scaling of the displayed trend curves
4. Button for resetting the min./max. parameters to the factory settings

***PARAMETER OVERVIEW***

| Parameter name | Setting value (Default setting) | Unit | Setting range |
|---|---|---|---|
| Curve history | | | |
| Start time | 2016/01/01 12:00:00 | yyyy/mm/dd hh/mm/ss | |
| End time | 2112/01/01 12:00:00 | yyyy/mm/dd hh/mm/ss | |
| Displayed time frame (X-axis) | | | |
| Time frame | 1 | min | 1 ... 1e+10 min |
| Displayed measuring ranges (Y-axis) | | | |
| RUN frequency | | | |
| Min. | -50/(-60)* | Hz | -1e+10 ... 50/(60)* |
| Max. | 50/(60)* | Hz | -50/(60)* ... 1e+10 |
| Output current | | | |
| Min. | -100 | A | -1e+10 ... 100 |
| Max. | 100 | A | -100 ... 1e+10 |
| Output voltage | | | |
| Min. | -6000 | V | -1e+10 ... 6000 |
| Max. | 6000 | V | -6000 ... 1e+10 |

*depends on MV mains frequency (see parameter *Maximum frequency*)

*Tab. 4-7 Trend recorder - Parameter overview*

## Parameter description

### „SETTINGS" MENU

| Parameter: | Start time |
|---|---|

This parameter defines the *start time* of the *data recording* for the function *Export curve history*.

**Setting via keypad**

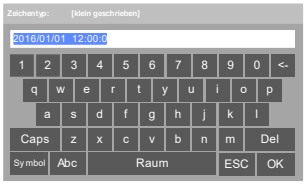



*Fig. 4-51 Keypad – "Start time"*

**CHAPTER REFERENCE**

➢ For parameter setting, see chapter „4.5.6 Changing Parameter Settings (General)".

| Parameter: | End time |
|---|---|

This parameter defines the *end time* of the *data recording* for the function *Export curve history*.

**Setting via keypad**

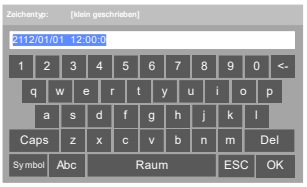



*Fig. 4-52 Keypad – "End time"*

**CHAPTER REFERENCE**

➢ For parameter setting, see chapter „4.5.6 Changing Parameter Settings (General)".

### DISPLAYED TIME FRAME (X-AXIS)

| Parameter: | Time frame |
|---|---|

This parameter defines the *length* of the *display range* [min] for the trend curves on the time axis.

**Setting via numeric keypad**


*Fig. 4-53 Numeric keypad – "Time frame"*

**CHAPTER REFERENCE**

➢ For parameter setting, see chapter „4.5.6 Changing Parameter Settings (General)".

**NOTE**

| | |
|---|---|
| 1e+10 | (e-notation) |
| = $10^{10}$ | (potency notation) |
| = 10 000 000 000 | (decimal notation) |

### DISPLAYED MEASURING RANGES (Y-AXIS)

| Parameter: | (RUN frequency:) Min. (and) Max. |
|---|---|

The *Min.* and *Max.* parameters each define the *range* for the *displayed value scale* on the Y-axis for:

- the RUN frequency,

- the output current, and
- the output voltage


*Fig. 4-54 Numeric keypad - RUN frequency „Min."*

### Settings via numeric keypad

**CHAPTER REFERENCE**

➢ For parameter setting, see chapter „4.5.6 Changing Parameter Settings (General)".

**NOTE**

| | |
|---|---|
| -1e+10 | (e-notation) |
| = $-10^{10}$ | (potency notation) |
| = -10 000 000 000 | (decimal notation) |


*Fig. 4-55 Numeric keypad - RUN frequency „Max."*

**Parameter:** **(Output current:) Min. (and) Max.**

The *Min.* and *Max.* parameters define the *range* for the *displayed value scale* of the VFD output current on the Y-axis.

### Settings via numeric keypad

**CHAPTER REFERENCE**

➢ For parameter setting, see chapter „4.5.6 Changing Parameter Settings (General)".


*Fig. 4-56 Numeric keypad – Output current „Min."*


*Fig. 4-57 Numeric keypad – Output current „Max."*

| Parameter: | (Output voltage:) Min. (and) Max. |
|---|---|

The *Min.* and *Max.* parameters define the *range* for the *displayed value scale* of the VFD output voltage on the Y-axis.

### Settings via numeric keypad

**CHAPTER REFERENCE**

➢ For parameter setting, see chapter „4.5.6 Changing Parameter Settings (General)".


*Fig. 4-58 Numeric keypad – Output voltage „Min."*


*Fig. 4-59 Numeric keypad – Output voltage „Min."*

***BUTTON***

Tap this button to open the parameter menu *Set time range* to set the *start* of the *display range* on the time axis (X-axis). *Three different configuration modes* are available for this purpose:

- *Recent time*
- *Fixed time*
- *Given time*

The following parameters each define the *time* from which the trend curves are *to be displayed.*

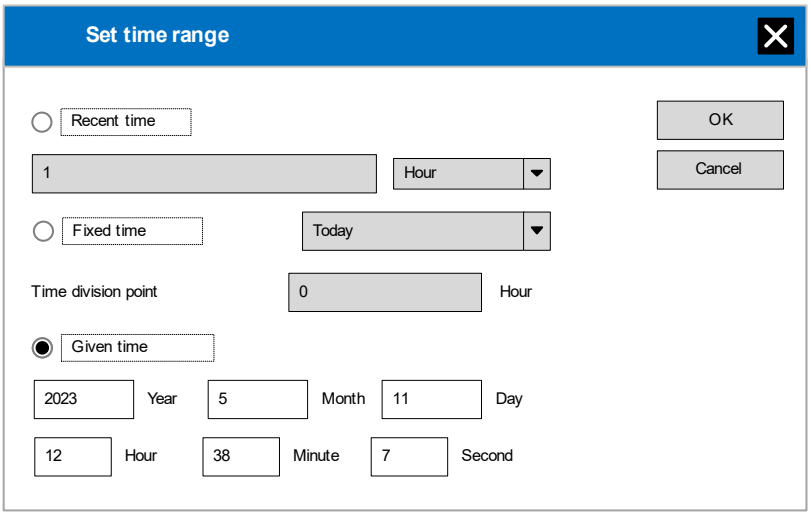



*Fig. 4-60 Trend recorder – Start time configuration of the displayed time frame*

◉: enabled
○: disabled

*PARAMETER OVERVIEW*

| Parameter name | Setting value (Default setting) | Setting range or setting options |
|---|---|---|
| Recent time | ○ | ○ / ◉ |
| (Numerical value) | 10 | 0 ... 596523 [Unit] |
| (Unit-dropdown menu) | Hour | Second / Minute / Hour / Day / Month / Year |
| Fixed time | ○ | ○ / ◉ |
| (Dropdown menu) | Today | Today / This month / Yesterday / Last month |
| Time division point | 0 | 0 ... 23 (Hour) |
| Given time | ◉ | ○ / ◉ |
| Year | (Current year) | 1970 ... 2036 |
| Month | (Current month) | 1 ... 12 |
| Day | (Current day) | 1 ... 31 |
| Hour | (Current hour) | 0 ... 23 |
| Minute | (Current minute) | 0 ... 59 |
| Second | (Current second) | 0 ... 59 |

*Tab. 4-8 Start time configuration of the displayed time frame - Parameter overview*

*BUTTONS*

You can use these following buttons to shift the displayed trend curves on the time axis to the left or right by a defined period.

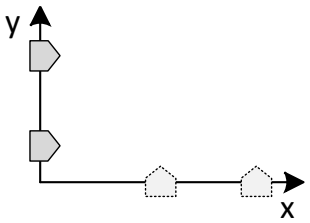
The arrows indicate the shift direction and range displayed.

| Symbol | Shift direction | Amount of time segment per tap |
|---|---|---|
| ⏮ | to the left | The full is set displayed |
| ◀◀ | to the left | Half of the set is displayed |
| ◀ | to the left | One fifth of the set is displayed |
| ▶ | to the right | One fifth of the set is displayed |
| ▶▶ | to the right | Half of the set is displayed |
| ⏭ | to the right | The full set is displayed |

*Tab. 4-9 Buttons to shift the trend curves*

### *SLIDERS FOR ZOOM*

The resolution of the displayed trend curves can be scaled in relation to the effective values (Y-axis) and the displayed time window (X-axis). (Zoom).




*Scaling of the rms values (Y-axis)*
When moving the sliders on the Y-axis, the scaling of the time axis (X-axis) is always maintained.

- *Moving the upper slider down*

  The minimum value (zero line) and the maximum value of the trend curves shift *upwards*. The amount of the shift of the maximum values of the trend curves is *greater* than that of the minimum values.

- *Moving the upper slider up*

  The minimum value (zero line) and the maximum value of the trend curves shift *downwards*. The amount of the shift of the maximum values of the trend curves is *greater* than that of the minimum values.

- *Moving the lower slider up*

  The minimum value (zero line) and the maximum value of the trend curves shift *upwards*. The amount of the shift of the maximum values of the trend curves is *less* than that of the minimum values.

- *Moving the lower slider down*

  The minimum value (zero line) and the maximum value of the trend curves shift *downwards*. The amount of the shift of the maximum values of the trend curves is *less* than that of the minimum values.

The following figure illustrates the *scaling* of the *rms values* for the following *cases*:

- *Moving the upper slider down*, and
- *Moving the lower slider up*

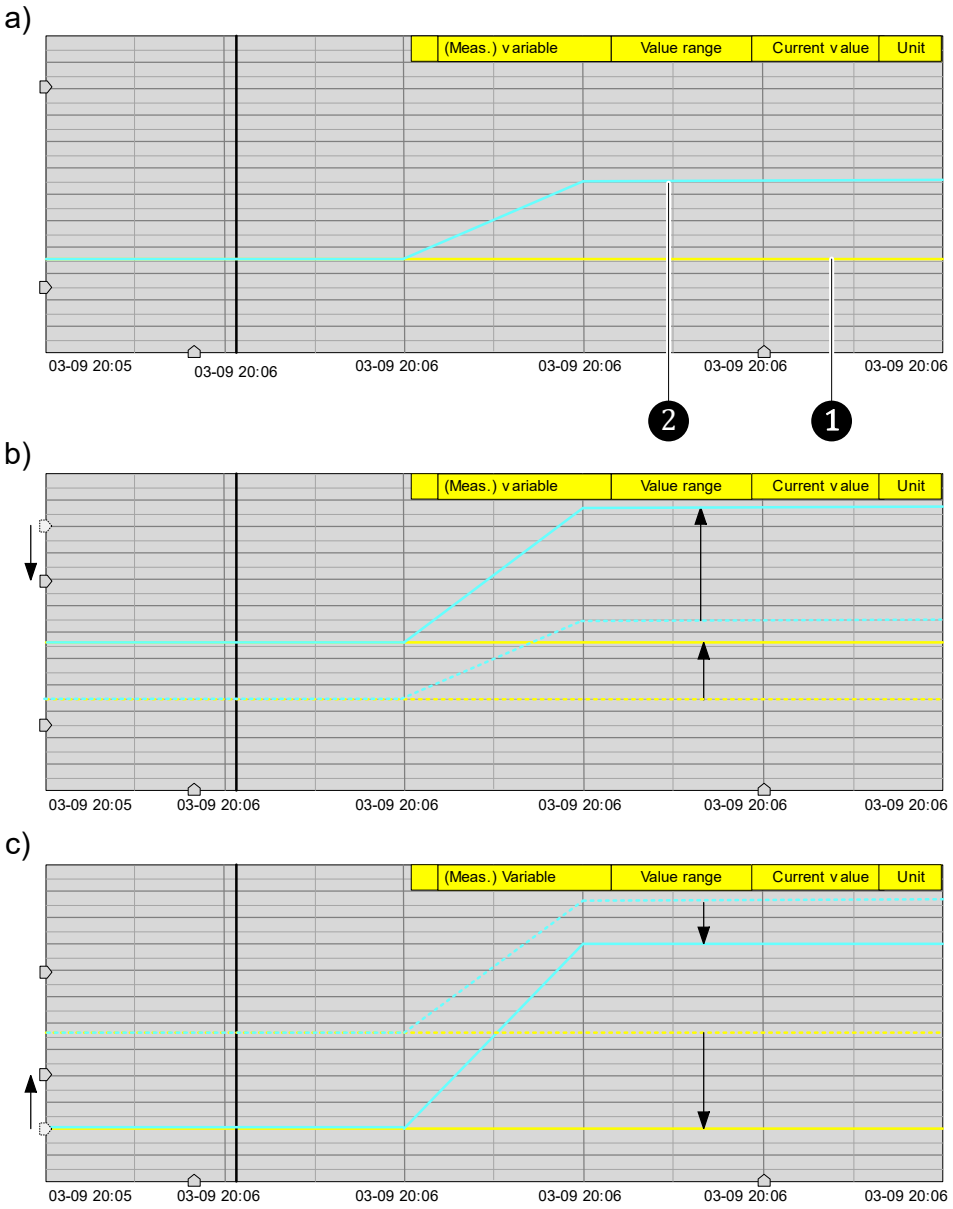
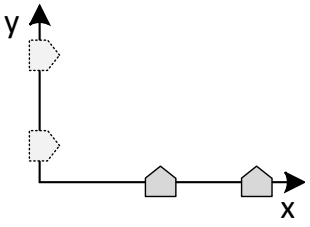



*Fig. 4-61 Zooming on the rms values (Y-axis)*
*a) Initial position of the sliders*
*b) Upper slider moving downwards*
*c) Lower slider moving upwards*

1. Minimum value of a trend curve (zero line)
2. Maximum value of a trend curve




*Scaling the time axis (X-axis)*

When moving the sliders on the X-axis, the scaling of the time rms values is always maintained.

- *Moving the left slider to the left*

  If you move the slider at max. shift (1/5 of the total time frame) to the *left*, it will increase the time frame by 24 seconds.

- *Moving the right slider to the right*

  If you move the slider at max. shift (1/5 of the total time frame) to the *right*, it will increase the time frame by 24 seconds.

- *Moving the left slider to the right*

If you move the slider at max. shift (1/5 of the total time frame) to the *right*, it will *decrease* the time frame by 24 seconds.

- *Moving the right slider to the left*

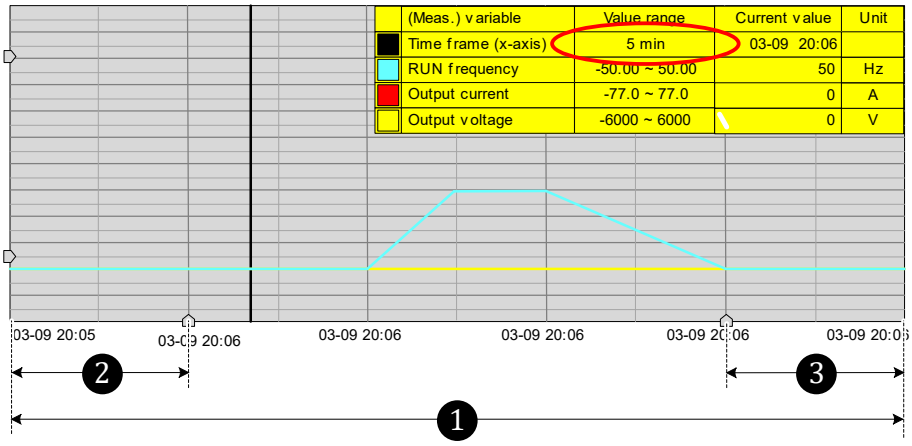
  If you move the slider at max. shift (1/5 of the total time frame) to the *left*, it will *increase* the time frame by 24 seconds.

The following figure illustrates the *scaling* of the *rms values* for the following cases:

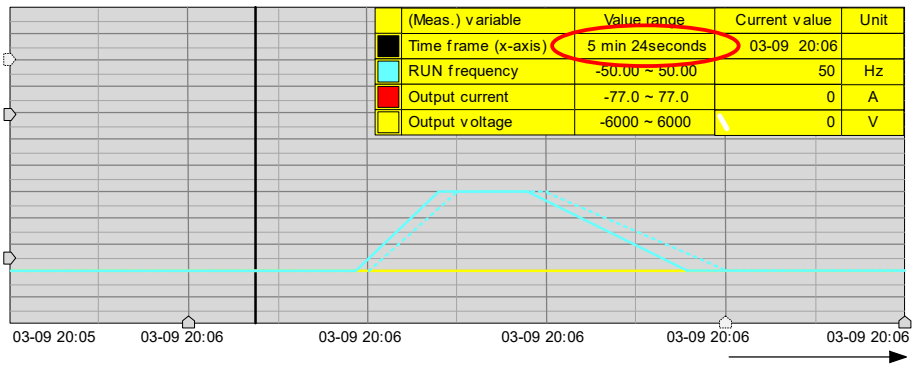
- *Moving the left slider – shift by 1/5* ❷ *of the total time frame* ❶ *to the left,* and
- *Moving the right slider – shift by 1/5* ❸ *of the total time frame* ❶ *to the right*

The *value range* shows the *width* of the respective current time window:

a)




b)




c)

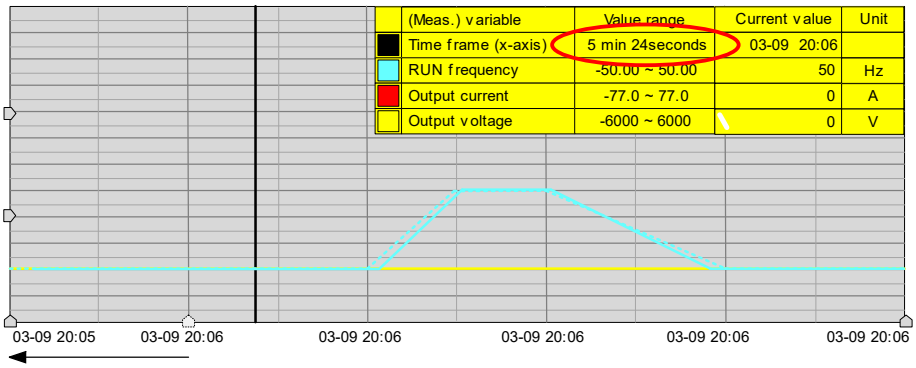



*Fig. 4-62 Zooming on the time axis (X-axis)*
*a) Initial position of the sliders*
*b) Right slider moved to the right*
*c) Left slider moved to the left*

## CURVE HISTORY

When you tap the STOP button, the display shows the curves of the VFD measured variables up to the time when the STOP button was pressed.

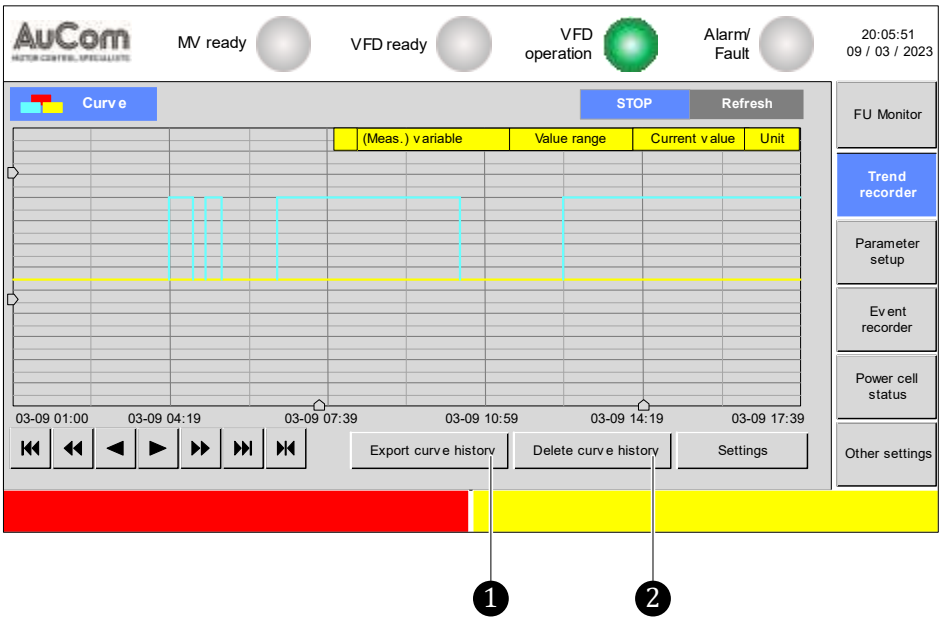



*Fig. 4-63 Trend curves: curve history*

1. Button to export (save) curve history
2. Button to delete curve history

***BUTTON***

Export curve history

You can save the curve history as a history *data.csv file* on an *external storage medium*. All data points of the three trend curves are stored in the csv file. You can open this file with a text editor or with MS EXCEL.

**NOTE**

You can set the *start* and *end* times for data storage in the *Parameter setup menu* via the parameters *Start time* and *End time*. The maximum recording duration is 30 days, based on the VFD's current system time.

***BUTTON***

Delete curve history

Taping this button *deletes all curves* from the trend recording.

**NOTE**

The button "Delete curve progression" only applies when the *Engineer* user level is activated.

## INSTRUCTION – Export curve history

**START** *USER LEVEL:* (Standard)

*CONNECT EXTERNAL MEMORY*

**STEP 1:** Insert the USB-A memory stick (max. memory size: 4MB) into the USB1 port on the HMI.

*Fig. 4-64 USB-A interface for external memory*

*ENTER "SETTINGS" MENU*

**STEP 2:** Tap the *Settings* button.

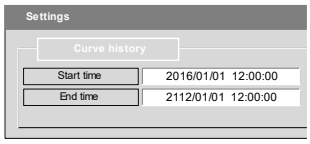



*Fig. 4-65 Start time and End time parameters*

➢ The *Settings* menu opens, and the parameters *Start time* and *End time* are displayed.

*DEFINE PERIOD FOR DATA RECORDING*

**STEP 3:** Define the period for data recording by setting the *Start time* and *End time* parameters.

**CHAPTER REFERENCE**

➢ For parameter setting see chapter „4.5.6 Changing Parameter Settings (General)".

*CLOSE "SETTINGS" MENU*

**STEP 4:** Tap  .

➢ The display goes back to the *Curve* menu.

*LAUNCH DATA EXPORT*

**STEP 5:** Tap the button *Export curve history*.

➢ After approx. 10 s, the following message pops up, if data storage was successful:

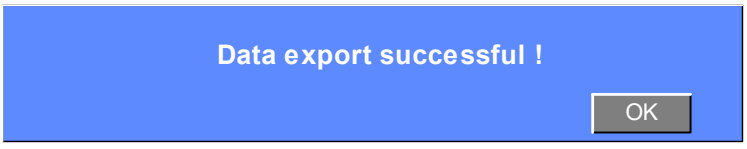



*Fig. 4-66 Curve history successfully saved*

*CLOSE PROCESS*

**STEP 6:** Tap *OK*.

➢ The pop-up message closes.

**END**

### 4.6.3 MAIN MENU: PARAMETER SETUP

The *Parameter setup menu* provides all the parameters required to set the VFD for the specific application. The settable parameters are divided into three categories:

- VFD (inverter) parameters
- Parameters related to the motor in the application
- Parameters related to the software functions of the VFD control unit

**NOTE**

Required *access levels* for parameter setting:

- ➢ To edit parameter settings, you need to log in as *Operator* or *Engineer*. If a parameter setting is not available for the selected user level, the field is greyed out.
- ➢ To enter the valid password for the required user level, refer to the example instructions in chapter „4.5.5 User Levels".

For parameter settings, there are *seven menu pages* available:

1/7: Inverter parameters 1

2/7: Inverter parameters 2

3/7: Motor parameters 1

4/7: Motor parameters 2

5/7: Function parameters 1

6/7: Function parameters 2

7/7: Function parameters 3

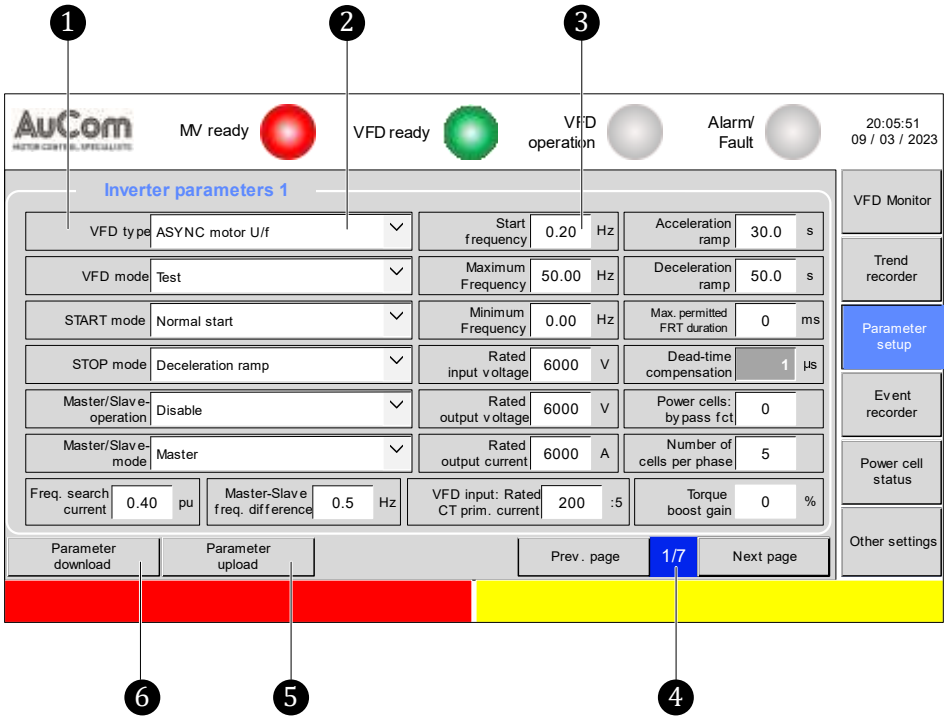



*Fig. 4-67 Main menu page 1/7: Parameter setup – Inverter parameters 1*

1. Parameter name
2. Drop down menu with a list of options
3. Entry field to set a value
4. Current menu page / total number of pages in the menu
5. Button *Parameter upload*
6. Button *Parameter download*

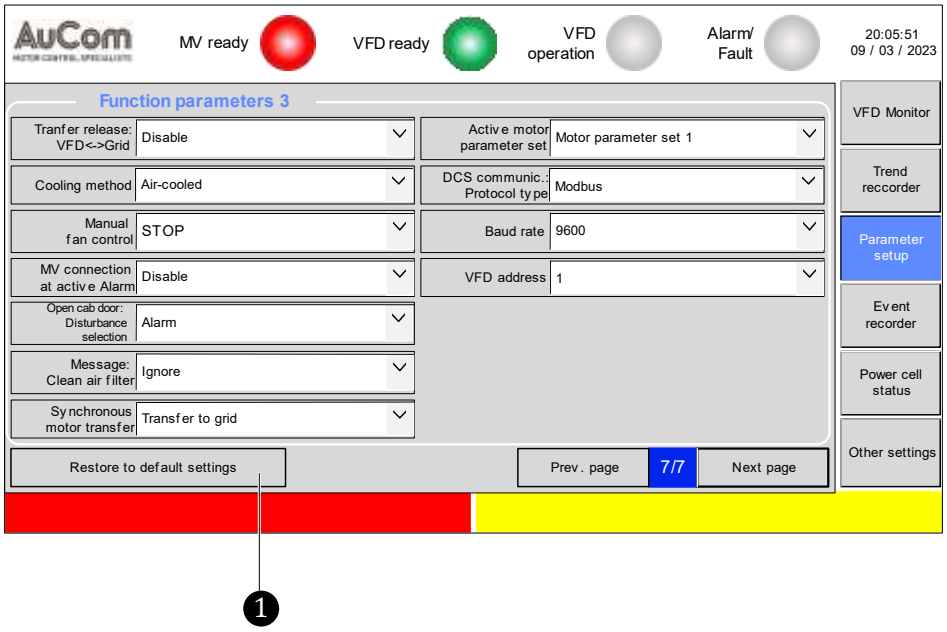



*Fig. 4-68 Main menu page 7/7: Parameter setup – Function parameters 3*

1. Button *Restore to default settings*

There are three procedures for saving and resetting parameter settings:

- Parameter download,
- Parameter upload, and
- Restore to default settings.

***BUTTON: PARAMETER DOWNLOAD***

All parameter settings of the *Parameter setup* menu are transferred (downloaded) from the operating unit (HMI) to the PLC and, subsequently, to the VFD control unit.

***BUTTON: PARAMETER UPLOAD***

All parameter settings of the *Parameter setup* menu are transferred from the VFD control unit to the PLC and, subsequently, to the operating unit (HMI) (uploaded).

***BUTTON: RESTORE TO DEFAULT SETTINGS***

All parameters of the *Parameter setup* menu are restored to the factory settings.

**NOTE**

The button *Restore to default settings* is only available if parameter setting *Restore to default settings = Enable*.

## INVERTER PARAMETERS 1

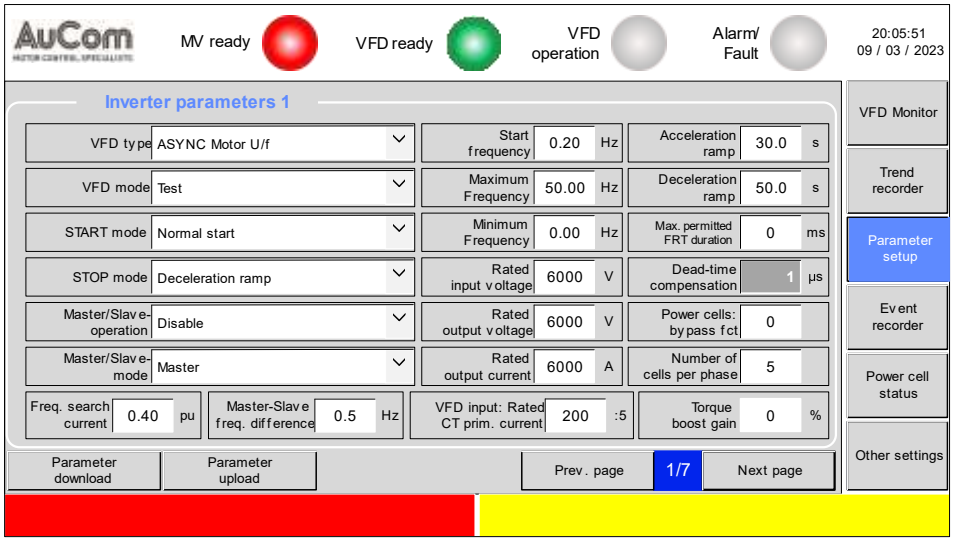



*Fig. 4-69 Main menu: Parameter setup – Inverter parameters 1*

### *PARAMETER OVERVIEW*

| Parameter name | Setting value (Default setting) | Unit | Setting range or setting options |
|---|---|---|---|
| VFD applications | | | |
| VFD type | ASYNC Motor U/f | - | ASYNC Motor U/f / ASYNC VC with sensor / SYNC Motor U/f / SYNC VC with sensor / ASYNC VC without Sensor / SYNC VC without Sensor |
| VFD modes | | | |
| VFD mode | Test | - | Test / Operation |
| Motor Start/Stop | | | |
| START mode | Normal start | - | Normal start / Speed start / Parameter identification 1 / Parameter identification 2 / |
| STOP mode | Free-wheel stop | - | Deceleration ramp / Free-wheel stop |
| Master/Slave operation | | | |
| Master/Slave operation | Disable | | Disable / Enable |
| Master/Slave mode | Master | - | Master / Slave |
| Master-Slave freq. difference | 0.5 | Hz | 0.0 ... 1.0 Hz |
| Speed start | | | |
| Freq. search current | 0.40 | pu | 0.10 ... 1.00 [pu] |
| Motor start | | | |

| Parameter name | Setting value (Default setting) | Unit | Setting range or setting options |
|---|---|---|---|
| Start frequency | 0.2 | Hz | 0.0 ... 5.0 Hz |
| Frequency range for VFD operation | | | |
| Maximum frequency | 50.00 | Hz | 00.00 ... 80.00 Hz |
| Minimum frequency | 00.00 | Hz | 00.00 ... 80.00 Hz |
| VFD rated vales | | | |
| Rated input voltage | 6000 | V | 380 ... 15000 V |
| Rated output voltage | 6000 | V | 380 ... 15000 V |
| Rated output current | 77.0 | A | 30.0 ... 3000.0 A |
| VFD input: Rated CT prim. current | 100:5 | - | 100:5 ... 2000:5 |
| Motor Start/Stop | | | |
| Acceleration ramp | 30.0 | s | 5.0 ... 6000.0 s |
| Deceleration ramp | 50.0 | s | 5.0 ... 6000.0 s |
| MV loss | | | |
| Max. permitted FRT duration | 0 | ms | 0 ... 2000 ms |
| VFD system setting | | | |
| Dead-time compensation | 1 | µs | 0 ... 20 µs |
| Power cells | | | |
| Power cells: Bypass fct. | 0 | - | 0 ... 2 |
| Number of cells per phase | 5 | - | 2 ... 9 |
| Motor start | | | |
| Torque boost gain | 0 | % | 1 ... 15 % |

*Tab. 4-10 Inverter parameters 1 – Parameter overview*

### Parameter description

*VFD APPLICATIONS*

**Parameter: VFD type**

This parameter defines the *VFD control* according to the applied motor type.

- For standard applications, such as *fan* or *pump loads*, select *ASYNC motor V/f* setting.
- For applications with *higher, dynamic requirements*, select *vector control without sensor*.
- For Applications that require *precise speed control*, select *vector control with speed sensor*.
- For applications with *one master* and *several slave drives*, select *ASYNC Motor U/f* or *ASYNC VC without sensor*.

**Setting options:**

| | |
|---|---|
| ASYNC Motor U/f | Asynchronous motor with extended U/f characteristic |
| ASYNC VC with sensor | Asynchronous motor, vector control with speed sensor (speed feedback) |
| SYNC Motor U/f | Synchronous motor with extended U/f characteristic |

| | |
|---|---|
| SYNC VC with sensor | Synchronous motor, vector control with rotor position sensor (pole wheel angle feedback) |
| ASYNC VC without sensor | Asynchronous motor, vector control without speed sensor |
| SYNC VC without sensor | Synchronous motor, vector control with rotor position sensor |

**CHAPTER REFERENCE**

- For further information on excitation settings, see chapter „4.6.6 Main Menu: Other Settings".

### *VFD MODES*

| **Parameter:** | **VFD mode** |
|---|---|

This parameter defines the VFD mode.

| | |
|---|---|
| Test | Use this setting for *commissioning* and *service* as well as factory tests *without* applied medium voltage. |
| Operation | Use this setting for operation *with* medium voltage applied. |

### *MOTOR START/STOP*

| **Parameter:** | **START mode** |
|---|---|

This parameter defines the *motor start mode.*

**Setting options:**

| | |
|---|---|
| Normal start | The VFD accelerates from the *start frequency* to the *set motor frequency* according to the *acceleration ramp*.<br><br>For *asynchronous* motors, the VFD operates with *voltage boost* at start-up and switches to *U/f control characteristic* above 10 Hz. Use the *Torque boost gain* parameter to set the VFD output current (starting torque). |
| Speed start | Use this setting for applications where the VFD is connected to a motor that is *still rotating*. The VFD detects the speed of the motor and then starts according to the detected frequency of the already rotating motor.<br>This allows the motor to start without current peaks. *Speed start* is suitable for restarting motors after *mains failures* and *starting loads with high inertia*, such as fans.<br><br>To use the *Speed start* option, select the parameter setting *STOP mode = Free-wheel stop* and set the parameters *Freq. search current* and *Frequency search mode* as required. |

***AUTOMATIC MOTOR-PARAMETER IDENTIFICATION***

The *relative stator resistance Rs[%]* is a referred value determined by the VFD according to the following formula:

$$R_s[\%] = 100\ \% * \sqrt{3} * R_s[\Omega] * \frac{\text{Motor rated current [A]}}{\text{Motor rated voltage [V]}}$$

where: $R_s[\Omega]$: *Absolute* value of the stator resistance per phase (quotient of measured phase voltage and measured phase current)

$R_s[\%]$ *Relative* value of the stator resistance per phase, related to the stator resistance, which is determined from the nominal data of the motor

The above formula applies to the parameter settings *Parameter identification 1* as well as *Parameter identification 2.*

**NOTE**

*Parameter identification 1* and *Parameter identification 2* are sub-programmes that are only executed once during commissioning.

Parameter identification 1

*Static motor parameter identification*
Use this option if *no motor data* is available and the motor should *not be disconnected* from the load before starting. The VFD determines:

- the *stator resistance* and
- the *stator leakage inductance*

of the motor and starts the motor with *open loop vector control*. Turning the rotor is part of parameter detection.

Parameter identification 2

*Dynamic motor parameter identification*
Use this option if *no motor data* is available and the motor must be *disconnected* from the load before starting. The VFD determines:

- the *idle current* and
- the *mass moment of inertia*

of the motor and starts the motor with *open loop vector control*.

**Parameter: STOP mode**

This parameter defines the *motor stop mode*.

**Setting options:**

Deceleration ramp

After receiving a stop command, the VFD decreases the output frequency according to the deceleration time curve. When the VFD reaches the minimum frequency, the output is disabled and the VFD goes into standby state.

The VFD monitors the DC bus voltage of the power cells during deceleration to avoid VFD tripping due to *DC bus overvoltage*. If the DC bus voltage of the power cell is too high, the VFD interrupts the deceleration according to the *deceleration ramp*. The actual motor run-down time can therefore be longer than the programmed motor run-down time.

Free-wheel stop

The VFD turns off the output voltage immediately after receiving a stop command, and the motor coasts to a stop.

*MASTER/SLAVE OPERATION*

**Parameter:** **Master/Slave operation**

This parameter enables/disables *Master/Slave operation*.

**Setting options:**

| | |
|---|---|
| Disable | Master/Slave operation is disabled. |
| Enable | Master/Slave operation is enabled. |

**CHAPTER REFERENCE**

For the master/slave operation, communication via fibre optic cable (FO) between the master VFD and the slave VFD is necessary.

- The fibre optic cables are connected to the fibre optic interfaces TX and RX on the AP4 module of the VFD control units. Refer to chapter "3.5.1 VFD Control Unit – Assemblies".

**Parameter:** **Master/Slave mode**

This parameter is used to assign the *function of master* or *slave* to the VFD.

**NOTE**

- This parameter only applies to the parameter setting *Master/Slave operation = Enable*.
- In an application with multiple drives, *one VFD* must be designated as the *master*. All other VFDs must be *slaves*.

**Setting options:**

| | |
|---|---|
| Master | The VFD is *Master*. |
| Slave | The VFD is *Slave*. |

**Parameter:** **Master-Slave freq. difference**

This parameter defines the *max. permissible frequency difference (droop)* between the *master VFD* and the *slave VFD* in a master/slave configuration with several drives.

Setting range: 0.0 ... 1.0 Hz

- If there is a *flexible* connection between motors, the maximum master/slave frequency difference is 1.0 Hz (e.g., for conveyor belt drives).
- If there is a *rigid* connection between motors, set the master/slave frequency difference to 0 Hz (e.g., ball mills or sag mills).

**NOTE**

This parameter only applies to the parameter setting *Master/Slave operation = Enable.*

*SPEED START*

**Parameter:** **Freq. search current**

This parameter defines the *motor current* applied *during frequency search* that occurs during a *Speed start*.

The VFD ramps up from 0 Hz with the current set in parameter *Freq. search current* until it experiences a counter-torque. When the counter-torque is detected, it means that the inverter has detected the motor speed and ramps up the motor speed setpoint.

Setting range:
0.10 ... 1.00 pu

The setting value is entered as a *relative* and *dimensionless pu value* in the per unit system, which corresponds to a *factor* of the *multiple of the motor rated current*.

**NOTE**

This parameter only applies to the parameter setting *START mode = Speed start.*

***MOTOR START***

**Parameter: Start frequency**

This parameter defines the *initial VFD output frequency*.

Setting range:
0.0 ... 5.0 Hz

A *non-zero start frequency* can provide motor torque when first starting. The VFD maintains the start frequency for a fixed amount of time so the motor can establish magnetic flux.

**NOTE**

Setting the start frequency *too high* may cause the VFD to trip on *VFD overcurrent* at start.

***FREQUENCY RANGE FOR VFD OPERATION***

**Parameter: Maximum frequency**

This parameter defines the *maximum output frequency* that the VFD will operate at.

Setting range:
00.00 ... 80.00 Hz

If the VFD runs more than 10 % over the maximum frequency for longer than 0.5 s, the VFD will trip and the fault message *System overspeed* is displayed.

**Parameter: Minimum frequency**

This parameter defines the minimum output frequency that the VFD will operate at.

Setting range:
00.00 ... 80.00 Hz

*Motor stop*:
For parameter setting *STOP mode = Deceleration ramp*, the VFD ramps down the motor to the minimum frequency set in parameter *Minimum frequency* and then switches to *Free-wheel stop*. The VFD goes into standby state and the motor coasts to a stop.

*Motor start*:
When start command is given, the VFD ramps up the motor to the minimum frequency set in parameter *Minimum frequency* if no setpoint is specified.

### *VFD RATED VALES*

**NOTE**

The following four parameters are set at the factory to match the VFD's specifications. These parameter settings must not be changed!

**Parameter:** **Rated input voltage**

Setting range:
380 ... 15000 V

This parameter defines the *rated input voltage* of the VFD.

**Parameter:** **Rated output voltage**

Setting range:
380 ... 15000 V

This parameter defines the *rated output voltage* of the VFD.

**Parameter:** **Rated output current**

Setting range:
3.0 ... 3000.0 A

This parameter defines the *rated output current* of the VFD.

**Parameter:** **VFD input: Rated CT prim. current**

Setting range:
100:5 ... 2000:5

This parameter defines the *primary nominal value of the current transformers (CTs)* used for VFD input current measurement.

The VFD input current is measured via two current transformers in V circuit at the star point of the multi-level transformer's primary winding.

**NOTE**

The *secondary nominal value* of the current transformers is defined as 5 A and cannot be changed.

### *MOTOR START/STOP*

**Parameter:** **Acceleration ramp**

This parameter defines the *motor ramp-up time* $T_1$, the VFD will take to accelerate from 0 Hz to the value set in parameter *Motor rated frequency*.

Setting range:
5.0 ... 6000.0 s

The following figure shows the relationship between the *VFD output frequency* and the *motor run-up time T1* as well as the *motor deceleration time T2,* which are set in parameter *Deceleration ramp*.

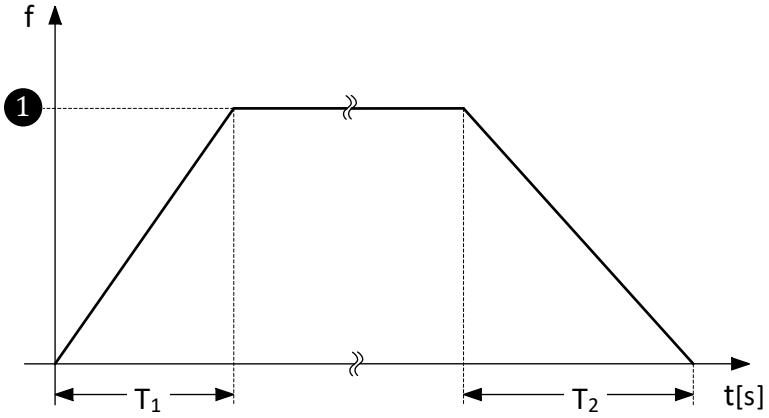



*Fig. 4-70 Frequency/time diagram: Acceleration ramp and Deceleration ramp*

where: f: VFD output frequency
1 Motor rated frequency (motor rated speed)
$T_1$: Motor ramp-up time
$T_2$: Motor ramp-down time

**NOTE**

If the motor *ramp-up time $T_1$* is set *too short*, the VFD may trip on *overcurrent*.

**Parameter: Deceleration ramp**

Setting range: 5.0 ... 6000.0 s

This parameter defines the *motor ramp-down time $T_2$*, the VFD will take to decelerate from the value set in parameter *Rated motor frequency* to 0 Hz (see previous figure for parameter *Acceleration ramp*).

**NOTE**

If the *motor ramp-down time $T_2$* is set *too short*, the VFD may trip on *DC bus power cell overvoltage*.

### *MV LOSS*

**Parameter: Max. permitted FRT duration**

Setting range: 0 ... 2000 ms

This parameter defines the *maximum permissible outage duration* of the *MV mains supply* during which the *FRT function can be effective* and VFD operation can be maintained.

### *VFD SYSTEM SETTING*

**Parameter: Dead-time compensation**

Setting range: 0 ... 20 µs

This parameter is used to compensate for the *dead-time effect* of the *power devices*.

**NOTE**

This parameter is set at the factory to match the VFD's specifications. Changing this parameter setting is generally not necessary and is the responsibility of the manufacturer!

### *POWER CELLS*

**Parameter:** **Power cells: bypass fct.**

This parameter enables/disables the *power cell bypass function* (software function) of the VFD to match it`s hardware configuration.

**NOTE**

The *power cell bypass function* can only be used if the power cells each have a cell bypass unit according to the *ordering options*: MCB, ICB, RMB and RIB under *ordering identifier 12* in the product code.

**Setting options:**

| | |
|---|---|
| 0 | Die power cell bypass function of the VFD is *disabled*. |
| 1 | Die power cell bypass function of the VFD is *enabled*. |

**Parameter:** **Number of cells per phase**

Setting range: 2 ... 9

This parameter defines the *number of power cells per Phase* of the VFD.

**NOTICE**

Incorrect settings may damage the equipment.

- This parameter is set at the factory to match the specification of the VFD. Only change this parameter setting after consultation with AuCom!

### *MOTOR START*

**Parameter:** **Torque boost gain**

This parameter defines the *amount of torque boost at the VFD output* to increase the starting torque of the motor at start-up.

Setting range: 1 ... 15 %

For high torque loads (such as compressors, slurry machines or belt conveyors), torque boost can improve starting. Set the torque boost level to suit the characteristics of the load.

**NOTE**

high torque boost setting can generate high current levels during start and can cause the VFD to trip on overcurrent.

The behaviour of torque boost differs depending on the setting of parameter *VFD type*:

- **Asynchronous motor: 0 Hz < f < 10 Hz**

  The *torque boost* increases the *VFD output voltage* while the VFD output frequency is below 10 Hz.

  *Increasing* the torque boost gain results in an *increase* of the motor current in the lower speed range. The amount of current depends on the requirements of the load.

  The *torque boost gain setting* must *not exceed* the maximum VFD output current. The setting must be conducted step-by-step, checking the measured values of the motor current.

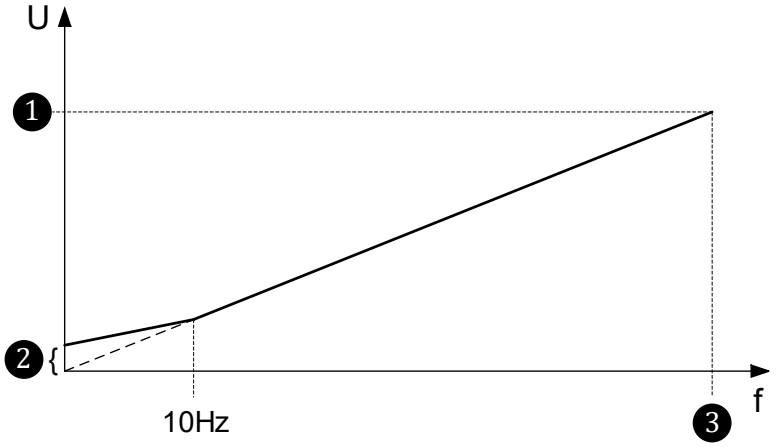



*Fig. 4-71 U/f control characteristic with torque boost*

where: U: VFD output voltage
f: VFD output frequency
1 Motor rated voltage
2 Voltage increase
3 Motor rated frequency

- **Synchronous motor: 0 Hz < f < 5 Hz** (only *VFD type = SYNC motor U/f* ):

  For synchronous motors, the *torque boost gain* acts as a *current setpoint* (VFD output current) up to 5 Hz. For a frequency greater than 5 Hz, a transition to U/f control characteristic follows.

  Use the following formula to set the *starting current* when starting a synchronous motor. To adjust the starting current you must set the parameter *Torque boost gain*.

  The formula for the referred *starting current [pu]* is as follows:

  | Starting current [pu] = Torque boost gain [%] * 0.001 * Motor overload limit [%] |
  |---|

  It applies:

  $$\text{Starting current [pu]} = \frac{\text{Starting current [A]}}{\text{Motor rated current [A]}}$$

  To determine the *absolute starting current [A]* at a given torque boost gain [%] use the following formula:

  | Starting current [A] = Motor rated current [A] * Torque boost gain [%] * 0.001 * Motor overload limit [%] |
  |---|

  Example 1:

  - For a *Torque boost gain = 10 %*
  - and a *Motor overload limit = 100 %*
  - and a referred *Starting current [pu] = 1,0*
  - and a *Motor rated current = 61 A*,

  Then, the *absolute starting current* is 61 A.

  Example 2:

  - For a *Torque boost gain = 5 %*
  - and a *Motor overload limit = 120 %*
  - and a referred *Starting current [pu] = 0.6*

- and a *Motor rated current = 61 A,*

Then, the *absolute starting current* is 36,6 A

To determine the *torque boost gain [%]* at a given starting current, the following results:

Torque boost gain [%]:

$$= \frac{\text{Starting current [A]}}{\text{Motor rated current [A]} * \text{Motor overload limit [\%]} * 0.001}$$

or:

$$= \frac{\text{Starting current [pu]}}{\text{Motor overload limit [\%]} * 0.001}$$

## INVERTER PARAMETERS 2

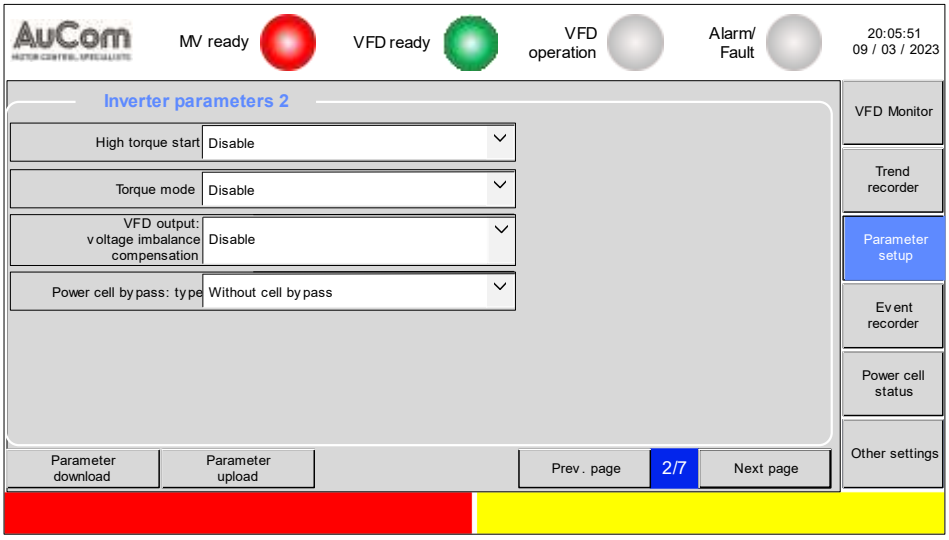



*Fig. 4-72 Main menu: Parameter setup – Inverter parameters 2*

### *PARAMETER OVERVIEW*

| Parameter name | Setting value (Default setting) | Setting range or setting options |
|---|---|---|
| Motor start | | |
| High torque start* | Disable | Disable / Enable |
| Torque mode* | Disable | Disable / Enable |
| Voltage quality | | |
| VFD output: voltage imbalance* compensation | Disable | Disable / Enable |
| Power cells | | |
| Power cell bypass: type | Without cell bypass | Without cell bypass / Contactor bypass / IGBT bypass / Redundancy: IGBT bypass / Redundancy: contactor bypass |

** This function is not available yet!*

*Tab. 4-11 Inverter parameters 2 - Parameter overview*

### Parameter description

### *POWER CELLS*

**Parameter: Power cell bypass: type**

This parameter defines the *power cell bypass function* (software function of the control unit) that corresponds to the hardware variant of the power cells used for the power cell bypass type.

**NOTE**

The hardware variant for the power cell bypass is defined by the selected *ordering option* under the *ordering identifier 12* in the product code.

**NOTICE**

Incorrect settings may damage the equipment.

- This parameter is set at the factory to match the specification of the VFD. Generally, it is not necessary to change this parameter setting.

**Setting options:**

Without cell bypass

This setting is used when the option for *ordering identifier 12* is *NCB* in the product code.

In that case, the power cells in the VFD *do not include* cell bypass units. In the event of a defective power cell, the VFD switches off.

IGBT bypass

*Electronic cell bypass (IGBT bypass)*:
This setting is used when the option for *ordering identifier 12* is *ICB* in the product code.

All power cells of the VFD are equipped with an *IGBT bypass unit*. If a power cell fails *during operation*, the control unit sends appropriate control signals to the *integrated bypass IGBTs* so that they short-circuit the output of the faulty power cell. At the same time, the *neutral point shift function* is enabled in order to continue operating the VFD with reduced, symmetrical output power. A shutdown of the VFD is *not* necessary.

Contactor bypass

*Electro-mechanical cell bypass (Contactor bypass)*:
This setting is used when the option for *ordering identifier 12* is *MCB* in the product code.

All power cells of the VFD are equipped with a *contactor bypass unit*. If a power cell fails during operation, the control unit sends a control signal to the *integrated contactor bypass*, whose *auxiliary contact* (normally open contact) short-circuits the output of the faulty power cell. At the same time, the neutral point shift function is enabled in order to continue operating the VFD with reduced, symmetrical output power. A shutdown of the VFD is *not* necessary.

Redundancy: IGBT bypass

*Redundant power cell with IGBT bypass:*
This setting is used when the option for *ordering identifier 12* is *RMB* in the product code.

All power cells of the VFD are equipped with an *IGBT bypass unit*. Each phase has an *additional (redundant) power cell* that also contributes to the VFD output voltage during VFD operation. If a power cell fails *during operation*, the control unit sends corresponding control signals to the integrated IGBTs bypasses of the *corresponding cell number in all three phases*. The redundant power cell means that the *full level of VFD output voltage* is still available.

Redundancy: contactor bypass

*Redundant power cell with contactor bypass:*
This setting is used when the option for *ordering identifier 12* is *RIB* in the product code.

All power cells of the VFD are equipped with a *contactor bypass unit*. Each phase has an *additional (redundant) power cell* that also contributes to the formation of the VFD output voltage during VFD operation. If a power cell fails *during operation*, the control unit sends corresponding control signals to the integrated contactor bypasses of the *corresponding cell number in all three phases*. The redundant power cell means that the full level of VFD output voltage is still available.

## MOTOR PARAMETERS 1

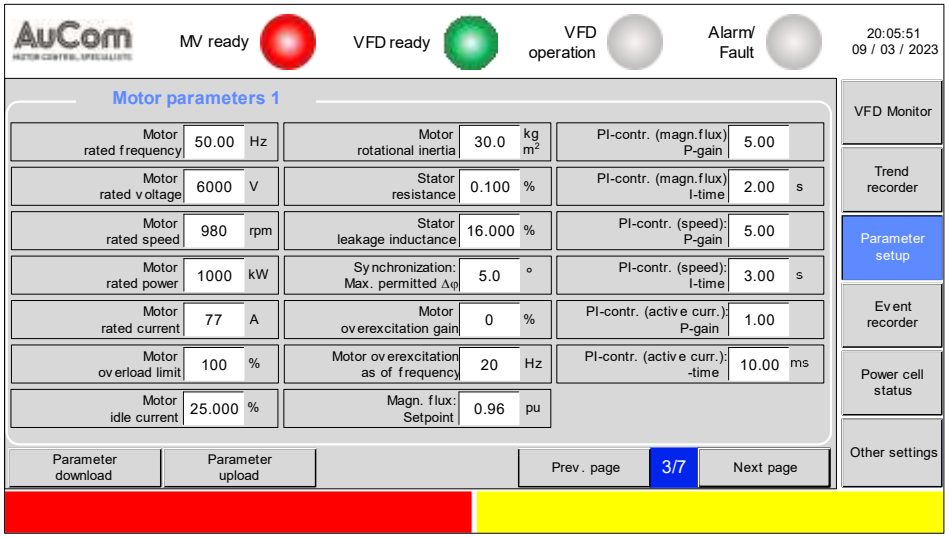



*Fig. 4-73 Main menu: Parameter setup – Motor parameters 1*

### *PARAMETER OVERVIEW*

| Parameter name | Setting value (Default setting) | Unit | Setting range |
|---|---|---|---|
| Motor rated values | | | |
| Motor rated frequency | 50.00 | Hz | 5.00 ... 80.00 Hz |
| Motor rated voltage | 6000 | V | 50 ... 15000 V |
| Motor rated speed | 980 | rpm | 0 ... 3600 rpm |
| Motor rated power | 1000 | kW | 1 ... 60000 kW |
| Motor rated current | 77 | A | 1.0 ... 1600.0 A |
| Overload operation | | | |
| Motor overload limit | 100 | % | 100 ... 200 % [of In] |
| Motor rated values | | | |
| Motor idle current | 25.000 | % | 0.000 ... 50.000 % |
| Motor rotational inertia | 30.0 | kg m² | 1.0 ... 3000.0 kg m² |
| Stator resistance | 0.1 | % | 0.000 ... 25.000 % |
| Stator leakage inductance | 16.000 | % | 0.000 ... 50.000 % |
| Synchronous transfer | | | |
| Synchronization: Max. permitted Δφ | 3.00 | Grad | 0.5 ... 5.0 ° |
| Motor deceleration | | | |
| Motor overexcitation gain | 0 | % | 0 ... 30 % |
| Motor overexcitation as of frequency | 3.00 | Hz | 1 ... 30 Hz |
| Motor rated values | | | |
| Magn. flux: Setpoint | 0.96 | pu | 0.10 ... 1.00 pu |
| PI-controllers | | | |
| PI-contr. (magn.flux): P-gain | 5.00 | - | 0.50 ... 20.00 |
| PI-contr. (magn.flux): | 2.00 | s | 0.10 ... 20.00 s |

| Parameter name | Setting value (Default setting) | Unit | Setting range |
|---|---|---|---|
| I-time | | | |
| PI-contr. (speed): P-gain | 5.00 | - | 0.50 ... 20.00 |
| PI-contr. (speed): I-time | 3.00 | s | 0.10 ... 20.00 s |
| PI-contr. (active curr.): P-gain | 1.00 | - | 0.10 ... 20.00 |
| PI-contr. (active curr.): I-time | 3.00 | s | 0.10 ... 50.00 ms |

*Tab. 4-12 Motor parameters 1 - Parameter overview*

**Parameter description:**

*MOTOR RATED VALUES*

**Parameter: Motor rated frequency**

Setting range: 5.00 ... 80.00 Hz

This parameter defines the *rated frequency of the motor*. Set the motor rated frequency according to the motor nameplate data.

**Parameter: Motor rated voltage**

Setting range: 50 ... 15000 V

This parameter defines die *rated voltage of the motor*. Set the motor rated voltage (line-to-line voltage) according to the motor nameplate data.

The following figure shows the relationship between the *motor rated frequency* and the *motor rated voltage* (U/f control curve).

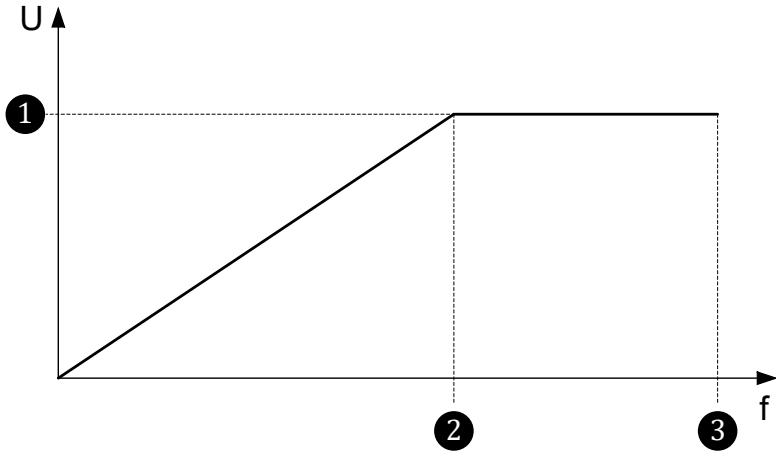



*Fig. 4-74 Voltage/time curve: Motor rated voltage depending on motor rated frequency (U/f control characteristic)*

where:
- U: VFD output voltage
- f: VFD output frequency
- ❶ Motor rated voltage
- ❷ Motor rated frequency [Hz]
- ❸ Maximum motor frequency

**NOTE**

- If *motor rated voltage* is set *lower* than the motor nameplate voltage, the VFD and motor will operate at reduced capacity (*motor underexcitation*).
- If *motor rated voltage* is set *greater* than the motor nameplate voltage, it can cause the motor to magnetically saturate, reduce operating efficiency and increase heating (*motor over-excitation*)

**Parameter:** **Motor rated speed**

Setting range:
0 ... 3600 rpm

This parameter defines the *rated speed of the motor.* Set the motor rated speed according to the motor nameplate data.

**Parameter:** **Motor rated power**

Setting range:
1 ... 60000 kW

This parameter defines the *rated power of the motor*. Set the motor rated power [kW] according to the motor nameplate data.

**Parameter:** **Motor rated current**

Setting range:
1.0 ... 1600.0 A

This parameter defines the *rated current of the motor*. Set the motor rated current according to the motor nameplate data.

### *OVERLOAD OPERATION*

**Parameter:** **Motor overload limit**

This parameter defines the *maximum VFD output current* referred to the motor rated current.

Setting range:
100 ... 200 %

Enter the setting value as a *percentage* of the motor rated current.

Example:
100 % corresponds to motor rated current. For example, if Motor rated current is 61 A and *Motor overload limit* is set to 100 %, then the *VFD maximum output current* is 61 A. If *Motor overload limit* is set to 120 %, then the *VFD maximum output current* is 73.2 A.

**NOTE**

If *Motor overload limit* is set to 100 %, the VFD will *not allow* more than the rated current. If demand is *higher*, the VFD will *reduce* the speed without displaying any message. For this reason, it is recommended to set this value to 110 % (control reserve).

### *MOTOR RATED VALUES*

**Parameter:** **Motor idle current**

This parameter defines the *motor no load current*. Set the motor idle current according to the motor nameplate data.

Setting range:
0.000 ... 50.000 %

Enter the setting value is entered as a *percentage* of the motor rated current.

**NOTE**

If no detailed motor data is available, the VFD can determine the motor characteristics automatically. To do this, select the option *Parameter identification 1* or *Parameter identification 2* for the *START mode* parameter.

- Incorrect settings of the *Motor idle current* can have an influence on the maximum VFD output voltage.

**Parameter: Motor rotational inertia**

Setting range: 1.0 ... 3000.0 kgm²

This parameter defines the *mass moment of inertia of the motor*. Set the mass moment of inertia according to the motor data sheet, Alternatively, it can be *automatically determined* by setting parameter *START mode* to *Parameter identification 2*.

**Parameter: Stator resistance**

This parameter defines the *ohmic resistance of the motor stator*. Set the stator resistance according to the motor data sheet. Alternatively, it can be *automatically determined* by setting parameter *START mode* to *Parameter identification 1* or *Parameter identification 2.*

Setting range: 0.000 ... 25.000 %

Enter the setting value as a percentage. You can calculate it according to the following formula:

$$R_s[\%] = 100\ \% * \sqrt{3} * R_s[\Omega] * \frac{\text{Motor rated current [A]}}{\text{Motor rated voltage [V]}}$$

where: $R_S[\Omega]$: *Absolute* value of the *stator resistance* (from the motor data sheet or automatically determined)

$R_S[\%]$ *Relative* value of the *string stator resistance*, referred to the string stator resistance, which is determined from the motor rated data

**Parameter: Stator leakage inductance**

This parameter defines the *stator leakage inductance of the motor*. Set the stator leakage inductance according to the *motor data sheet* or based on *experience*.

Setting range: 0.000 ... 50.000 %

Enter the setting value as a percentage. Alternatively, it can be value or is automatically determined by setting parameter *START mode* to *Parameter identification 1*.

***SYNCHRONOUS TRANSFER***

**Parameter: Synchronization: Max. permitted Δφ**

This parameter defines the *maximum permissible phase angle difference* between the phase voltages of the VFD voltage system and the phase voltages of the MV mains for frequency inverters with synchronous switching (motor transfer from the VFD to the mains, or motor transfer from the mains to the VFD).

Setting range: 0.5 ... 5.0 °

*low settings*:
The *smaller* the max. permissible phase angle difference, the *smaller* the transient motor current when switching over. However, a smaller setting makes the synchronisation process more difficult, and it may take *longer* until the synchronous changeover can take place.

*high settings*:

The synchronisation process is *faster*, but the transient motor current may be *higher* during the motor changeover.

### MOTOR DECELERATION

**Parameter: Motor overexcitation gain**

You can use this parameter to *set a motor overexcitation* that is automatically used during a decelerating process.

A *large* load inertia during braking can cause power regeneration to occur (*generating operation* of the motor). This may cause capacitor *overvoltage faults* in the power cells. Enabling overexcitation can prevent this issue by dissipating some of the rotational energy in the motor (higher motor losses).

Setting range: 0 ... 30 %

Enter the setting value as a percentage related to parameter *Magn. flux: Rated value*.

If *Motor overexcitation gain* is set *too high*, the motor output current can become *too high* and could cause *overcurrent faults*.

**NOTE**

You can use this feature with overhauling or out-of-balance loads, such as ball mills to prevent overvoltage during operation.

- For further information on such applications, consult the plant operator.

**Parameter: Motor overexcitation as of frequency**

Setting range: 1 ... 30 Hz

This parameter defines the *frequency* at which *overexcitation will begin* during deceleration.

### MOTOR RATED VALUES

**Parameter: Magn. flux: Setpoint**

This parameter defines the magnetic flux setpoint for the motor.

Setting range: 0.10 ... 1.00 pu

Enter the setting value as a relative and dimensionless pu value in the per unit system.

### PI-CONTROL OF MAGNETIC FLUX

The following two parameters:

- *PI-contr. (Magn.flux): Proportional gain* and
- *PI-contr. (Magn.flux): Integral time*

control the behaviour of the internal *magnetic flux control loop*. You can optimise the dynamic response characteristic of the magnetic flux control by adjusting the parameters.

**Parameter: PI-contr. (Magn.flux): P-gain**

Setting range: 0.50 ... 20.00

This parameter defines the *proportional gain* of the *magnetic flux controller*.

**Parameter: PI-contr. (Magn.flux): I-time**

Setting range:
0.10 ... 20.00 s

This parameter defines the *integral time* of the *magnetic flux controller*.

### *PI-CONTROL OF SPEED*

The following two parameters:

- *PI-contr. (speed): Proportional gain* and
- *PI-contr. (speed): Integral time*

control the behaviour of the internal *speed control loop*. You can optimise the dynamic response characteristic of the speed control by adjusting the parameters.

Increasing the *speed proportional gain* and reducing the *speed integral time* can speed up the dynamic response of the speed loop. However, if the gain setting is too large or the integration time is too short, the system may oscillate and even go unstable.

If the default values do not give suitable performance, follow these steps:

**STEP 1:** Gradually *increase* the *speed proportional gain* setting, testing each time to ensure the system does *not* oscillate.

**STEP 2:** When the system is stable, gradually *reduce* the *speed integral time* so that the system response is *faster* (fine-tuning).

**NOTE**

This parameter only applies when using a vector control mode (see parameter *VFD type*).

**Parameter:** **PI-contr. (speed): P-gain**

Setting range:
0.50 ... 20.00

This parameter defines the *proportional gain* of the *speed controller*.

**Parameter:** **PI-contr. (speed): I-time**

Setting range:
0.10 ... 20.00 s

This parameter defines the *integral time* of the *speed controller* (fine-tuning).

### *PI-CONTROL OF MOTOR ACTIVE CURRENT*

The following two parameters:

- *PI-controller (active curr.): Proportional gain* and
- *PI-controller (active curr.): Integral time*

control the behaviour of the internal *active current control loop*. You can optimise the dynamic response characteristic of the active current control by adjusting the parameters.

**NOTE**

If you use *U/f control* in a *master/slave operation*, these parameters control the response characteristics of master/slave power balance.

**NOTICE**

➢ *Carefully monitor* the output waveform when adjusting these parameters.

- Inappropriate parameter settings can *distort* the output circuit waveform.
- Inappropriate parameter settings can cause the VFD to trip on *motor overcurrent*.

**Parameter:** **PI-contr. (active curr.): P-gain**

Setting range:
0.10 ... 15.00

This parameter defines the *proportional gain* of the *active current controller*.

**Parameter:** **PI-contr. (active curr.): I-time**

Setting range:
0.10 ... 50.00 ms

This parameter defines the *integral time* of the *active current controller* (fine-tuning).

## MOTOR PARAMETERS 2

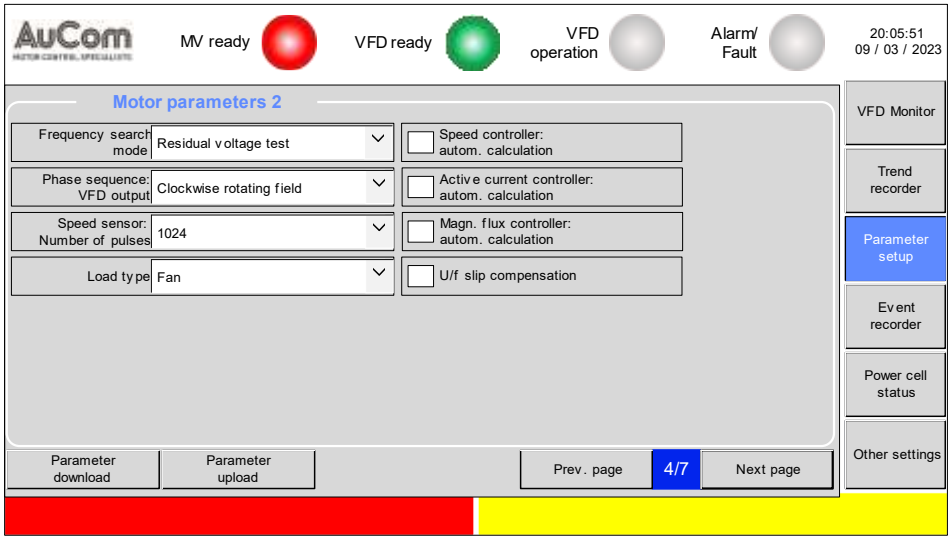



*Fig. 4-75 Main menu: Parameter setup – Motor parameters 2*

### *PARAMETER OVERVIEW*

| Parameter name | Setting value (Default setting) | Setting options |
|---|---|---|
| Speed start | | |
| Frequency search mode | Residual voltage test | Residual voltage test / Forward search / Reverse search / Bidirectional search |
| VFD phase sequence | | |
| Phase sequence: VFD output | Clockwise rotating field | Clockwise rotating field / Counterclockwise rotating field |
| Speed sensor: Number of pulses | 1024 | 512 ... 65535 |
| Motor Start/Stop | | |
| Load type | Fan | Fan / Pump |
| PI-controller | | |
| Speed controller: autom. calculation | ☐ | ☐ / ☑ |
| Active current controller: autom. calculation | ☐ | ☐ / ☑ |
| Magn. flux controller: autom. calculation | ☐ | ☐ / ☑ |
| U/f slip compensation | ☐ | ☐ / ☑ |

*Tab. 4-13 Motor parameter 2 - Parameter overview*

### Parameter description

### *SPEED START*

**Parameter: Frequency search mode**

This parameter defines the *mode for detecting the current motor speed* when the motor shaft is *still rotating* (parameter setting *Start-Modus = Speed start*).

**Setting options:**

Residual voltage test

A freely coasting motor induces a residual voltage at its terminals due to the residual magnetism in the stator plate and the still rotating motor shaft. The VFD measures this *voltage* and determines its *current frequency* and *phase position*. With the determined values, the VFD is switched to the motor and drives it back to the specified setpoint using the set ramps.

Forward search

The VFD will ramp up its output frequency using the setting of *Acceleration ramp* with *positive* frequency values, until the output frequency matches the frequency of the motor that is still rotating.

Reverse search

The VFD will ramp up its output frequency using the setting of *Acceleration ramp* with *negative* frequency values, until the output frequency matches the frequency of the motor that is still rotating.

Bidirectional search

The VFD will first ramp up its output frequency using the setting of *Acceleration ramp* with *positive* frequency values, until the output frequency matches the frequency of the motor that is still rotating. If the frequencies *do not match*, the VFD will then ramp up its output frequency using the setting of *Acceleration ramp* with *negative* frequency values.

### *VFD PHASE SEQUENCE*

**Parameter:** **Phase sequence: VFD output**

This parameter defines the *phase sequence of the VFD output voltage* for the *VFD forward direction.*

**Setting options:**

Counterclockwise rotating field

The VFD output voltages have a *counterclockwise* rotating field: phase sequence U → W → V

Clockwise rotating field

The VFD output voltages have a *clockwise* rotating field: phase sequence U → V → W

**NOTE**

- You can use this parameter if, for example, two phases have been swapped due to a *wiring error*.
- Changing the setting of this parameter does not change the *direction of rotation display* in the VFD monitor!

**Parameter:** **Speed sensor: Number of pulses**

This parameter defines the *number of pulses per revolution* of the *speed sensor*.

Setting range: 512 ... 65535

The setting of the number of pulses must match the specification of the speed sensor used.

**CHAPTER REFERENCE**

- For connecting the speed sensor to the module of the VFD control unit (terminals VCO, AP, AN, ... of AP5), refer to chapter „3.5.1 VFD Control Unit – Assemblies".

### *MOTOR START/STOP*

**Parameter:** **Load type**

Use this parameter to *optimise the start-up of different load moments of inertia*. With a *high* load moment of inertia, it can provide a *longer* time for the build-up of *magnetic flux* before the frequency run-up starts.

**Setting options:**

| | |
|---|---|
| Fan | This setting offers a *long* excitation waiting time. It is suitable for most medium/heavy loads (not just *fan* loads). |
| Pump | This setting offers a *short* excitation waiting time. It is suitable for most *light* loads (not just *pump* loads). |

*PI-CONTROLLER*

**Parameter: Speed controller: autom. calculation**

This parameter enables/disables *automatic calculation* of the *speed controller*.

Use the automatic calculation function if the motor data is not available or the application requires further tuning.

**Setting options:**

| | |
|---|---|
| ☐ | Automatic calculation function is *disabled*. |
| ☑ | Automatic calculation function is *enabled*. |

**Parameter: Active current controller: autom. calculation**

This parameter enables/disables *automatic calculation* of the *active current controller*.

Use the automatic calculation function if the motor data is not available or the application requires further tuning.

**Setting options:**

| | |
|---|---|
| ☐ | Automatic calculation function is *disabled*. |
| ☑ | Automatic calculation function is *enabled*. |

**Parameter: Magn. flux controller: autom. calculation**

This parameter enables/disables *automatic calculation* of the *magnetic flux controller*.

Use the automatic calculation function if the motor data is not available or the application requires further tuning.

**Setting options:**

| | |
|---|---|
| ☐ | Automatic calculation function is *disabled*. |
| ☑ | Automatic calculation function is *enabled*. |

**Parameter: U/f slip compensation**

This parameter enables/disables the *internal function for U/f slip compensation* for the VFD with the parameter setting *VFD type = ASYNC motor U/f*.

You can use the V/f slip compensation can be used to keep the *motor speed constant* during load changes.

**Setting options:**

| | |
|---|---|
| ☐ | U/f slip compensation function is *disabled*. |

| | |
|---|---|
| ☑ | U/f slip compensation function is *enabled*. |

- *Increase of drive load* ⇒ automatic *increase* of output frequency and output voltage
- *Decrease of drive load* ⇒ automatic decrease of output frequency and output voltage

## FUNCTION PARAMETERS 1

These parameters cannot be modified during VFD operation, unless otherwise stated.

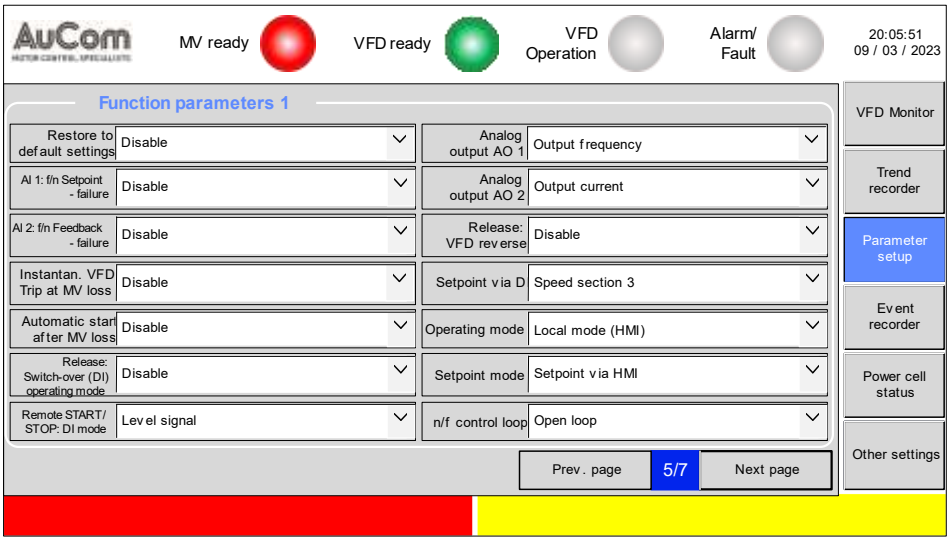



*Fig. 4-76 Main menu: Parameter setup – Function parameters 1*

### *PARAMETER OVERVIEW*

| Parameter name | Default setting | Setting options |
|---|---|---|
| Default settings | | |
| Restore to default settings | Disable | Disable / Enable |
| Analog inputs | | |
| AI 1: f/n Setpoint - failure | Enable | Minimum frequency / Last setpoint |
| AI 2: f/n Feedback - failure | Enable | Zero / Last act. value |
| MV loss | | |
| Instantan. Trip at MV loss | Enable | Disable / Enable |
| Automatic start after MV loss | Enable | Disable / Enable |
| VFD operating modes | | |
| Release: Switch-over (DI) operating mode | Enable | Disable / Enable |
| Remote START/STOP: DI mode | Level signal | Level signal / Pulse signal |
| Analog outputs | | |
| Analog output AO 1 | Output frequency | Output frequency / Output current / Power cell temperature / Excitation current / Output power / Output power factor / Output voltage |
| Analog output AO 2 | Output frequency | Output frequency / Output current / Power cell temperature / Excitation current / Output power / |

| Parameter name | Default setting | Setting options |
|---|---|---|
| | | Output power factor / Output voltage |
| Motor reverse operation | | |
| Release: VFD reverse | Disable | Disable / Enable |
| Preset fixed setpoint frequency | | |
| Setpoint via DI | Speed section 3 | Speed section 3/ Speed section 7 |
| VFD operating modes | | |
| Operating mode | Local control (HMI) | Local control (HMI) / Remote control (DCS) / Remote control (DI) |
| Set target frequency | | |
| Setpoint mode | Setpoint via HMI | Setpoint via HMI / Setpoint via AI / Setpoint via DI / Setpoint via DCS |
| f/n control loop | | |
| f/n control loop | Open loop | Open loop / Closed loop |

*Tab. 4-14 Function parameters 1 – Parameter overview*

**Parameter description**

*DEFAULT SETTINGS*

**Parameter: Restore to default settings**

This parameter enables/disables the *Restore set to factory settings* button of the touchscreen.

**NOTE**

- The *Restore to default settings* button is located on menu page 7/7 of the *Parameter setup* main menu.
- Pressing the *Restore to default settings* button resets all parameter settings of the *Parameter setup* main menu to their factory settings.
- After resetting to factory settings, you must check again *Inverter parameters 1* and *Inverter parameters 2* and if necessary, adjust these to the same state as when the VFD was delivered!

**Setting options:**

| | |
|---|---|
| Disable | The button *Restore to default settings* is *disabled*. |
| Enable | The button *Restore to default settings* is *enabled*. |

*ANALOG INPUTS*

**Parameter: AI 1: f/n Setpoint - failure**

This parameter defines the *behaviour of the VFD* if the *analog input signal* for the setpoint frequency is *no longer available* during VFD operation.

**Setting options:**

| | |
|---|---|
| Minimum frequency | The setpoint frequency is set to the value set in parameter *Minimum frequency*. |

| | |
|---|---|
| Last setpoint | The last received frequency setpoint is retained. |

**Parameter:** **AI 2: f/n Feedback - failure**

This parameter defines the behaviour of the VFD if the *analogue input signal* for the actual speed value (feedback) is *no longer available* during VFD operation.

**Setting options:**

| | |
|---|---|
| Zero | The frequency feedback value is set to 0. |

**NOTICE**

There is a risk that the VFD will accelerate to maximum speed!

| | |
|---|---|
| Last act. value | The last received frequency feedback value is retained. |

***MV Loss***

**Parameter:** **Instantan. Trip at MV loss**

This parameter defines the VFD trip behaviour in case of a mains failure (MV loss).

**Setting options:**

| | |
|---|---|
| Disable | When the mains voltage is restored within the time delay set in parameter *Max. permitted MV loss duration*, the VFD will perform the action set in parameter *Automatic start after MV loss*. |
| Enable | In case of mains failure (MV loss) the VFD instantaneously trips. |

**Parameter:** **Automatic start after MV loss**

This parameter enables/disables the *automatic restart* of the VFD on voltage recovery after a previous failure of the MV mains voltage.

**Setting options:**

| | |
|---|---|
| Disable | After an MV loss, the VFD does not restart automatically, but returns to standby mode. |
| Enable | After an MV loss, the VFD performs an automatic restart. |

**NOTE**

The VFD will only start if:

- the start conditions are still active, and
- if the duration of the mains failure is *shorter* than the time delay set in parameter *Max. permitted MV loss duration* (see chapter "5.1.8 MV Mains Failure (MV Loss)").

*VFD OPERATING MODES*

**Parameter: Release: Switch-over (DI) operating mode**

This parameter enables/disables the activation of VFD operating mode *Remote control (DI)* via digital input (DI) *Switch-over operating mode* (terminals -XS1:1,4) of the I/O interface unit (PLC).

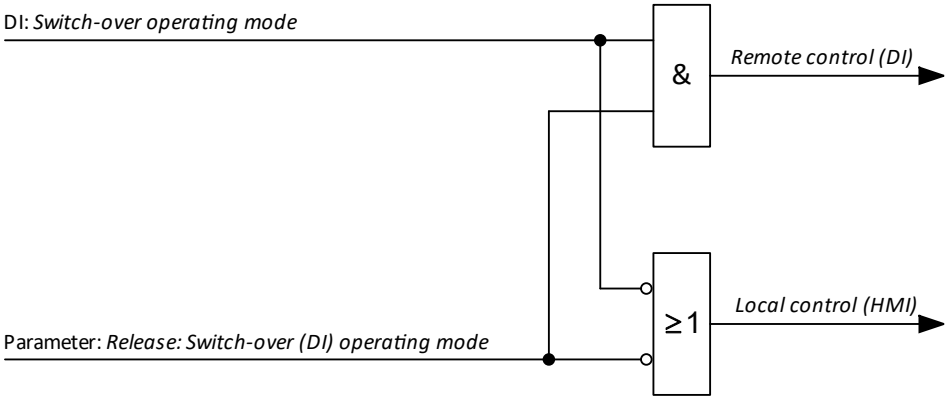



*Fig. 4-77 Block diagram – Release for changing over the VFD operating mode via DI*

**Setting options:**

Disable — Switching the VFD operating mode via DI is *not released*.

Enable — Switching the VFD operating mode via DI is *released*. You can set DI *Switch-over operating mode* to switch between the two operating modes, *Local control (HMI)* and *Remote control (DI)*:

- If the DI is inactive: VFD operation mode *Local control (HMI)* is active.
- If the DI is active: VFD operation mode *Remote control (DI)* Is active.

**NOTE**

When DI *Switch-over operating mode* is active, the current setting of parameter *Operating mode* (e.g. *Local operation (HMI)* or *Remote control (DCS)*) is overwritten by the setting *Remote control (DI)*!

**Parameter: Remote START/STOP: DI- mode**

This parameter defines the *signal mode (signal type)* for the remote start/stop commands given via *digital inputs (DI)* of the I/O interface unit (PLC).

**NOTE**

This parameter only applies for parameter setting *Operation mode = Remote control (DI)*.

**Setting options:**

Pulse signal — The digital inputs (DI) are activated/deactivated by pulses. The pulse length is at least 500 ms.

**NOTE**

I/O interface unit (PLC):

- Terminals -XS1:1,10 are defined as *Pulse START*.
- Terminals -XS1:1,9 are defined as *Pulse STOP*.

Level signal — The digital inputs (DI) are activated/deactivated by high/low level signals.

**NOTE**

I/O interface unit (PLC):

- Terminals -XS1:1,10 are defined as *Level forward START/STOP.*
- Terminals -XS1:1,9 are defined as *Level reverse START/STOP* (START or STOP function of the DI depends on positive or negative setpoint).

### *ANALOG OUTPUTS*

**Parameter: Analog output AO 1**

This parameter defines *the measured variable to be transmitted* by *Analog output AO 1*.

The signal line of the *Analog output AO 1* is connected to terminals 11 (I4) and 10 (M4) of terminal block -XS18T of the I/O interface unit.

**Setting options:**

| | |
|---|---|
| Output frequency | Momentary VFD output frequency value |
| Output current | Momentary VFD output phase current value |
| Power cell temperature | Temperature in power cell cabinet value |
| Excitation current | Excitation current setpoint (synchronous motors only) |
| Output power | Momentary VFD output power value |
| Output power factor | Momentary motor active power factor (*cos phi* of the motor) |
| Output voltage | Momentary mean value of the line-to-line voltages at VFD output |

**Parameter: Analog output AO 2**

This parameter defines *the measured variable to be transmitted* by *Analog output AO 2.*

The signal lines of the *Analog output AO 2* are connected to terminals 11 (I4) and 12 (M4) of terminal block -XS18T of the I/O interface unit.

**NOTE**

**Setting options:** (see description of parameter: *Analog output AO 1*)

### *MOTOR REVERSE OPERATION*

**Parameter: Release: VFD reverse**

This parameter enables/disables the VFD to operate the motor in reverse.

**NOTE**

*Reverse motor operation* requires *negative* frequency setpoints to the VFD.

**Setting options:**

| | |
|---|---|
| Disable | Release for a motor reverse operation is *disabled*. Reverse running of the motor is *not* possible. |

Enable

Release for a motor reverse operation is *enabled*. Reverse running of the motor is possible.

### *PRESET FIXED SETPOINT FREQUENCY*

**Parameter: Setpoint via DI**

This parameter defines the *mode* for selecting the *fixed setpoint for the VFD output frequency*.

Each mode evaluates the *binary states* of three digital inputs (DI). *Binary coding* of the DI states provides the *corresponding algorithm* for selecting the VFD setpoint frequency.

**NOTE**

- This parameter only applies to the parameter setting *Setpoint mode = Setpoint via DI*.
- This parameter can be modified during VFD operation.

Setting options:

Speed section 3

VFD set frequency is determined to:

- f1, or
- f2, or
- f3

Speed section 7

VFD set frequency is determined to:

- f1, or
- (2 * f1+ f2) / 3, or
- f2, or
- (2 * f2+ f1) / 3, or
- (2 * f2+ f3) / 3, or
- (2 * f3+ f2) / 3, or
- f3

The following table represents the relationship between the *selected parameter setting option*, the *individual binary states* of the three digital inputs (DI) and the *resulting fixed set frequency* at the VFD output.

| **Selection of *Speed section*** | **Status of the digital inputs** | | | **Fixed set frequency** |
|---|---|---|---|---|
| | DI: *Set frequency 3* (-XS1:1,5) | DI: *Set frequency 2* (-XS1:1,4) | DI: *Set frequency 1* (-XS1:1,3) | |
| *Speed section 3* | 0 | 0 | 0 | invalid |
| | 0 | 0 | 1 | f1 |
| | 0 | 1 | 0 | f2 |
| | 1 | 0 | 0 | f3 |
| | 0 | 1 | 1 | invalid |
| | 1 | 0 | 1 | invalid |
| | 1 | 1 | 0 | invalid |
| | 1 | 1 | 1 | invalid |
| *Speed section 7* | 0 | 0 | 0 | invalid |
| | 0 | 0 | 1 | f1 |
| | 0 | 1 | 0 | (2 * f1+ f2) / 3 |
| | 1 | 0 | 0 | f2 |
| | 0 | 1 | 1 | (2 * f2+ f1) / 3 |
| | 1 | 0 | 1 | (2 * f2+ f3) / 3 |
| | 1 | 1 | 0 | (2 * f3+ f2) / 3 |
| | 1 | 1 | 1 | f3 |

*Tab. 4-15 Set frequency – Setpoint via digital inputs (DI)*

### *VFD OPERATING MODE*

**Parameter:** **Operating mode**

This parameter defines the *source for operating the VFD*.

**NOTE**

- This parameter only applies to the parameter setting *Release: Switch-over (DI) operating mode= Disable*.
- If parameter *Release: Switch-over (DI) operating mode* is set to *Enable* and parameter *Operating mode* is set to *Remote control (DI)* or *Remote control (DCS),* then, parameter *Operating mode* is automatically set to *Local control (HMI).*
- This parameter can be modified during VFD operation. The operating status of the VFD before switching from Remote control (DI) to Local control (HMI) is maintained.
- When *Operating mode = Remote control (DCS)* and communication fails between the VFD control unit and DCS, the VFD continues running with the current settings. You can change *required* operating mode to *Remote operation (DI)* or *Local operation (HMI)* via the operating unit (HMI).

**Setting options:**

Local control (HMI) — The START/STOP commands can only be given via the operating unit (HMI) (local operation). You can reset fault messages via the *RESET* button on the HMI or the DI *RESET door pushbutton* (terminal -XS3:1,6) on the panel.

Remote control (DCS) — The START/STOP commands can only be given via the *communication protocol* of the Distributed control system (DCS). Resetting fault messages via the *RESET* button of HMI is disabled. You can reset fault messages via the DI *External RESET* (terminal -XS1:1,3) or using the DI *RESET door pushbutton*.

Remote control (DI) — The START/STOP commands can only be given from external control signals via the *digital inputs (DI)* of the I/O interface unit. Resetting fault messages via the *RESET* button of HMI is disabled. You can reset fault messages via the DI *External RESET* or using the DI *RESET door pushbutton*.

### *SETPOINT MODE*

**Parameter:** **Setpoint mode**

This parameter defines the *mode (method) to set the frequency setpoint* at the VFD output.

**NOTE**

This parameter can be modified during VFD operation.

**Setting options:**

Setpoint via HMI — You can enter the setpoint for the VFD output frequency directly via the *operating unit (HMI)* (local operation).

Setpoint via AI — The setpoint for the VFD output frequency is issued via the *analog input signal (AI 1: f/n setpoint)* at the I/O interface unit (-XS18) and the settings of the *Maximum frequency* and *Minimum frequency* parameters.

- If f/n control loop is set to *Open loop*, the analog setpoint signal ranges from 0 Hz to the highest permissible frequency.
- If f/n control loop is set to *Closed loop*, the analog setpoint signal ranges from 0 Hz to 100 %.

Setpoint via DI

The setpoint for the VFD output frequency is determined via the *binary states* of the *three digital inputs* for presetting the fixed setpoint frequency and the speed section set in parameter *Setpoint via DI*.

**NOTE**

This setting option only applies to *open* f/n control loop; it is not used for *closed* f/n control loop.

Setpoint via DCS

The setpoint for the VFD output frequency is issued via DCS communication protocol. The maximum setpoint frequency is defined by parameter *Maximum frequency.*

### *f/n control loop*

| **Parameter:** | **f/n control loop** |
|---|---|

This parameter defines the *working mode* of the *f/n control loop*.

**Setting options:**

Open loop

The *setpoint frequency* is set according to the *mode* set in parameter *Setpoint mode*:

- Setpoint via HMI, or
- Setpoint via AI, or
- Setpoint via DI, or
- Setpoint via DCS.

Closed loop

The *setpoint frequency* is controlled by the *internal PID-controller* of the VFD control system.

## FUNCTION PARAMETERS 2

These parameters can be modified during VFD operation, unless otherwise stated.

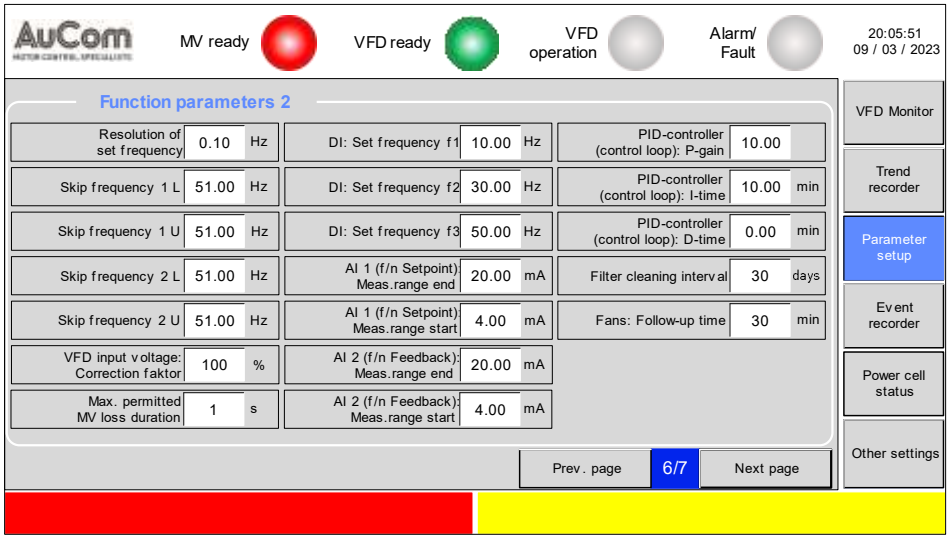



*Fig. 4-78 Main menu: Parameter setup – Function parameters 2*

### *PARAMETER OVERVIEW*

| Parameter name | Setting value (Default setting) | Unit | Setting range |
|---|---|---|---|
| Accuracy of set frequency | | | |
| Resolution of set frequency | 0.10 | Hz | 0.01 ... 1.00 Hz |
| Skip ranges of motor frequencies | | | |
| Skip frequency 1 L | 0.00 | Hz | 0.00 ... 80.00 Hz |
| Skip frequency 1 U | 0.00 | Hz | 0.00 ... 80.00 Hz |
| Skip frequency 2 L | 0.00 | Hz | 0.00 ... 80.00 Hz |
| Skip frequency 2 U | 0.00 | Hz | 0.00 ... 80.00 Hz |
| Measured value adjustment VFD input voltage | | | |
| VFD input voltage: correction factor | 50 | - | 50 ... 200 % |
| MV loss | | | |
| Max. permitted MV loss duration | 1 | s | 1 ... 100 s* |
| Preset fixed setpoint frequency | | | |
| DI Set frequency f1 | 10.00 | Hz | 0.00 ... 80.00 Hz |
| DI Set frequency f2 | 30.00 | Hz | 0.00 ... 80.00 Hz |
| DI Set frequency f3 | 50.00 | Hz | 0.00 ... 80.00 Hz |
| Analog inputs | | | |
| AI 1 (f/n Setpoint): Meas.range end | 20.00 | mA | 10.00 ... 25.00 mA |
| AI 1 (f/n Setpoint): Meas.range start | 4.00 | mA | 0.00 ... 8.00 mA |
| AI 2 (f/n Feedback): Meas.range end | 20.00 | mA | 10.00 ... 25.00 mA |
| AI 2 (f/n Feedback): Meas.range start | 4.00 | mA | 10.00 ... 25.00 mA |
| PID-controller: f/n control loop | | | |

| Parameter name | Setting value (Default setting) | Unit | Setting range |
|---|---|---|---|
| PID-controller (control loop): P-gain | 10.00 | - | 0.00 ... 50.00 |
| PID-controller (control loop): I-time | 10.00 | min | 0.01 ... 20.00 Min |
| PID-controller (control loop): D-time | 0.00 | min | 0.01 ... 20.00 Min |
| VFD maintenance | | | |
| Filter-cleaning interval | 30 | days | 15 ... 30000 days |
| VFD cooling | | | |
| Fans: Follow-up time | 30 | min | 0 ... 30 Min |

* 100 s ≙ instantaneous VFD trip

*Tab. 4-16 Function parameters 2 - Parameter overview*

### Parameter description

*ACCURACY OF SET FREQUENCY*

**Parameter: Resolution of set frequency**

Setting range: 0.01 ... 1.00 Hz

This parameter defines the *step size* with which the *frequency setpoint* is to be changed.

*SKIP RANGES OF MOTOR FREQUENCIES*

For certain applications, there are frequencies in which the drive *is not allowed* to be operated permanently. To prevent permanent operation within these frequency ranges, the VFD offers two adjustable frequency bands (skip ranges). In this way, you can avoid natural resonances of the mechanical system.

To define a skip frequency region, you must set two parameters for each skip frequency point:

- *Skip frequency x U*, for the *upper* cut-off frequency of the skip range, and
- *Skip frequency x L*, for the *lower* cut-off frequency of the skip range.

➢ Within the same skip frequency region, the *upper* limit frequency value must be *greater* than the *lower* limit frequency value.

➢ If two skip frequency points are defined, the setting of skip frequency 2 must be *greater* than skip frequency 1.

*Start-up and acceleration process:*

If the setpoint frequency is within a defined skip frequency range during motor acceleration or deceleration, the VFD will automatically adjust the output frequency to the upper limit of the skip frequency.

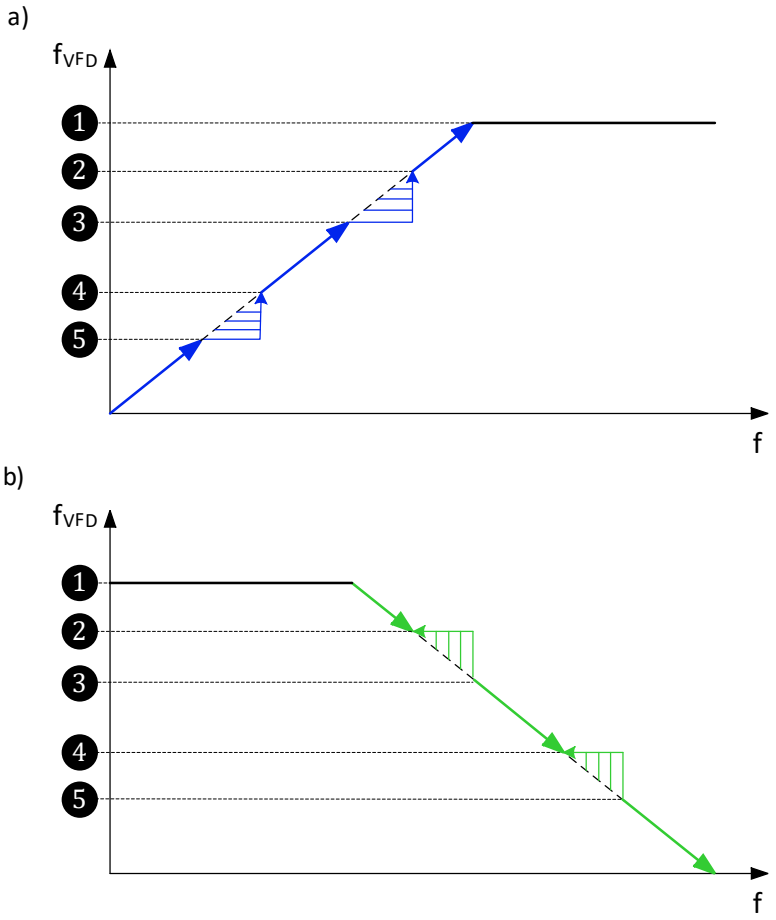



*Fig. 4-79 Frequency skip ranges for the VFD output frequency*
*a) Motor acceleration process*
*b) Motor deceleration process*

where: $f_{VFD}$: VFD output frequency
f: Set frequency
1 Maximum frequency
2 Upper Skip frequency 2 U
3 lower Skip frequency 2 L — frequency skip range 2
4 Upper Skip frequency 1 U
5 lower Skip frequency 1 L — frequency skip range 1

The following four parameters define two skip ranges for unwanted operating frequencies:

**Parameter: Skip frequency 1 L**

Setting range: 0.00 ... 80.00 Hz

This parameter defines the *lower* limit of the *first* frequency range to be skipped.

**Parameter: Skip frequency 1 U**

Setting range: 0.00 ... 80.00 Hz

This parameter defines the *upper* limit of the *first* frequency range to be skipped.

**Parameter: Skip frequency 2 L**

Setting range: 0.00 ... 80.00 Hz

This parameter defines the *lower* limit of the *second* frequency range to be skipped.

| Parameter: | Skip frequency 1 L |
|---|---|

Setting range:
0.00 ... 80.00 Hz

This parameter defines the *upper* limit of the *second* frequency range to be skipped.

### *MEASURED VALUE ADJUSTMENT VFD INPUT VOLTAGE*

| Parameter: | VFD input voltage: correction factor |
|---|---|

This parameter defines the *correction factor* for the measured value of the *VFD input voltage*.

**NOTE**

The correction factor for the VFD input voltage affects all VFD functions and algorithms that process the VFD input voltage as a calculation variable!

Setting range:
50 ... 200 %

- If the displayed measured value of the VFD input voltage is *smaller* than the measured value of the reference display, *increase* the parameter setting step by step until the measured value of the input voltage displayed in the VFD monitor *corresponds to* the reference display.
- If the displayed measured value of the VFD input voltage is *greater* than the measured value of the reference display, *decrease* the parameter setting step by step until the measured value of the input voltage displayed in the VFD monitor *corresponds to* the reference display.

### *MV LOSS*

| Parameter: | Max. permitted MV loss duration |
|---|---|

Setting range:
1 ... 100 s

This parameter defines the *time window* for a *maximum permissible MV loss duration* (MV mains failure duration) during which the VFD can perform an *automatic restart* if no STOP command is active.

**NOTE**

- This parameter only applies to the parameter setting *Automatic start after MV loss = Enable.*
- Parameter setting *Max. permitted MV loss duration = 100 s* deactivates the *MV voltage failure protection* and disables *automatic restart*.
- This parameter cannot be modified during VFD operation.
- For information on the VFD's response to a MV loss, see chapter „5.1.8 MV Mains Failure (MV Loss "

### *PRESET FIXED SETPOINT FREQUENCY*

The following three parameters define the fixed setpoint frequencies used to determine the VFD output frequency, provided the setpoint input is controlled via the binary coding of three digital inputs.

**NOTE**

- This parameter only applies to the parameter setting *Setpoint mode = Setpoint via DI.*

- For further information, refer to the description of parameter *Setpoint via DI.*
- This parameter cannot be modified during VFD operation.

**Parameter:** **DI: Set frequency f1**

Setting range: 0.00 ... 80.00 Hz

This parameter defines the *fixed setpoint f1* for DI *Set frequency 1* (terminal -XS1:1,7).

**Parameter:** **DI: Set frequency f2**

Setting range: 0.00 ... 80.00 Hz

This parameter defines the *fixed setpoint f2* for DI *Set frequency 2* (terminal -XS1:1,6).

**Parameter:** **DI: Set frequency f3**

Setting range: 0.00 ... 80.00 Hz

This parameter defines the *fixed setpoint f3* for DI *Set frequency 3* (terminal -XS1:1,5).

### *ANALOG INPUTS*

The following four parameters define the start and the end of the measuring range of transfer characteristics for the *Analog inputs AI 1* and *AI 2*. The *start point* and the *end point* of transfer characteristics are each defined by a pair of values:

| | AI measuring range | Measurement value scale |
|---|---|---|
| Start point value pair: | *Parameter* | Defined scale beginning |
| End point value pair: | *Parameter* | Defined scale end |

*Tab. 4-17 AI 1/2-Transfer characteristics: f/n setpoint/feedback [Hz] – Start and end points*

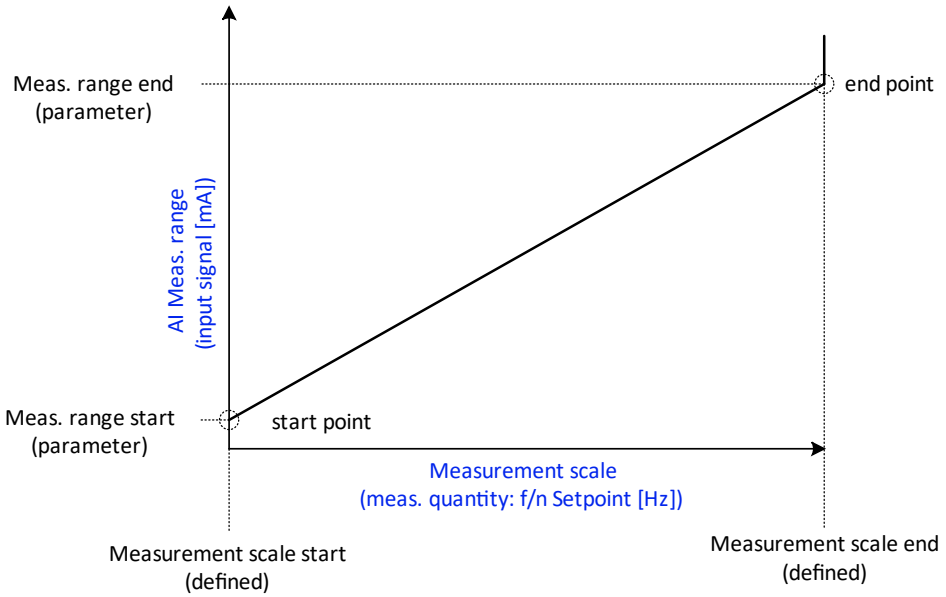



*Fig. 4-80 Analog input AI 1 – Transfer characteristics: f/n setpoint*

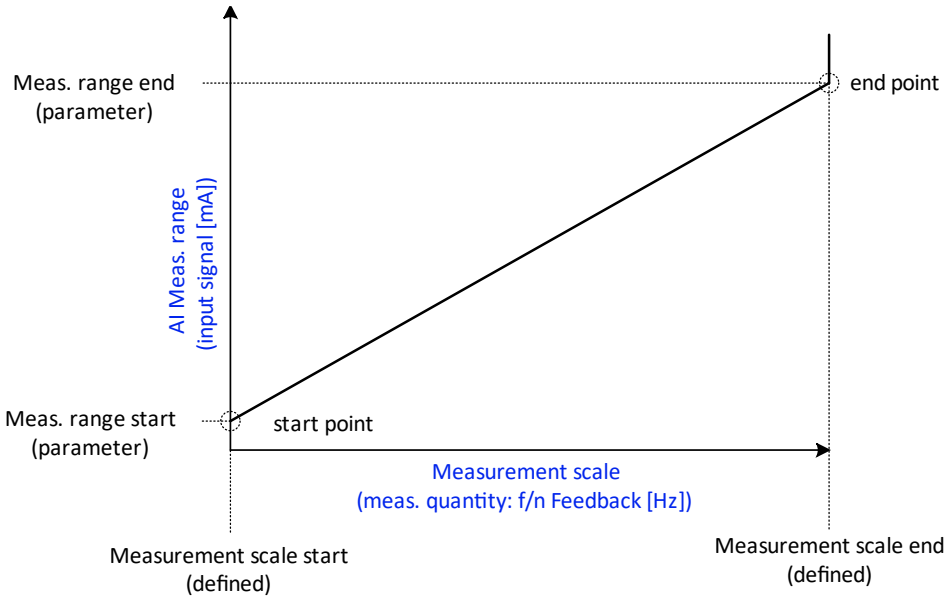



*Fig. 4-81 Analog input AI 2 – Transfer characteristics: f/n-Feedback*

**Parameter: AI 1 (f/n Setpoint): Meas.range end**

Setting range:
10.00 ... 25.00 mA

This parameter defines the *maximum input signal current* (measured range end) for *Analog input AI 1*, that can flow for the *maximum frequency setpoint* set in parameter *Maximum frequency* (measurement scale end).

**Parameter: AI 1 (f/n Setpoint): Meas.range start**

Setting range:
0.00 ... 8.00 mA

This parameter defines the *minimum input signal current* (measured range start) for *Analog input AI 1*, that can flow for the *minimum frequency setpoint of 0 Hz* (measurement scale start).

**Parameter: AI 2 (f/n Feedback): Meas.range end**

Setting range:
10.00 ... 25.00 mA

This parameter defines the *maximum input signal current* (measured range end) for *Analog input AI 2*, which should flow for the *maximum frequency feedback* set in parameter *Maximum frequency* (measurement scale end).

**Parameter: AI 2 (f/n Feedback): Meas.range start**

Setting range:
10.00 ... 25.00 mA

This parameter defines the *minimum input signal current* (measured range start) for *Analog input AI 2*, that can flow for the *minimum frequency feedback of 0 Hz* (measurement scale start).

***PID-CONTROLLER: f/n CONTROL LOOP***

For parameter setting *f/n control loop* = *Closed loop*, the *speed setpoint* is calculated by the internal PID-controller.

**NOTE**

- The following three PID parameters only apply to the parameter setting *f/n control loop* = *Closed loop.*
- You cannot modify this parameter during VFD operation.
- For further information, contact the manufacturer.

You can set the *f/n PID-controller* via the following three parameters:

**Parameter:** **PID-controller (control loop): P-gain**

Setting range: 0.00 ... 50.00

This parameter defines the *proportionality coefficient* of the P-control.

**Parameter:** **PID-controller (control loop): I-time**

Setting range: 0.01 ... 20.00 min

This parameter defines the *integral time* of the I-control.

**Parameter:** **PID-controller (control loop): D-time**

Setting range: 0.01 ... 20.00 min

This parameter defines the *differential time* of the D-control.

### *VFD MAINTENANCE*

**Parameter:** **Filter cleaning interval**

Setting range: 15 ... 30000 days

This parameter defines the *time interval* between each display of the message *Alarm: Clean air filter*.

**NOTE**

This reminder only applies to the parameter setting *Message: Clean air filter = Remind*.

### *VFD COOLING*

**Parameter:** **Fans: Follow-up time**

Setting range: 0 ... 30 min

This parameter sets the *follow-up time for the cooling fans*. It starts directly after switching off the VFD operation and returning to standby mode.

**NOTE**

To ensure cooling fans can operate, check that the auxiliary voltage for the fan supply is present after switching off the VFD operation.

## FUNCTION PARAMETERS 3

These parameters can be modified during VFD operation, unless otherwise stated.

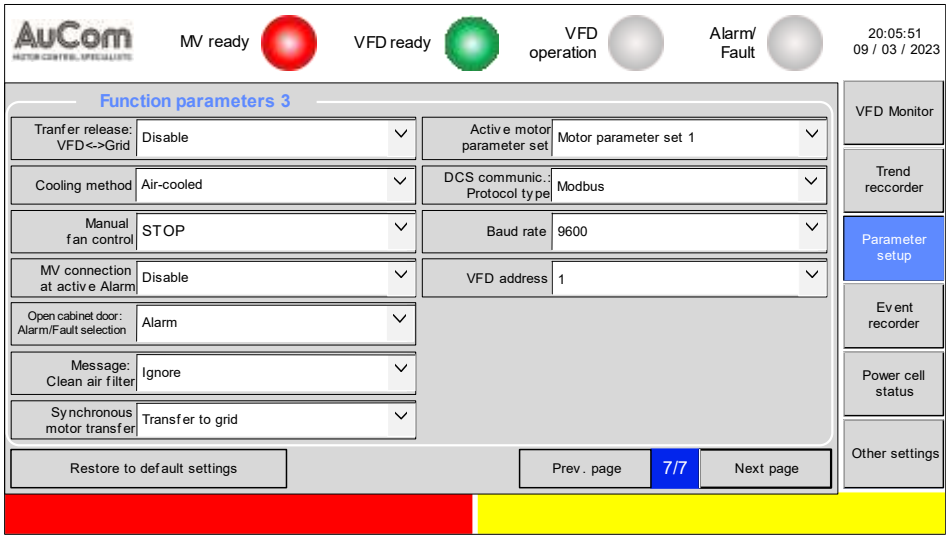



*Fig. 4-82 Main menu: Parameter setup – Function parameters 3*

### *PARAMETER OVERVIEW*

| Parameter name | Setting value (Default setting) | Unit | Setting options |
|---|---|---|---|
| Synchronous transfer | | | |
| Transfer release: VFD<->Grid | Disable | - | Disable / Enable |
| VFD cooling | | | |
| Cooling method | Air-cooled | - | Air-cooled / Water-cooled |
| Manual fan control | STOP | - | STOP<br>START |
| Alarm/Fault messages | | | |
| MV connection with active Alarm | Disable | - | Disable / Enable |
| Open cabinet door: Alarm/Fault selection | Alarm | - | Alarm/ Fault |
| VFD cooling | | | |
| Message: Clean air filter | Ignore | | Ignore / Remind |
| Synchronous transfer | | | |
| Synchronous motor transfer | Transfer to Grid | | Transfer to Grid / Transfer to VFD |
| Motor parameter sets | | | |
| Active motor parameter set | Motor parameter set 1 | - | Motor parameter set 1 / Motor parameter set 2 / Motor parameter set 3 / Motor parameter set 4 |
| Distributed control system (DCS) | | | |
| DCS communic.: Protocol type | Modbus | - | Modbus/ Profibus / |

| Parameter name | Setting value (Default setting) | Unit | Setting options |
|---|---|---|---|
| | | | Profinet |
| Baud rate | 9600 | Baud | 1200 / 4800 / 9600 / 19200 / 38400 |
| VFD address | 1 | - | 247 |

: function buttons

*Tab. 4-18 Function parameters 3 – Parameter overview*

### Parameter description

*SYNCHRONOUS TRANSFER*

**Parameter: Transfer release: VFD<->Grid**

This parameter enables/disables the activation of *synchronous transfer* of the motor between the VFD and MV mains (grid) via digital input (DI) *Synchronous transfer start* (terminals -XS2:1,8) on the I/O interface unit (PLC).

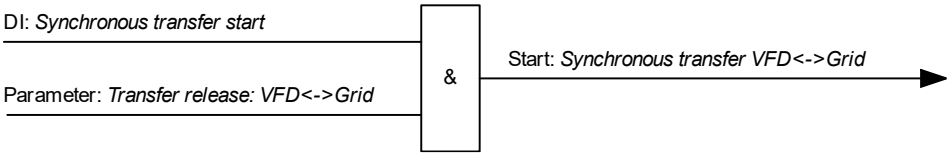



*Fig. 4-83 Block diagram – Release for synchronous changeover VFD<->Grid via DI*

**Setting options:**

Disable — Synchronous transfer VFD<->Grid via DI is *not released*.

Enable — Synchronous transfer VFD<->Grid via DI is *released*. Motor transfer is enabled to start via DI *Synchronous transfer start*:

- DI is inactive: no function
- DI is active: Synchronous transfer VFD<->Grid starts.

**NOTE**

You can set the transfer direction (*Transfer to grid* or *Transfer to VFD*) in parameter *Synchronous motor transfer*.

*VFD COOLING*

**Parameter: Cooling method**

This parameter defines the *cooling method* used for the VFD.

**Setting options:**

Air-cooled — VFD cooling by ventilation

Water-cooled — VFD cooling by water

**Parameter: Manual fan control**

You can use these *buttons* to *switch the fans on and off* manually for service and commissioning purposes.

**NOTE**

- The function buttons apply to both VFD modes, *Test* and *Operation*.
- During VFD operation, the VFD system takes over fan control.
- When the VFD is in standby (*VFD mode = Test* or *Operation*), you can control the fans via the function buttons.

**Function buttons:**

| | |
|---|---|
| STOP | Tap this button to turn off the cooling fans. |
| START | Tap this button to turn on the cooling fans. |

### *ALARM/FAULT MESSAGES*

**Parameter: MV connection at active Alarm**

This parameter defines, whether an *active alarm message*:

- will trip the VFD (if the VFD is running) or block connection to the medium voltage (if the VFD is in standby)
- let the VFD continue to run (if the VFD is already running) or allow connection to the medium voltage (if the VFD is in standby).

**Setting options:**

| | |
|---|---|
| Disable | The VFD will trip or connection to the medium voltage is blocked when an alarm occurs. |
| Enable | The VFD continues to run or connection to the medium voltage is allowed when an alarm occurs. |

**Parameter: Open cabinet door: Alarm/Fault selection**

This parameter defines the *behaviour of the VFD* when *the cabinet door* is opened during VFD operation. This setting applies to both, the power cell cabinet door, and the transformer cabinet door.

**Setting options:**

| | |
|---|---|
| Alarm | When opening a door of the cell cabinet or transformer cabinet, the following message is displayed:<br>• *Alarm: Door alarm cell cabinet*, or<br>• *Alarm: Door alarm transformer cabinet*<br>The VFD remains in operation. |

**WARNING**

Danger due to electric shock!

For parameter setting *Open cabinet door: Fault selection = Alarm*, the VFD is *not switched off* when a door of the power cell cabinet is opened during VFD operation or VFD standby!

- Never open a door of the power cell / transformer cabinet during VFD operation or VFD standby!
- Before opening a door of the power cell / transformer cabinet, always disconnect the VFD from the medium voltage and earth it.

| | |
|---|---|
| Fault | When opening a door of the cell cabinet or transformer cabinet, the following message is displayed:<br>• *Fault: Door alarm cell cabinet, or*<br>• *Fault: Door alarm transformer cabinet*<br>Der VFD is switched off. |

### *VFD COOLING*

| Parameter: | Message: Clean air filter |
|---|---|

This parameter enables/disables the display of the reminder message *Alarm: Clean air filter*.

**Setting options:**

| | |
|---|---|
| Remind | The reminder message will be displayed cyclically according to the setting of parameter *Filter cleaning interval.* |
| Ignore | No reminder message will be displayed. |

### *SYNCHRONOUS TRANSFER*

| Parameter: | Synchronous motor transfer |
|---|---|

This parameter defines the *motor transfer direction* for the *synchronous transfer function*.

**Setting options:**

| | |
|---|---|
| Transfer to Grid | The motor is switched from the VFD to the MV mains (grid). |
| Transfer to VFD | The motor is switched from the MV mains to the VFD. |

### *MOTOR PARAMETER SETS*

The VFD can store four different motor parameter sets to support operation of multiple motors. One VFD can be used to operate different motors, or a single motor can be operated in different modes.

Each parameter set includes *Motor parameters 1* and *Motor parameters 2*.

| Parameter: | Active motor parameter set |
|---|---|

This parameter defines the *active motor parameter set* for the VFD.

**NOTE**

This parameter cannot be modified during VFD operation.

**Setting options:**

| | |
|---|---|
| Motor parameter set 1 | The VFD uses the *motor parameter settings* saved in *Motor parameter set 1*. |
| Motor parameter set 2 | The VFD uses the *motor parameter settings* saved in *Motor parameter set 2*. |
| Motor parameter set 3 | The VFD uses the *motor parameter settings* saved in *Motor parameter set 3*. |
| Motor parameter set 4 | The VFD uses the *motor parameter settings* saved in *Motor parameter set 4*. |

### *DISTRIBUTED CONTROL SYSTEM (DCS)*

The MVH 2.0 offers different protocol to enable VFD communication within a fieldbus system (DCS).

You can use the following three parameters to adapt the control unit to the desired communication protocol.

**NOTE**

- These parameters *cannot* be modified during VFD operation.
- The VFD is always a *slave* node on the fieldbus network. The fieldbus system itself is the *master* node.

**Parameter: DCS communic.: Protocol type**

This parameter defines the *communication protocol* of the VFD within a distributed control system (DCS).

**Setting options:**

| | |
|---|---|
| Modbus | The VFD supports Modbus RTU (using an RS485 interface). |
| Profibus | The VFD supports Profibus DP (on request). |
| PROFINET | The VFD supports Profinet (on request). |

**Parameter: Baud rate**

This parameter defines *symbol rate* for data transmission.

Definition *Symbol rate*: Number of symbols transmitted per second, unit: [Baud], abbreviation: [Bd]

**NOTE**

You must set the same baud rate on both the transmitter and receiver sides.

**Setting options:**

| | |
|---|---|
| 1200 | Baud |
| 4800 | Baud |
| 9600 | Baud |
| 19200 | Baud |
| 38400 | Baud |

**Parameter: VFD address**

| | |
|---|---|
| Setting range: 1 ... 247 | This parameter defines the address of the RS485 interface that is valid for the VFD (terminals -XS17:1,2,3) for *Modbus RTU* communication protocol. |

### 4.6.4 MAIN MENU: EVENT RECORDER

Events generated or captured by the VFD are logged by the event recorder as:

- *operating* events,
- *alarm* events, or
- *fault* events.

Events are stored according to the FIFO principle (First-In-First-Out). This means that when the maximum number of stored events is reached, the next (newest) event overwrites the oldest.

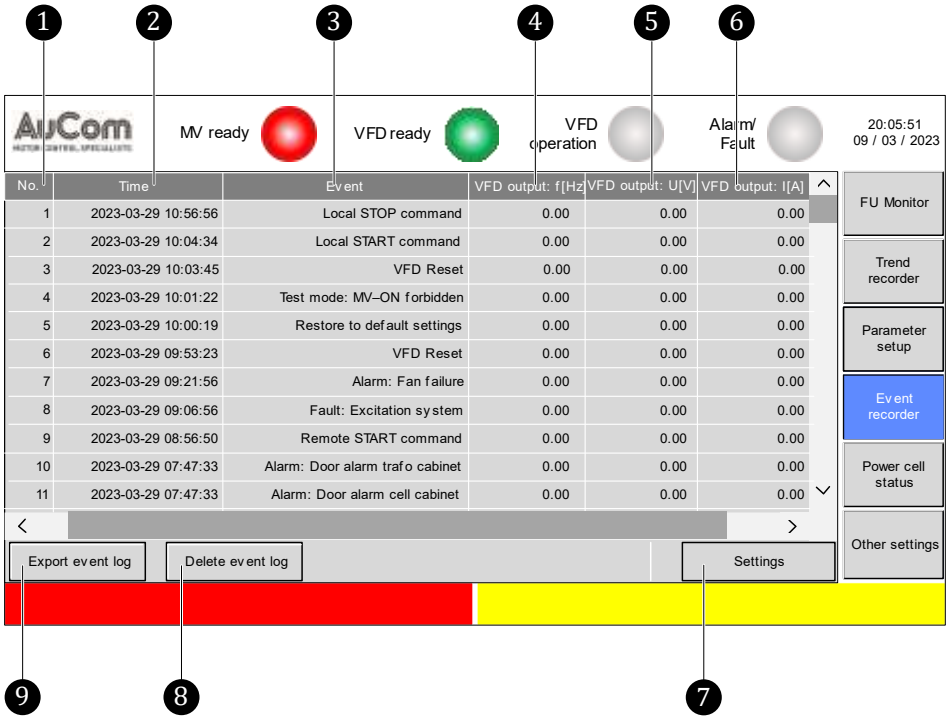



*Fig. 4-84 Main menu – Event recorder*

1. *No.*: consecutive number of the event
2. *Time*: time stamp of the event
3. *Event*: clear text describing the event
4. *VFD output.: f[Hz]*: Measured value of the VFD output frequency (RUN frequency) at the time of event recording
5. *VFD output.: U[V]*: Measured value of the VFD output voltage at the time of event recording
6. *VFD output.: I[A]*: Measured value of the VFD output current at the time of event recording
7. *Settings*: Access to parameters used to define the period during which the events are to be displayed or saved.
8. Button to delete all recorded events
9. Button to export all recorded events

***CONSECUTIVE NUMBER*** Each event entry is assigned a *consecutive number*. The last event entry is always displayed on the first line with number "1". The previous event entry is displayed the second line with number "2", etc. With each new event entry, all previous entries move down one line and their number is changed accordingly.

***TIME STAMP*** Each event entry is assigned a *time stamp* with the *date* and *time* at which the event message was generated by the VFD control unit.

***EVENTS - PLAIN TEXT MESSAGES***

For each event entry, the *plain text* of the message is given in the *Event* column. The message indicates the cause of the event, which correlates to either an **alarm** message, a *fault* message, or an *operational* message.

**CHAPTER REFERENCE**

➢ For the complete list of available *alarm* and *fault messages,* refer to chapter „7.1 Alarm/Fault – Causes and Remedy".

***MEASURED OPERATING VALUES - SNAPSHOT***

When the VFD is in operation or the virtual motor has been started in *Test* mode, the following operating readings are recorded as a *snapshot* at the time a registered event is detected:

- Measured VFD output frequency (RUN frequency) [Hz]
- Measured VFD output voltage [V], *VFD operation only*
- Measured VFD output current [A], *VFD operation only*

***BUTTON: DELETE EVENT LOG***

Tap the *Delete event log* button to delete *all entries* in the event log.

**NOTE**

The function key *Clear Event Log* is only available for user level *Engineer* or higher.

***BUTTON: EXPORT EVENT LOG***

Tap the *Export event log* button to save the *current event log*.

***"SETTINGS" MENU***

Tap this menu button to open the parameter menu *Set time range* and set the *display period* of the recorded events as well as its *time stamps*. Four different *configuration modes* are available for this purpose:

- *All storage data*
- *Recent time*
- *Fixed time*
- *Given time*

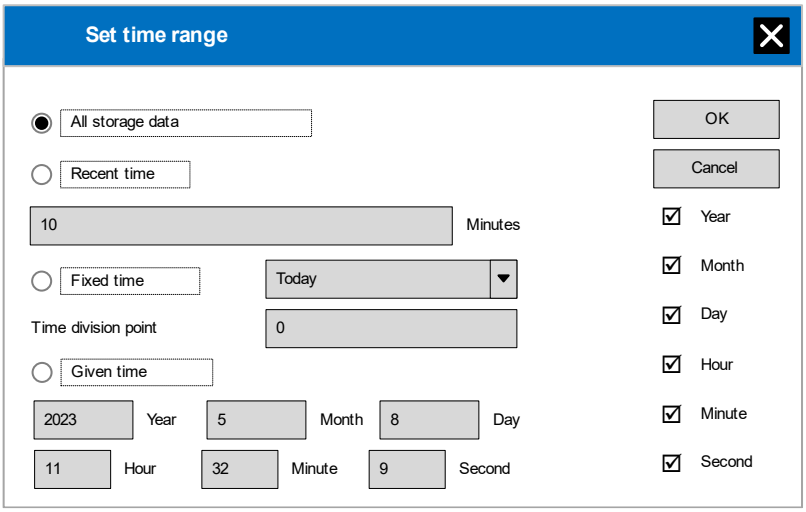



*Fig. 4-85 "Set time range" menu – Display period and time stamp configuration for event recording*

◉: enabled ☑: date displayed
○: disabled ☐: date not displayed

*PARAMETER OVERVIEW*

| Parameter name | Setting value (Default setting) | Setting range or setting options |
|---|---|---|
| Configure display period | | |
| All storage data | ◉ | ○ / ◉ |
| Recent time | ○ | ○ / ◉ |
| (Numerical value) | 10 | 0 ... 3.57914e+07 Minute |
| Fixed time | ○ | ○ / ◉ |
| (Dropdown menu) | Today | Today / This month / This week / Previous day / Previous month / Previous week |
| Time division point | 1 | 0 ... 23 (Today) / 1 ... 31 (This month) / 1 ... 7 (This week) / 0 ... 23 (Previous day) / 1 ... 31 (Previous month) / 1 ... 7 (Previous week) |
| Given time | ○ | ○ / ◉ |
| Year | (Current year) | 1970 ... 2036 |
| Month | (Current month) | 1 ... 12 |
| Day | (Current day) | 1 ... 31 |
| Hour | (Current hour) | 0 ... 23 |
| Minute | (Current minute) | 0 ... 59 |
| Second | (Current second) | 0 ... 59 |
| Configure displayed event time stamp | | |
| Year | ☑ | ☐ / ☑ |
| Month | ☑ | ☐ / ☑ |
| Day | ☑ | ☐ / ☑ |
| Hour | ☑ | ☐ / ☑ |
| Minute | ☑ | ☐ / ☑ |
| Second | ☑ | ☐ / ☑ |

*Tab. 4-19 Event recorder - Display period and time stamp configuration for event recording*

### 4.6.5 MAIN MENU: POWER CELL STATUS

This menu shows the *status* of the existing power cells.

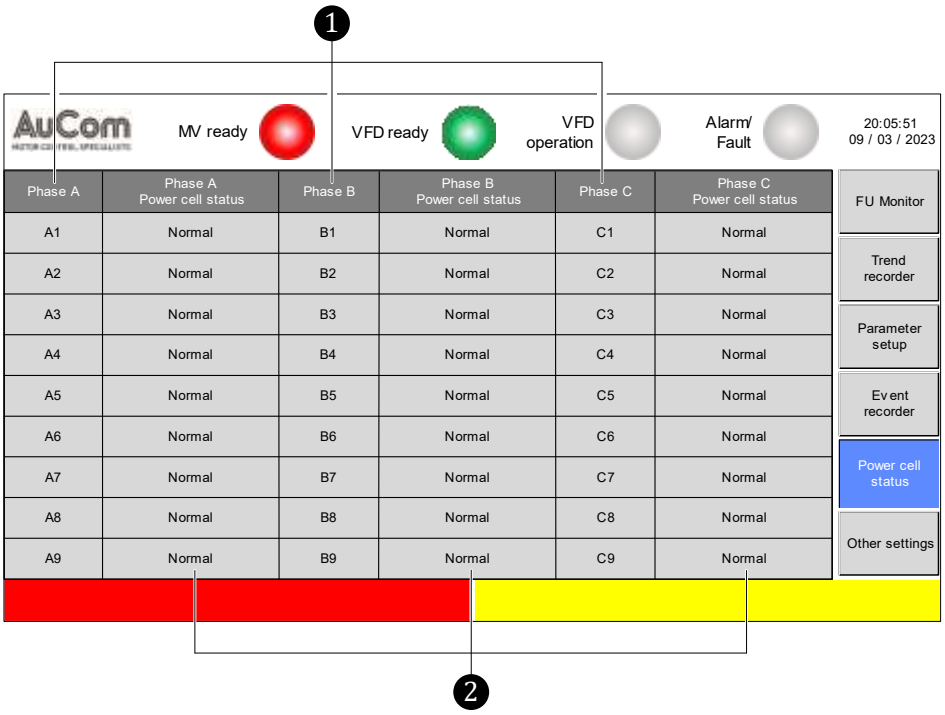



*Fig. 4-86 Main menu – Power cell status*

1. Power cells of the corresponding phases A, B and C for the three-phase voltage system formed at the VFD output.
2. Status displays of each individual power cells for phases A, B and C

***COLUMNS: PHASE A, PHASE B, PHASE C***

Depending on the performance class of the VFD, the individual power cells for a given phase are displayed and numbered in the columns *Phase A, Phase B* and *Phase C*.

***COLUMNS: PHASE A POWER CELL STATUS, PHASE B POWER CELL STATUS, PHASE C POWER CELL STATUS***

Each individual *power cell* is *permanently checked for availability* by the VFD control unit. The *status* is displayed as follows:

| Power cell status | Description |
|---|---|
| Normal | Power cell is ready for operation |
| Unknown state | Power cell is *not* ready for operation |

*Tab. 4-20 Power cells – Availability*

***POWER CELLS SELF-TEST***

Immediately after switching on the VFD, the control unit performs a *self-test* for each power cell. When all power cells have successfully completed the self-test, the VFD switches to standby mode.

In the event of a failed self-test or failure of the bypass unit of a power cell during operation, the VFD displays the message *Fault: Power cell* or *Alarm: Power cell bypass* for the affected power cell.

### 4.6.6 MAIN MENU: OTHER SETTINGS

The following figure shows the structure of the *Other settings* main menu.

| Menu level 1 | Menu level 2 | Menu level 3 |
|---|---|---|
| Other settings | | |
| | Other systems | |
| | | Monitoring: Water cooling transformer cabinet |
| | | Monitoring: Water cooling cell cabinet |
| | | Monitoring: Cell bypass units |
| | | Temperature monitoring |
| | Precharge System | |
| | Excitation system | |
| | Exitation monitor | |
| | Excitation options | |
| | Excitation parameters | |
| | Operating hours | |
| | SW versions | |
| | User center | |
| | | System settings |
| | | Change password |
| | | User Login |

*Tab. 4-21 Structure of the "Other settings" main menu*

#### MENU: OTHER SYSTEMS

The *Other systems* main menu contains four submenus:

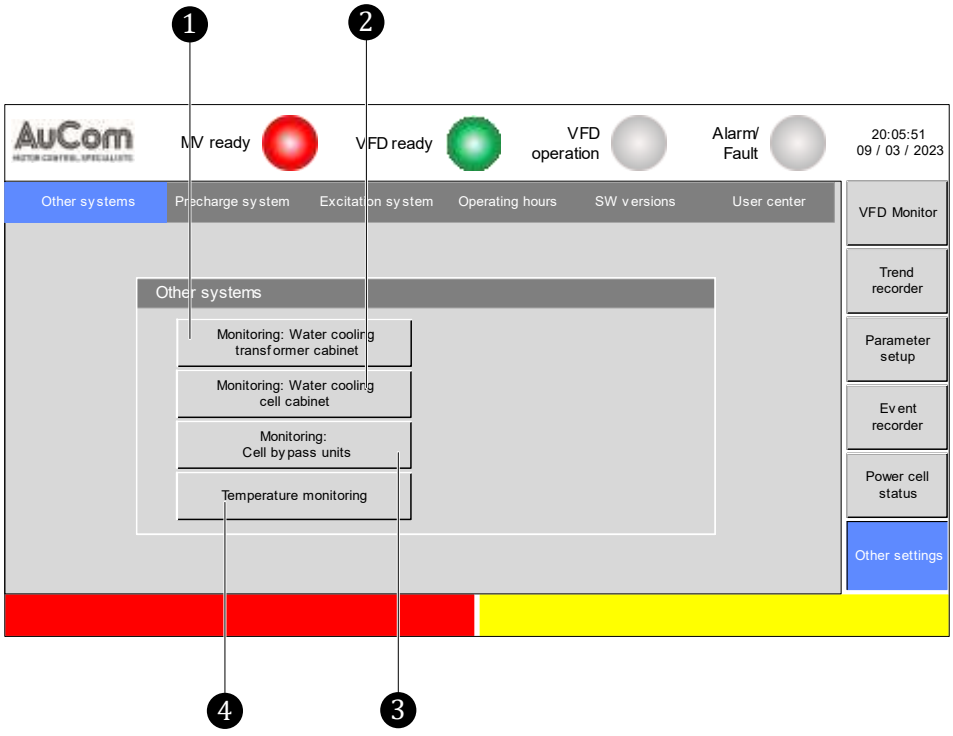



*Fig. 4-87 Menu: Other systems*

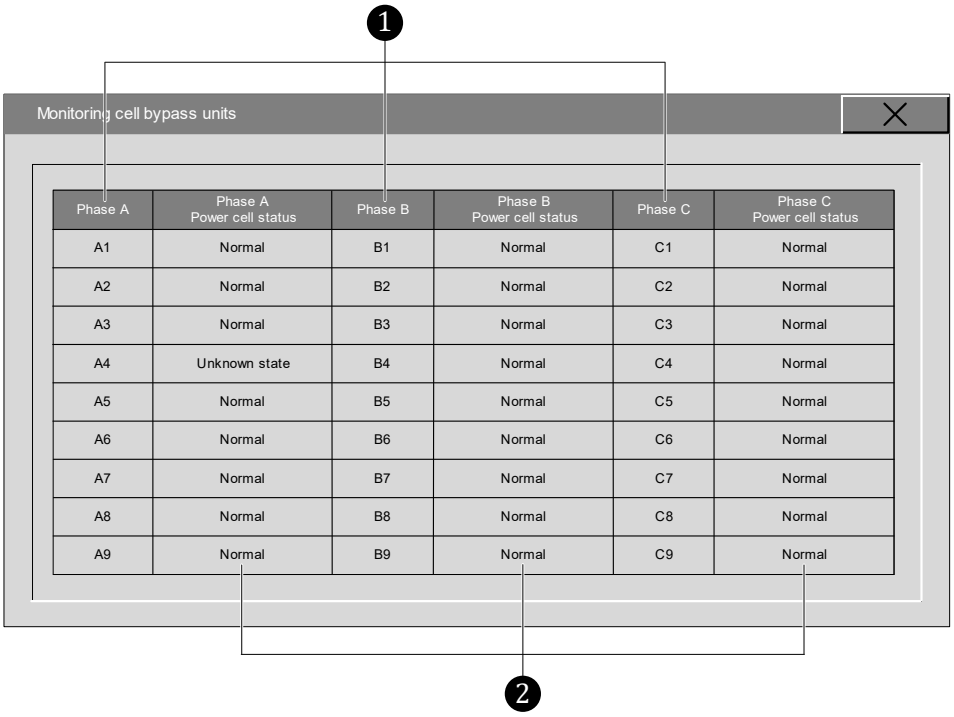
1. Menu: Monitoring water cooling transformer cabinet
2. Menu: Monitoring water cooling cell cabinet
3. Menu: Monitoring power cell bypass units
4. Menu: Temperature monitoring

**Menu: *Monitoring water cooling transformer cabinet***

**Menu: *Monitoring water cooling cell cabinet***

**Menu: *Monitoring power cell bypass units***

This menu shows the *status* for each individual *cell bypass unit* of the existing power cells.




| Phase A | Phase A Power cell status | Phase B | Phase B Power cell status | Phase C | Phase C Power cell status |
|---|---|---|---|---|---|
| A1 | Normal | B1 | Normal | C1 | Normal |
| A2 | Normal | B2 | Normal | C2 | Normal |
| A3 | Normal | B3 | Normal | C3 | Normal |
| A4 | Unknown state | B4 | Normal | C4 | Normal |
| A5 | Normal | B5 | Normal | C5 | Normal |
| A6 | Normal | B6 | Normal | C6 | Normal |
| A7 | Normal | B7 | Normal | C7 | Normal |
| A8 | Normal | B8 | Normal | C8 | Normal |
| A9 | Normal | B9 | Normal | C9 | Normal |

*Fig. 4-88 Menu: Monitoring power cell bypass units*

1. Power cells of the corresponding phases A, B and C for the three-phase voltage system formed at the VFD output
2. Status display of the cell bypass unit for each individual power cell for phases A, B and C

***COLUMNS: PHASE A, PHASE B, PHASE C***

Depending on the performance class of the VFD, the individual power cells of a given phase are displayed and numbered in the columns *Phase A, Phase B* and *Phase C*.

***COLUMNS: PHASE A POWER CELL STATUS, PHASE B POWER CELL STATUS, PHASE C POWER CELL STATUS***

Each individual *power cell bypass unit* is *permanently checked for availability* by the VFD control unit. The *status* is displayed as follows:

| Status of the cell bypass unit | Description |
|---|---|
| Normal | Cell bypass unit is ready for operation |
| Unknown state | Cell bypass unit is *not* ready for operation |

*Tab. 4-22 Power cell bypass units – Availability*

The status of each power cell bypass unit is updated cyclically.

*POWER CELL BYPASS UNITS SELF-TEST*

Immediately after switching on the VFD, the control unit performs a *self-test* for each *power cell bypass unit*. When all power cell bypass units have successfully completed the self-test, the VFD switches to standby mode.

In the event of a failed self-test or failure of the bypass unit of a power cell during operation, the VFD displays the message *Alarm: Power cell bypass* for the affected power cell.

### Menu: *Temperature monitoring*

The VFD offers optional measured value acquisition from up to 15 temperature sensors:

- 12 sensors for *motor* temperature (optional: 3 x Simatic modules with 4 x PT100 inputs each)
- 3 sensors for *transformer* temperature (standard: 1 x Simatic module with 4 x PT100 inputs)

The *Temperature monitoring* menu has two menu pages:

- *Measured values* displays the temperatures on the touchscreen (HMI).
- *Settings* allows you to edit temperature designations, configure the display on the touchscreen, and set limit values for alarm and fault messages.

*TEMPERATURE MONITORING – MEASURED VALUES*

The *Measured values* menu page shows the current temperature measured by the temperature sensors connected to the VFD.

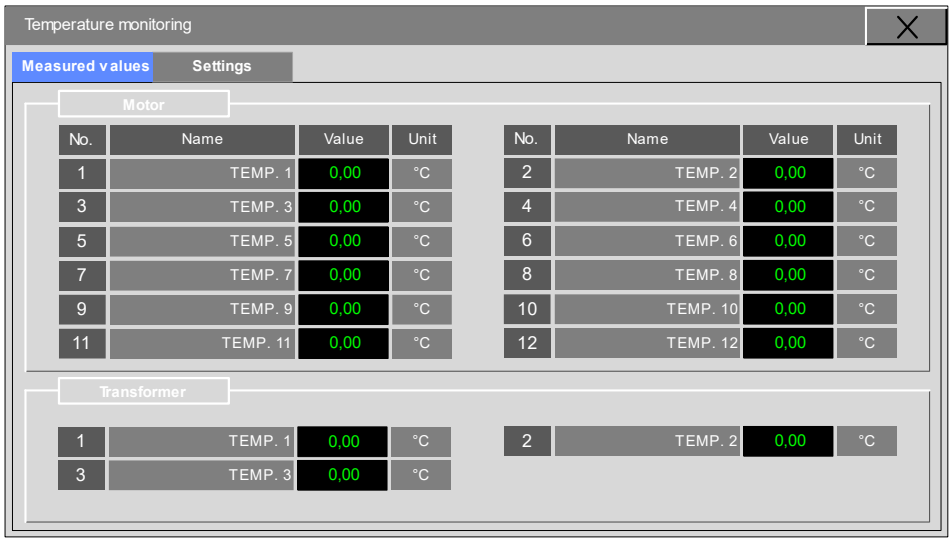



*Fig. 4-89 Temperature monitoring – Measured values*

*TEMPERATURE MONITORING – SETTINGS*

With the *Settings* menu you can configure information display on the *Measured values* page. You can also configure *alarm/fault handling* in the event of transformer or motor *overtemperature*.

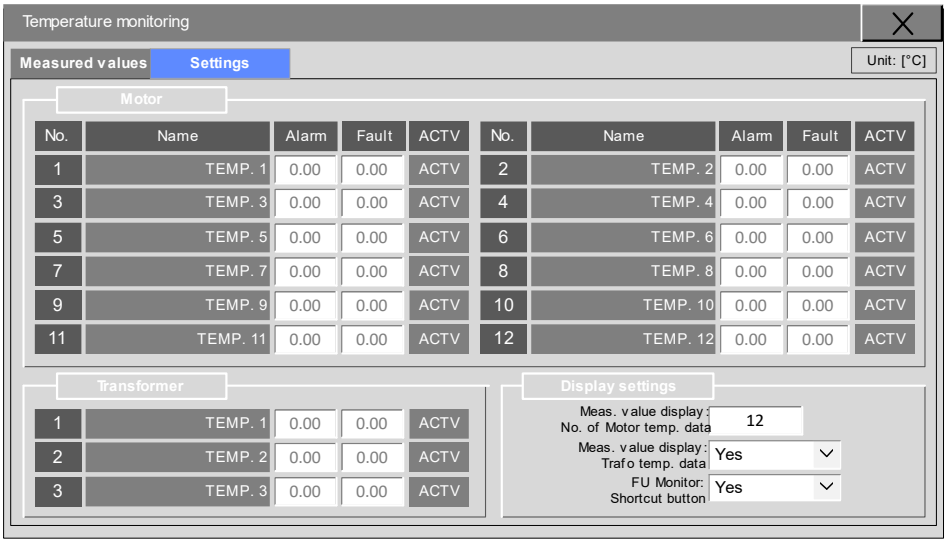



*Fig. 4-90 Temperature monitoring – Settings*

## Parameter description

### *MOTOR / TRANSFORMER*

**Parameter: Name**

Use this parameter to edit the temperature sensor's message to be displayed.

**Editing via keypad**


*Fig. 4-91 Editing via keypad*

**CHAPTER REFERENCE**

➢ For parameter setting see chapter „4.5.6 Changing Parameter Settings (General)".

### *ALARM AND FAULT MESSAGES*

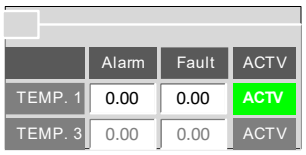



*Fig. 4-92 Example: Setting TEMP. 1*

To set *Alarm* and *Fault* parameters for a specific temperature, first tap the corresponding activation field *ACTV*.

➢ The *AKTV* field is highlighted green.

➢ The digits under *Alarm* and *Fault* parameters turn from grey to black.

➢ To set the temperature limits, tap in the *Alarm* and *Fault* fields and edit the value as needed.

The following table shows the different insulation classes according to IEC 60085, IEC 60034-1, as well as the *Alarm* and *Fault* temperature limits.

| Insulation class | Max. permissible continuous temperature at nominal operation [°C] | Limit temperature: *Alarm* [°C] | Limit temperature: *Fault* [°C] |
|---|---|---|---|
| B | 130 | 110 | 120 |
| F | 155 | 130 | 140 |
| H | 180 | 155 | 165 |

*Tab. 4-23 Insulation classes and temperature limits*

**Parameter:** **Alarm**

This parameter defines the *overtemperature limit* for the output of an *alarm* message.

**Setting via numeric keypad**


*Fig. 4-93 Parameter setting via numeric keypad*

**CHAPTER REFERENCE**

➢ For parameter setting see chapter „4.5.6 Changing Parameter Settings (General)".

**Parameter:** **Fault**

This parameter defines the *overtemperature limit* for the output of a *fault* message.

**Setting via numeric keypad**


*Fig. 4-94 Parameter setting via numeric keypad*

➢ CHAPTER REFERENCE

For parameter setting see chapter „4.5.6 Changing Parameter Settings (General)".

## *DISPLAY SETTINGS*

**Parameter:** **Meas. value display: No. of Motor temp. data**

Setting range: 0 ... 12

This parameter defines the *number of motor temperature readings* shown on the display.

**Parameter:** **Meas. value display: Trafo temp. data**

This parameter defines whether the *transformer temperature readings* will be *displayed or not*.

**Setting options:**

No — Transformer temperatures 1 to 3 are *not displayed* on the measured values menu page.

Yes — Transformer temperatures 1 to 3 are *displayed* on the measured values menu page.

**Parameter:** **VFD-Monitor: Shortcut button**

This parameter enables/disables the *shortcut button in the VFD Monitor* menu to call up the *Temperature monitoring* menu directly.

**Setting options:**

| | |
|---|---|
| No | The shortcut button is *disabled*. |
| Yes | The shortcut button is *enabled*. |

## MENU: PRECHARGE SYSTEM

(Description will follow.)

## MENU: EXCITATION SYSTEM

When powering *synchronous* motors, the VFD provides the following excitation adjustment functions:

- Change the *startup sequence* of the VFD and the excitation system to suit the startup requirements of a brushed or brushless synchronous motor.
- Change the *field excitation current* to improve the power factor of the motor during operation.
- During synchronous transfer to line, the synchronous switching can be made more stable by changing the control mode of the field excitation current.

**NOTE**

This menu can only be accessed if *VFD type* parameter is set to *synchronous* motor type and the setting have been saved in the controller via the *Parameter download* button (see "4.6.3 Main Menu: Parameter Setup").

This menu is divided into three sections:

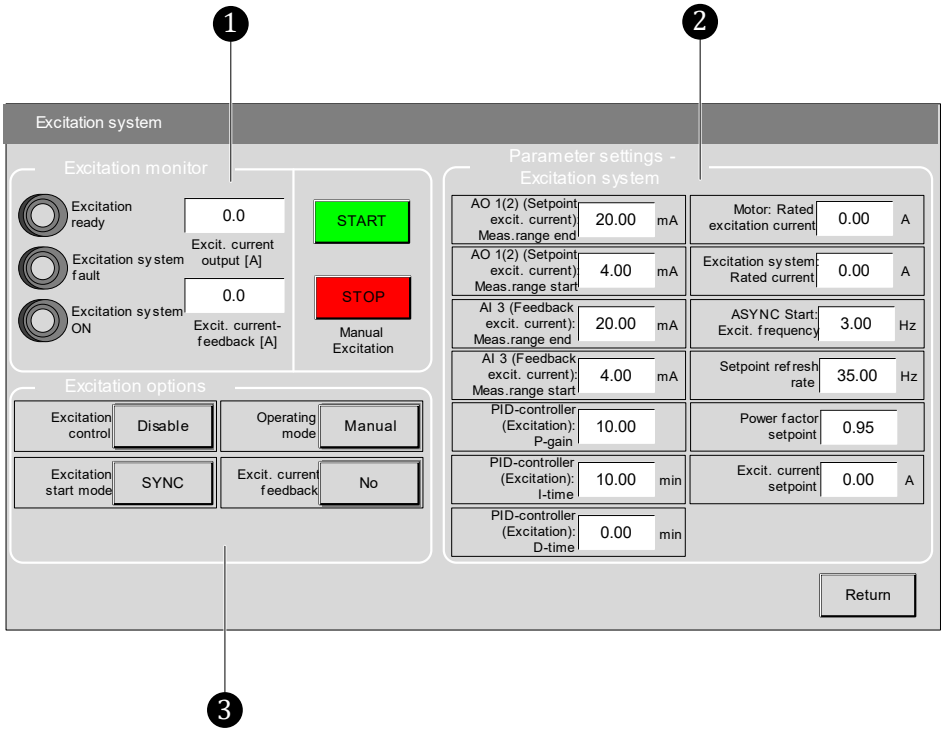



*Fig. 4-95 Menu: Excitation system*

1. Excitation monitor
2. Parameter settings – Excitation system
3. Excitation options

***EXCITATION MONITOR***

Status and measured value *display* as well as start/stop *control* for the excitation process.

***INDICATION ELEMENTS***

| LED indications | | |
|---|---|---|
| **LED name** | **Colour code** | **Description** |
| Excitation ready | grey  | Signal from external excitation field to PLC:<br>DI (-XS2:1,7) *Excitation system ready* is inactive. |
| | green  | Signal from external excitation field to PLC:<br>DI (-XS2:1,7) *Excitation system ready* is active: |
| Excitation system fault | grey  | Signal from external excitation field to PLC:<br>DI (-XS2:1,5) *Excitation system fault* is inactive. |
| | red  | Signal from external excitation field to PLC:<br>DI (-XS2:1,5) *Excitation system fault* is active: |
| Excitation system ON | grey  | Signal from external excitation field to PLC:<br>DI (-XS2:1,6) *Excitation system ON* is inactive. |
| | green  | Signal from external excitation field to PLC:<br>DI (-XS2:1,6) *Excitation system ON* is active. |

*Tab. 4-24 Excitation monitor – Status LEDs*

| Measurement readings | | |
|---|---|---|
| **Meas. quantity** | **Meas. range** | **Description** |
| Excit. current setpoint [A] | 0.1 ... 1600.0 A | Excitation current *setpoint* depending on excitation control |
| Excit. current feedback [A] | 0.0 ... 1600.0 A | Excitation current *feedback* depending on excitation control |

*Tab. 4-25 Excitation monitor – Measurement readings of excitation current*

***OPERATING ELEMENTS***

| Manueller Start/Stop excitation | |
|---|---|
| **Function button** | **Description** |
| START | Tap this button to activate the digital output (DO)<br>*Sync.Motor: Excitation ON/OFF* (-XS13:9,10) |
| STOP | Tap this button to deactivate the digital output (DO)<br>*Sync.Motor: Excitation ON/OFF* (-XS13:9,10) |

*Tab. 4-26 Manual Start/Stop of excitation system – Operating elements*

***EXCITATION OPTIONS***

Configuration of the *start mode* and the *operating mode* for the *excitation system*.

**Parameters**

| Parameter name | Setting value (Default setting) | Setting options |
|---|---|---|
| Excitation control | Disable | Disable / Enable |
| Excitation start mode | ASYNC | ASYNC / SYNC |
| Operating mode | Manual | Manual /<br>Constant power factor |
| Excitation feedback | No | No / Yes |

*Tab. 4-27 Excitation options – Parameters*

**Parameter description**

| Parameter: | Excitation control |
|---|---|

This parameter enables/disables the *excitation system function*.

| | |
|---|---|
| Disable | Excitation system is disabled. |
| Enable | Excitation system is enabled. |

| Parameter: | Excitation start mode |
|---|---|

This parameter defines the *start-up variant* for the synchronous motor: starting requirements for a *brushed* or *brushless* synchronous motor.

| | |
|---|---|
| ASYNC | The synchronous motor is ramped up to its rated frequency like an asynchronous motor. As soon as the nominal frequency is reached, the excitation is switched on and the motor pulls up to the synchronous speed. |
| SYNC | The synchronous motor is started immediately with excitation switched on. |

| Parameter: | Operating mode |
|---|---|

This parameter defines the *operating mode* for the *excitation system function*.

| | |
|---|---|
| Manual | The motor is operated with the value set in parameter *Excit. current setpoint*. |
| Constant power factor | The motor is operated with the value set in parameter *Power factor setpoint*. |

| Parameter: | Excit. current feedback |
|---|---|

This parameter defines the *presence* of an *excitation current feedback* (actual excitation current).

| | |
|---|---|
| No | There is *no feedback* of the excitation current. Excitation current control with a closed control loop is *not possible*. |
| Yes | The actual excitation current is *fed back* via the *Analog input AI 3*. Excitation current control with a closed control loop is *possible*. |

*PARAMETER SETTINGS – EXCITATION SYSTEM*

**Parameters**

| Parameter name | Setting value (Default setting) | Unit | Setting range |
|---|---|---|---|
| Setpoint setting: Excitation current | | | |
| AO 1(2) (Setpoint excit. current): Meas.range end | 0.00 | mA | 10.00 ... 25.00 mA |
| AO 1(2) (Setpoint excit. current): Meas.range start | 0.00 | mA | 0.00 ... 8.00 mA |
| Feedback: Excitation current | | | |
| AI 3 (Feedback excit. current): Meas.range end | 0.00 | mA | 0.00 ... 25.00 mA |
| AI 3 (Feedback excit. current): Meas.range start | 0.00 | mA | 0.00 ... 8.00 mA |
| PID-controller: Excitation control | | | |
| PID-controller (Excitation): P-gain | 0.00 | - | 0.00 ... 20.00 |

| Parameter name | Setting value (Default setting) | Unit | Setting range |
|---|---|---|---|
| PID-controller (Excitation): I-time | 0.10 | min | 0.10 ... 20.00 min |
| PID-controller (Excitation): D-time | 0.10 | min | 0.00 ... 30.00 min |
| Excitation system: Rated values | | | |
| Motor: Rated excitation current | 0.0 | A | 0.1 ... 1600.0 A |
| Excitation system: Rated current | 0.0 | A | 0.0 ... 1600.0 A |
| ASYNC Start: Excitation frequency | 0.00 | Hz | 0.00 ... 80.00 Hz |
| Setpoint refresh rate | 0.00 | Hz | 0.00 ... 80.00 Hz |
| Operating mode: Constant power factor | | | |
| Power factor setpoint | 0.00 | - | 0.00 ... 1.00 |
| Operating mode: Manual excitation | | | |
| Excit. current setpoint | 0.0 | A | 0.0 ... 1600.0 A |

*Tab. 4-28 Excitation system – basic and control parameters*

### Parameter description

***SETPOINT SETTING: EXCITATION CURRENT***

The *excitation current setpoint* can be transmitted either via *Analog output AO 1* or *Analog output AO 2*.

**NOTE**

To configure parameter *Analog output AO 1* or *Analog output AO 2*, select the following setting option:

- *Analog output AO 1 = Excitation current* or
- *Analog output AO 2 = Excitation current*

The following two parameters define the start and the end of the measuring range of transfer characteristic for the *Analog inputs AO 1* and *Analog inputs AO 2*. The *start point* and the *end point* of transfer characteristics are each defined by a pair of values:

| | AO Meas. range | Measurement value scale |
|---|---|---|
| Start point value pair: | *Parameter* | Defined scale beginning |
| End point value pair: | *Parameter* | Defined scale end |

*Tab. 4-29 AO 1/2 transfer characteristic: Excitation current setpoint – start point and end point*

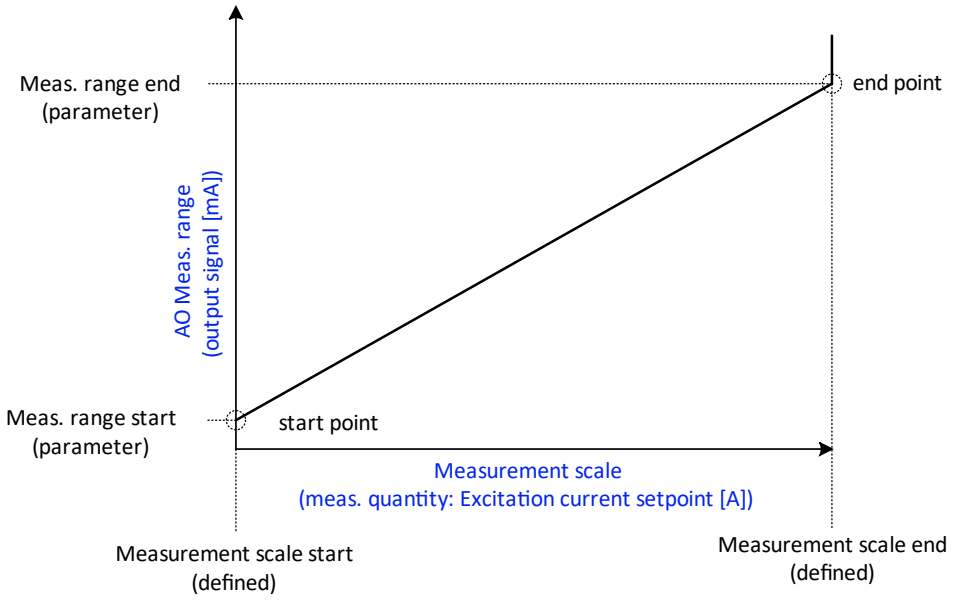



*Fig. 4-96 Analog output AO 1 or AO 2 – Transfer characteristics: Excitation current setpoint*

**Parameter: AO 1(2) (Setpoint excit. current): Meas.range end**

Setting range:
0.00 ... 25.00 mA

This parameter defines the *maximum output signal current* (measured range end) of *Analog output AO 1 or Analog output AO 2*, that can flow for the *maximum excitation current setpoint* set in parameter *Motor: Rated excitation current* (measurement scale end).

**Parameter: AO 1(2) (Setpoint excit. current): Meas.range start**

Setting range:
0.00 ... 8.00 mA

This parameter defines the *maximum output signal current* as (measured range start) of *Analog output AO 1 or Analog output AO 2*, that can flow for the *minimum excitation current setpoint* of 0 A (measurement scale start).

### *FEEDBACK: EXCITATION CURRENT*

The excitation current is *fed back* via the *Analog input AI 3*.

The following two parameters define the start and the end of the measuring range of transfer characteristics for the *Analog input AI 3*. The *start point* and *end point* of transfer characteristics are each defined by a pair of values:

| | AI Meas. range | Measurement value scale |
|---|---|---|
| Start point value pair: | *Parameter* | Defined scale beginning |
| End point value pair: | *Parameter* | Defined scale end |

*Tab. 4-30 AI 3-Transfer characteristics: Excitation current feedback – start point and end point*

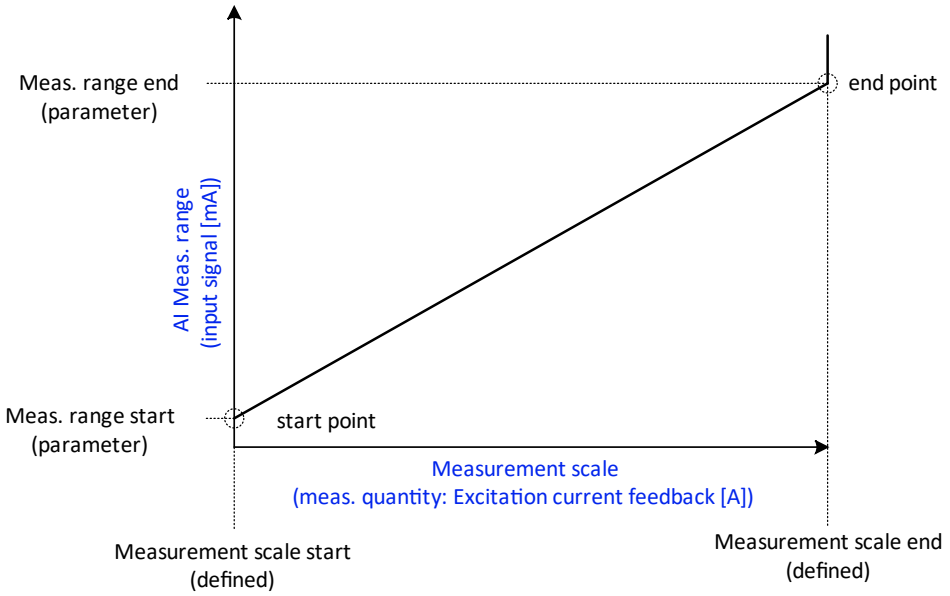



*Fig. 4-97 Analog input AI 3 – Transfer characteristics: Excitation current feedback*

**Parameter: AI 3 (Feedback excit. current): Meas.range end**

Setting range: 0.00 ... 25.00 mA

This parameter defines the *maximum input signal current* as (measured range end) of *Analog input AI 3* that can flow for the *maximum excitation current feedback* set with parameter *Motor: Rated excitation current* (measurement scale end).

**Parameter: AI 3 (Feedback excit. current): Meas.range start**

Setting range: 0.00 ... 8.00 mA

This parameter defines the *maximum input signal current* as (measured range start) of *Analog input AI 3*, that can flow for the *minimum excitation current feedback* of 0 A (measurement scale start).

***PID-CONTROLLER: EXCITATION CONTROL***

If parameter *Excitation control* is set to *Enable* and *Excit. current feedback* is set to *Yes*, the excitation current setpoint is given by the *internal PID controller*.

**Parameter: PID-controller (Excitation): P-gain**

Setting range: 0.00 ... 20.00

This parameter defines the *proportionality coefficient* of the P-control.

**Parameter: PID-controller (Excitation): I-time**

Setting range: 0.00 ... 20.00 min.

This parameter defines the *integral time* of the I-control.

**Parameter: PID-controller (Excitation): D-time**

Setting range: 0.00 ... 30.00 min.

This parameter defines the *differential time* of the D-control.

### *EXCITATION SYSTEM: RATED VALUES*

**Parameter:** **Motor: Rated excitation current**

Setting range: 0.1 ... 1600.0 A

This parameter defines the *rated excitation current* of the synchronous motor to be driven.

**Parameter:** **Excitation system: Rated current**

Setting range: 0.0 ... 1600.0 A

This parameter defines the *excitation system rated current*.

**Parameter:** **ASYNC Start: Excit. frequency**

Setting range: 0.00 ... 80.00 Hz

This parameter sets the *frequency* at which the *excitation is switched on*.

**Parameter:** **Setpoint refresh rate**

Setting range: 0.00 ... 80.00 Hz

(Description will follow.)

### *OPERATING MODE: CONSTANT POWER FACTOR*

**Parameter:** **Power factor setpoint**

Setting range: 0.00 ... 1.00

This parameter defines the *power factor setpoint* for the parameter setting *Operating mode = Constant power factor*.

### *OPERATING MODE: MANUAL EXCITATION*

**Parameter:** **Excit. current setpoint**

Setting range: 0.1 ... 1600.0 A

This parameter defines the *excitation current setpoint* for the parameter setting *Operating mode = Manual*.

## MENU: OPERATING HOURS

The operating hours menu provides information about the *motor running times* when the motor is operated via the VFD.

**NOTE**

When using the *synchronous transfer* VFD<->Grid function, the following applies:

- *VFD to Grid*:
  The counters for the motor running times stop as soon as the synchronisation of the VFD with the grid is successfully completed.
- *Grid to VFD*:
  The counters for the motor running times start as soon as the synchronisation of the grid with the VFD is successfully completed.

Two different counters are available for monitoring the motor running times:

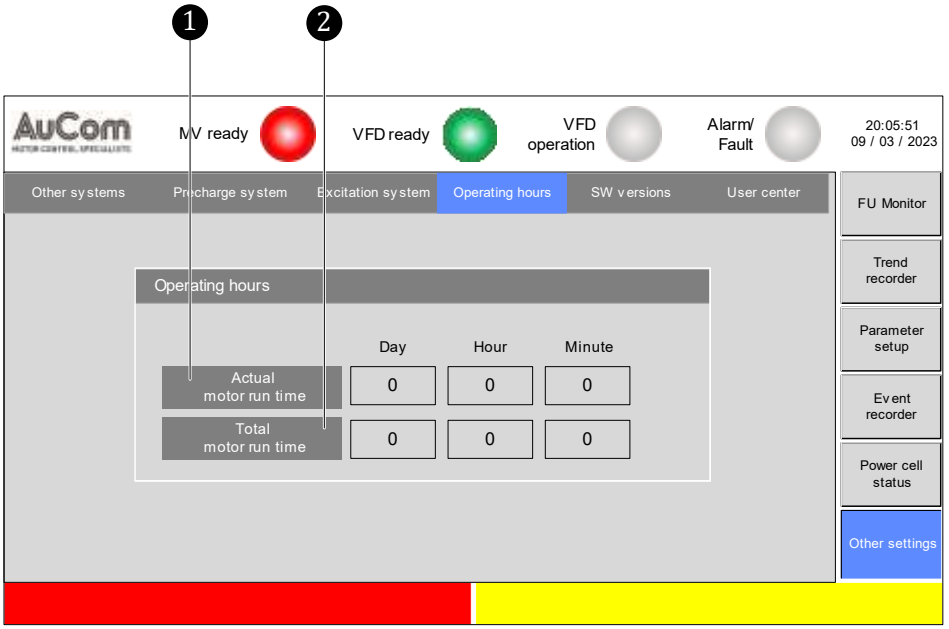



*Fig. 4-98 Menu: Operating hours*

1. Actual motor run time (operated via VFD)
2. Total motor run time (operated via VFD)

***ACTUAL MOTOR RUN TIME*** The counter starts as soon as the *start signal* for the motor is sent. As soon as the *stop signal* is sent, the counter stops and is automatically reset to zero.

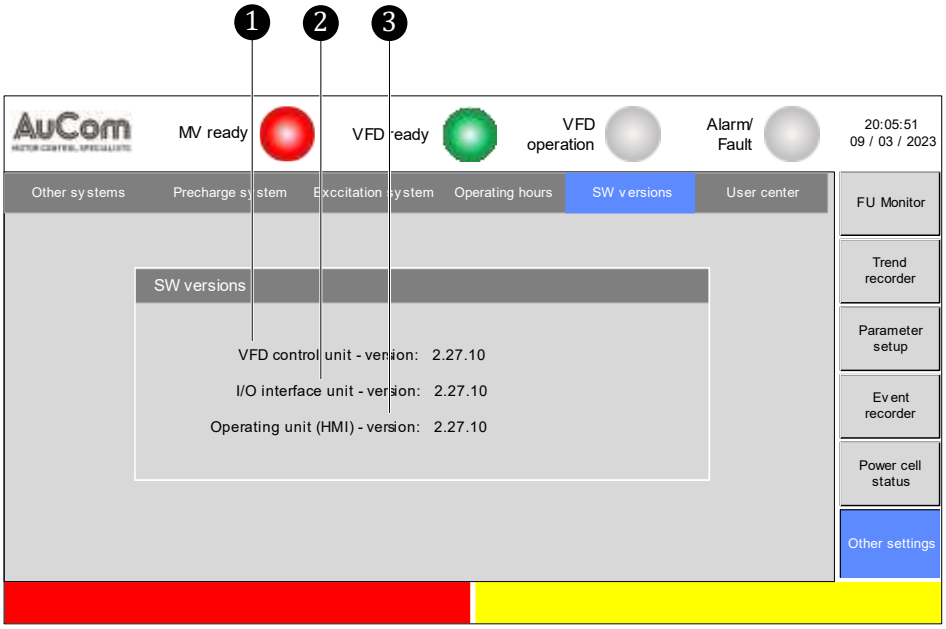
***TOTAL MOTOR RUN TIME*** The counter stores the individual motor running times (see *Actual motor run time*) and adds these times to the counter *Total motor running time*. The counter starts as soon as the *start signal* for the motor is sent. As soon as the *stop signal* is activated, the counter stops and saves the current total motor running time.

**NOTE**

The VFD controller saves the total running time of the engine in a non-volatile memory.

## MENU: SW VERSIONS

Once parameters are uploaded, this page displays the software versions of the VFD control system.




*Menu: SW versions*

1. VFD control unit – version
2. I/O interface unit– version
3. Operating unit (HMI) – version

The software versions displayed provide information about the compatibility of the three units of the control system with each other.

***VFD CONTROL UNIT – VERSION*** Software version of the main controller board AP4 on the VFD control unit

***I/O INTERFACE UNIT – VERSION*** Software version of the PLC as part of I/O interface unit

***OPERATING UNIT (HMI) – VERSION*** Software version of the touchscreen (HMI)

**NOTE**

When updating the software, ensure that the software versions are compatible. For queries, contact AuCom.

## MENU: USER CENTER

The *User center* menu is divided into two sections that contain further menus:

- *Configuration area*: system function settings and
- *Login area:* password and user level settings

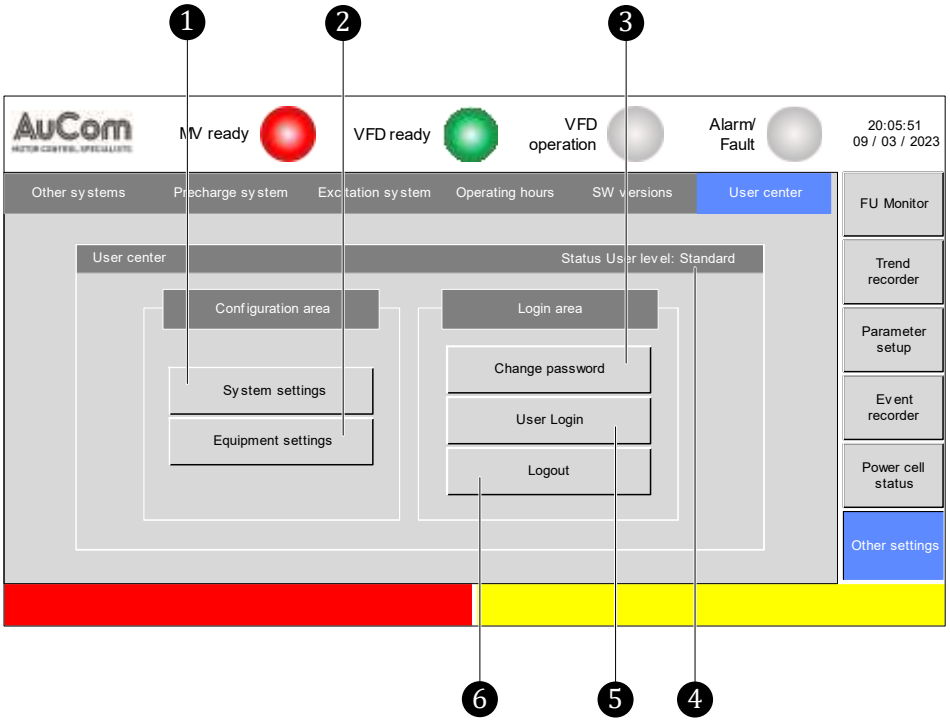



*Fig. 4-99 Menu: User center*

1. Menu: *System settings*
2. Menu: *Equipment settings* (AuCom only)
3. Menu: *Change password*
4. Display: Status of current user level
5. Menu: *User Login*
6. Button: *Logout*

## Configuration area: System settings

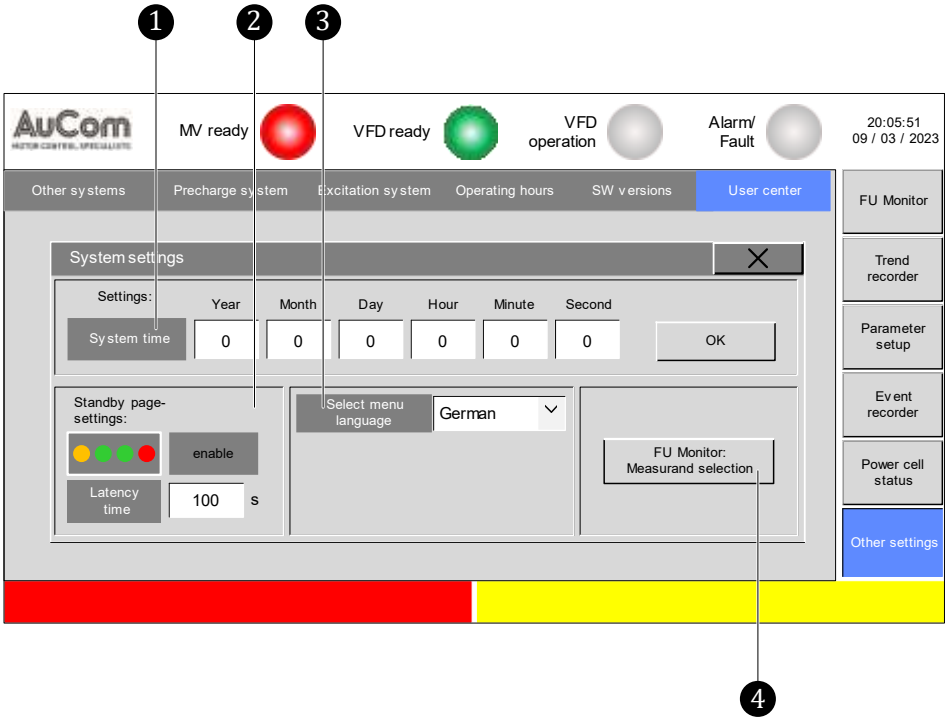



*Fig. 4-100 Menu: System settings*

1. Settings: System date and time
2. *Standby page settings* (activation and time delay)
3. *Select menu language* of HMI menu
4. *VFD Monitor:* Selection of measured variables for display on the *VFD Monitor*

***SYSTEM TIME***

The system time contains information about the *date* [DD/MM/YYYY] and *time* [hh:mm:ss] of the VFD control system and is shown on the display at the *top right* of the menu pages.

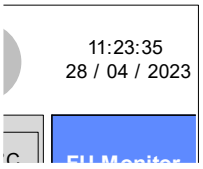



*Fig. 4-101 System date and time*

**CHAPTER REFERENCE**

➢ In chapter „4.5.6 Changing Parameter Settings (General)“ you will find an example instruction to set the system time.

### STANDBY PAGE–SETTINGS

This parameter group determines whether the *Standby page* is used and when it is displayed (time delay after the last touch on the touchscreen).

**CHAPTER REFERENCE**

➢ In chapter "4.5.6 Changing Parameter Settings (General)" you will find an example instruction to set the standby page.

### SELECT MENU LANGUAGE

You can display the HMI menu in the following languages:

- German
- English
- Russian
- French
- Spanish
- Chinese

**CHAPTER REFERENCE**

➢ In chapter "4.5.7 Selecting the Menu Language" you will find an example instruction to select the HMI menu language.

### FU MONITOR: MEASURAND SELECTION

This screen is used to individually select the readings of the following four measured variables to be displayed in the VFD Monitor.

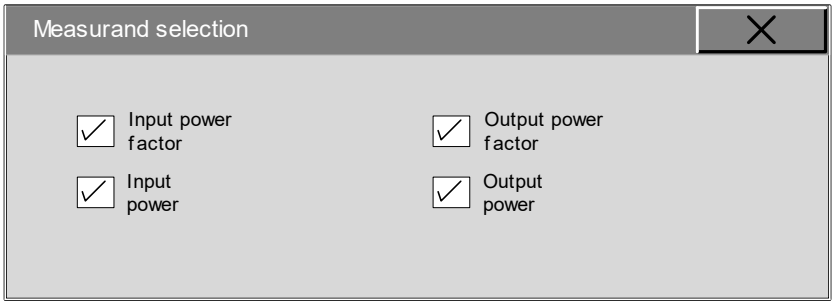



*Fig. 4-102 Measured variable selection for display in the VFD Monitor*

**Setting options:**

☐ The measured value of the selected measurand is *not displayed*.

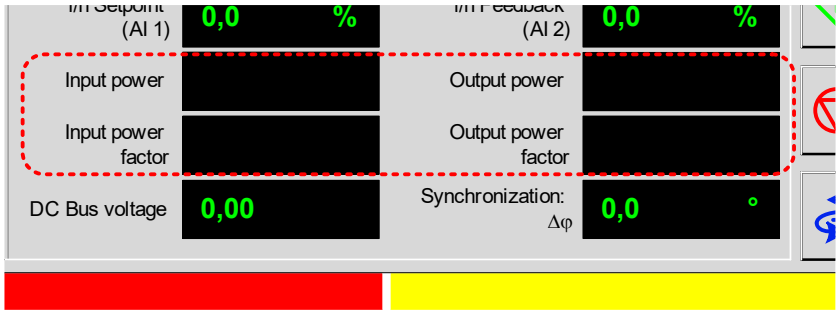



*Fig. 4-103 VFD Monitor – Example: no readings displayed*

☑ The measured value of the selected measurand is *displayed*.

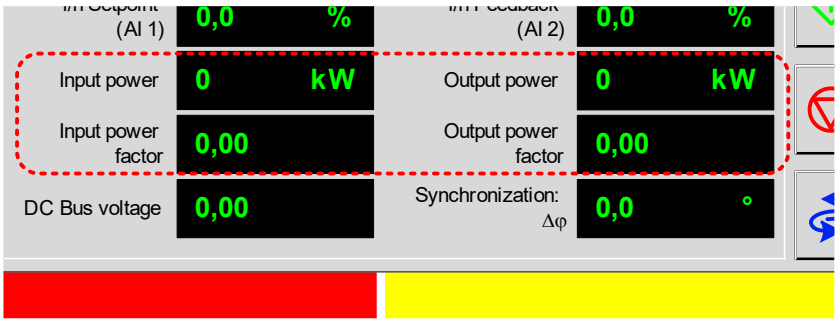



*Fig. 4-104 VFD Monitor – Example: all readings displayed*

## Login area

***CHANGE PASSWORD***

This screen is used to define new passwords for the user levels *Operator* and *Engineer*. To change the password for a specific user level, you must first activate this user level.

### INSTRUCTION – Set a new password for the *Operator* user level

***START*** ***USER LEVEL:*** **Operator**

***ENTER "CHANGE PASSWORD" MENU***

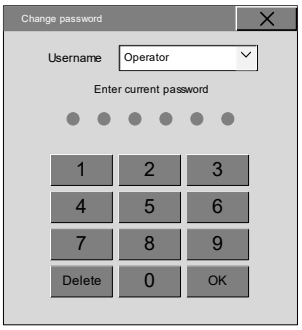



*Fig. 4-105 Enter current password*

**STEP 1:** Tap on the *Change password* button in the *System settings* menu.

➢ The screen *Change password* is displayed with a request to enter the currently valid password.

***CURRENT PASSWORD ENTRY***

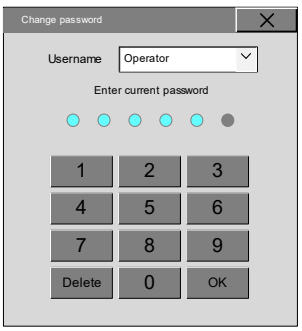



*Fig. 4-106 Entered password digits*

**STEP 2:** Enter the currently valid password for the *Operator* user level via the displayed numeric keypad.

➢ Each time you enter a digit for the current password, a blue circle is displayed above the numeric keypad.

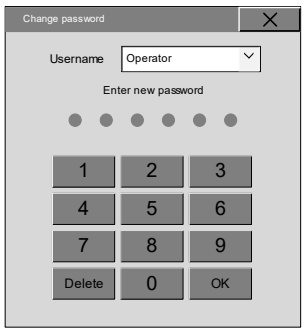



*Fig. 4-107 Enter new password*

➢ After entering the last password digit, the screen is displayed with the request to enter the new password.

***NEW PASSWORD ENTRY***

**STEP 3:** Enter the *new* password for the *Operator* user level via the displayed numeric keypad.

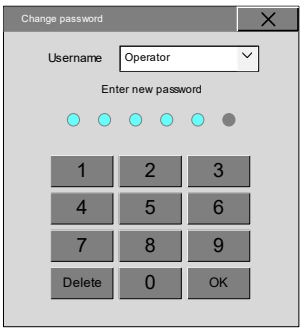



*Fig. 4-108 Entered password digits*

➢ Each time you enter a digit for the new password, a blue circle is displayed above the numeric keypad.

➢ The screen is closed automatically after the last password digit has been entered.

➢ The new password for the *Operator* user level is now saved.

➢ The *Operator* level is automatically exited, the *Standard* user level is reactivated.

➢ The current user level status is displayed in the *User center* menu:

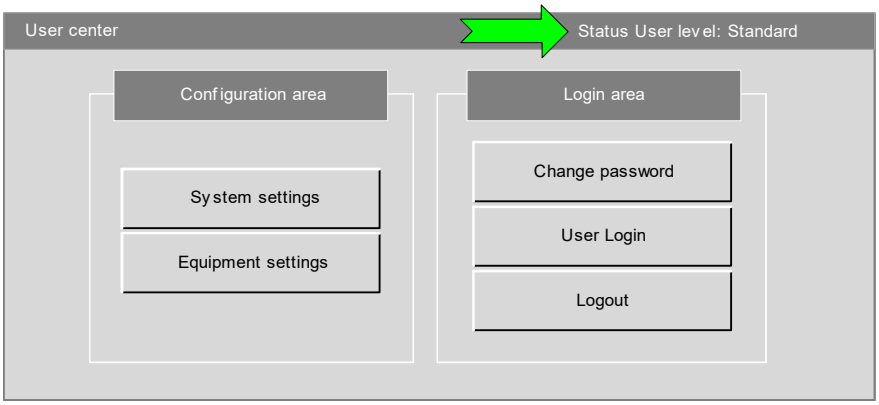



*Fig. 4-109 Status User level: Standard*

***END***

***USER LOGIN***

You can activate a password-protected user level via the user login. Select the user level *Operator* or *Engineer*.

**CHAPTER REFERENCE**

➢ Activating a password-protected user level is done according to the procedure described in chapter „4.5.5 User Levels“.

***LOGOUT***

Tap the *Logout* button to exit an active, password-protected user level and activate the *Standard* user level.

# 5 VFD OPERATION

## 5.1 OPERATING FUNCTIONS

The VFD includes a comprehensive range of operating functions to meet the needs of many different applications.

### 5.1.1 EXTENDED U/f-CONTROL

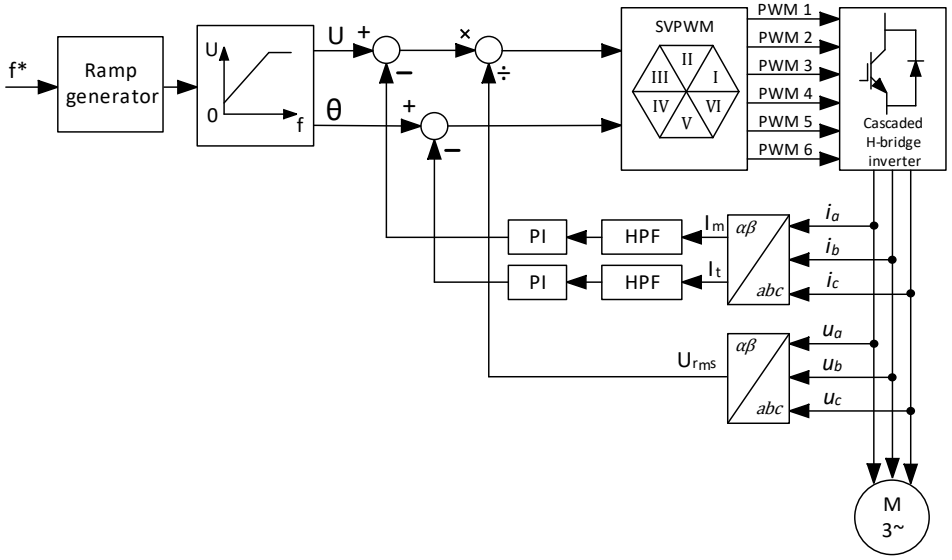



*Fig. 5-1 Block diagram of the extended U/f control – VFD type = ASYNC Motor U/f*

### 5.1.2 ASYNCHRONOUS MOTOR – OPEN LOOP VECTOR CONTROL

The MV VFD offers high-quality, reliable open loop vector control, for most single applications of asynchronous motors that require higher control dynamics.

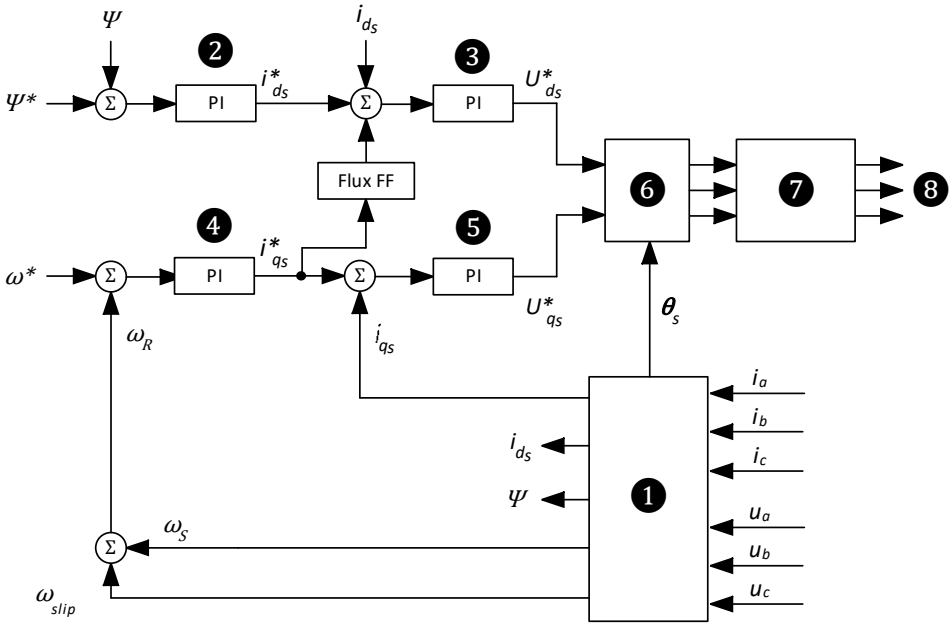



*Fig. 5-2 Block diagram of open loop vector control – VFD type = ASYNC VC without sensor*

1. Park's transformation (dq transformation) of measured values into vectors to depict the motor model
2. PI magnetic flux controller
3. PI reactive motor current controller (magnetising current)
4. PI speed controller
5. PI active motor current controller (torque)
6. inverse Park's transformation (inverse dq transformation)
7. Dead-time compensation and PWM modulation
8. IGBT ignition pulses

The VFD applies:

- the motor model,
- the measuring values of stator voltages $u_a$, $u_b$, $u_c$, and
- the measuring values of the stator currents $i_a$, $i_b$, $i_c$

to calculate

- the magnetic flux $\Psi$
- the synchronous speed $\omega_s$,
- the synchronous electrical angle $\theta_s$ and
- the slip $\omega_{slip}$

According to the *synchronous electrical angle* $\theta_s$ the transformation of the stator currents into the *dq coordinate system* results in:

- the *magnetising current* $i_{ds}$ and
- the *active motor current* $i_{qs}$.

***PI-CONTROLLER: MAGNETIC FLUX***

The PI-controller for *magnetic flux* performs a *proportional* and *integral control* depending on the difference between the *setpoint* $\Psi^*$ and the calculated *actual value* $\Psi$ of the magnetic flux, thus generating a *magnetising current setpoint* $i_{ds}^*$.

***PI-CONTROLLER: SPEED***

The PI controller for *speed* performs *proportional* and *integral control* depending on the difference between the *speed setpoint* $\omega^*$ and the *speed actual value* $\omega_r$, thus generating an *active current setpoint* $i_{qs}^*$.

***PI-CONTROLLER: MAGNETISING CURRENT***

The PI-controller for *magnetising current* performs a *proportional* and *integral control* depending on the difference between the *magnetising current setpoint* $i_{ds}^*$, the *magnetising current actual value* $i_{ds}$ (calculated) and a determined correction factor (flux FF) and thus generating the *voltage setpoint* $U_{ds}^*$ for the d-axis. This voltage setpoint determines the *required magnetising current* of the motor.

***PI-CONTROLLER: ACTIVE CURRENT***

The PI controller for *active current (torque)* performs *proportional* and *integral control* depending on the difference between the *active current setpoint* $i_{qs}^*$ and the *active current actual value* $i_{qs}$ (calculated), and thus generating a *voltage setpoint* $U_{qs}^*$ for the q-axis. This voltage setpoint determines the *required active current* of the motor.

The *voltage outputs* $U_{ds}^*$ and $U_{qs}^*$ of the dq-axes are subjected to an inverse transformation of the dg-coordinates depending on the *synchronous angle* $\theta_s$ and a dead-time compensation modulation to generate the *IGBT firing pulses* for all three phases.

### 5.1.3 SYNCHRONOUS MOTOR – OPEN LOOP VECTOR CONTROL

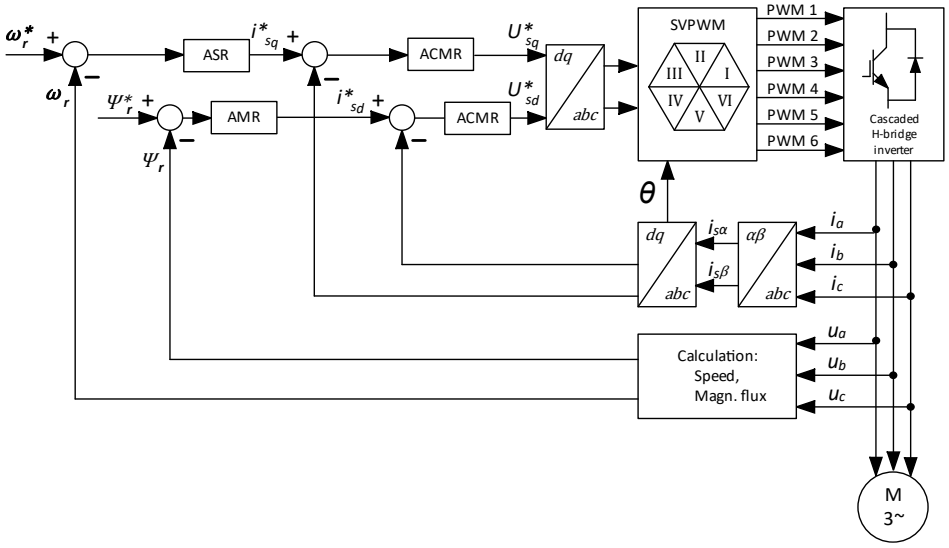



*Fig. 5-3 Block diagram of open loop vector control – VFD type = SYC VC without sensor*

### 5.1.4 SYNCHRONOUS TRANSFER

Synchronous transfer allows the VFD to soft start and control multiple motors, one at a time, in sequence. Synchronous transfer is divided into *two operations*:

***1. TRANSFER: VFD TO GRID:*** The VFD starts the motor then transfers the motor to the incoming line (MV grid).

***2. TRANSFER: GRID TO VFD:*** The VFD synchronizes to the motor then transfers it off the incoming line and on-to the VFD.

#### TRANSFER FROM VFD TO GRID

The VFD starts the motor, synchronizes the frequency, phase angle and magnitude relative to the power grid, then transfers the motor to the incoming line and disconnects the VFD.

***SYNCHRONISATION PROCESS*** After receiving the switching command for synchronous transfer, the VFD starts the *synchronisation process*. For this, it measures *frequency*, *phase angle*, and *magnitude* of the MV mains voltage. These measurements are used as reference values to synchronise the VFD output with the MV network.

When the level of the *output frequency* matches the level of the *input frequency*, the VFD synchronises the phase angle of its output voltage with the *phase angle* of the mains voltage.

When the *phase angles* match, the VFD synchronises the *magnitude* of its output voltage with the *magnitude* of the mains voltage.

If the frequency, magnitude, and phase of the VFD output match the MV grid, digital output (DO) *Synchronisation successful* is activated. You can use this signal for synchronous switching. The system status displays the operating message *Synchronisation successful*.

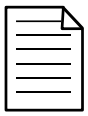
Once the transfer is successful, the VFD output contactor opens and the VFD stops.

#### TRANSFER FROM GRID TO VFD

The VFD synchronizes to a motor that is already running (powered by the MV grid), then transfers the motor from the incoming line to VFD control.

The VFD initially runs at no load until *frequency*, *phase angle,* and *magnitude* of the VFD output voltage are synchronised with those of the MV mains voltage.

If the *frequency*, *phase angle,* and *magnitude* of the VFD output match the MV grid, digital output (DO) *Synchronisation successful* is activated. You can use this signal for synchronous switching. The system status displays the operating message *Synchronisation successful*.



NOTE

- You can set the maximum permissible phase angle difference using parameter *Synchronization: Max. permitted* $\Delta\varphi$.
- You can set the synchronisation direction using parameter *Transfer release: VFD<->Grid*.
- You must configure the system parameters correctly before *synchronous transfer* can start. The settings of the *Maximum frequency* and *Setpoint mode* parameters may affect the output frequency of the VFD during synchronous switching, causing the motor transfer to fail.
- Synchronous transfer requires additional equipment such as a synchronous switch cabinet, a reactor cabinet and a synchronous transfer sampling board.

## 5.1.5 MASTER/SLAVE CONTROL FUNCTIONS

### MULTI-VFD APPLICATIONS

You can use the VFD in multi-VFD applications where two or more VFDs share control of the system. The motor shafts are coupled together through couplings, chains, gears or conveyor belts. Multi-drive control distributes the load evenly among the motors and VFDs.

***MASTER-SLAVE TOPOLOGY***

One VFD is designated as *master* of the system, and all others are *slaves*. The master VFD communicates with the slave via *optical fibres*. The master will transmit information on running, speed, torque, etc. to the slave VFD in real-time, and the slave will respond to the data commands from the master according to its own measured data.

***REQUIRED PARAMETER SETTINGS***

To enable the master/slave application, you must set the parameter *Master/Slave operation* to *Enable* for all VFDs involved. For each VFD you must set parameter *Master/Slave mode* as either *Master* or *Slave*.

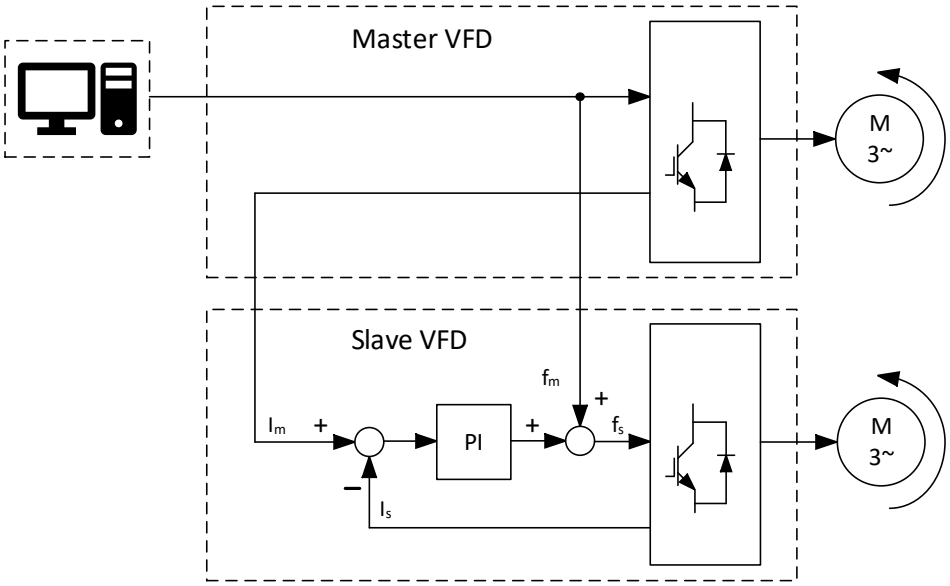



*Fig. 5-4 VFD type = ASYNC Motor U/f: Current balancing control in slave*

❶ Distributed control system (DCS)
$I_m$ Motor set current (Master)
$f_m$ Motor frequency
$f_s$ Set frequency (Slave)
$I_s$ Motor current (Slave)
PI Current balancing controller

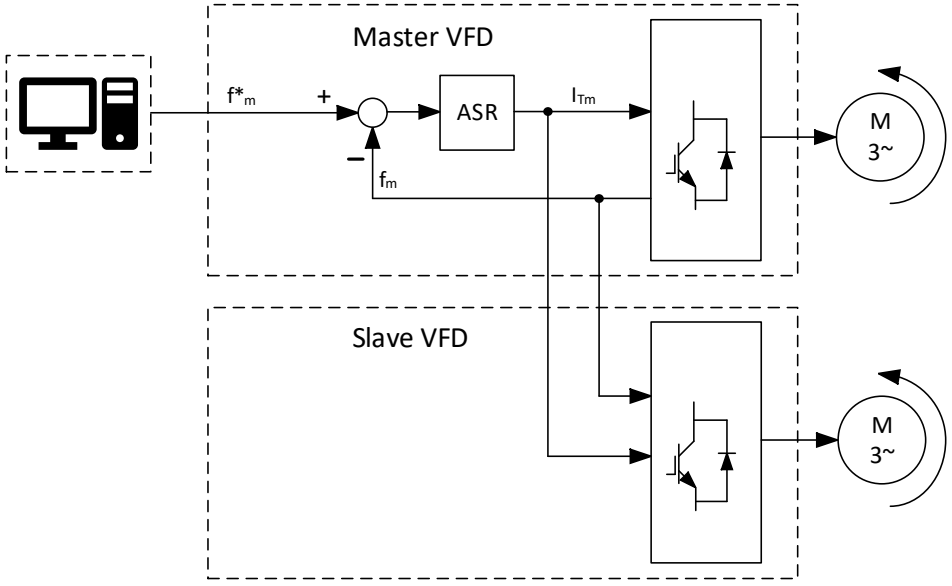



*Fig. 5-5 VFD type = ASYNC VC without sensor: active current control*

❶ Distributed control system (DCS)
$I_{Tm}$ Motor set current (Master)
$f^*_m$ Motor frequency
$f_m$ Motor frequency feedback

### 5.1.6 SPEED START / VFD START AT ROTATING MOTOR

The VFD can start a motor that is already rotating.

With the parameter setting *START mode = Speed start*, the VFD determines the speed of the still rotating motor before the VFD output is switched to the motor. The VFD then outputs a voltage with the same *frequency*, *phase angle*, and *magnitude* as that of the rotating motor and then accelerates the motor to the process setpoint.

### 5.1.7 MOTOR REVERSE OPERATION

The VFD can operate a motor in *reverse direction of rotation*. Reverse operation is available with the parameter setting *Release: VFD Reverse = Enable*. VFD operation in reverse direction depends on the parameter settings:

- *Operating mode* (for START/STOP motor control),
- *Remote START/STOP: DI mode* (with pulse or level signal when *Operating mode = Remote control (DI)*), and
- *Setpoint mode* (to set the frequency/speed setpoint).

**NOTE**

- Motor reverse operation via VFD always requires negative set frequency/speed.
- The VFD controls the motor in reverse and forward direction according to the settings of parameters *START mode* and *STOP mode*.

The following table provides information on the different variants ❶ to ❾ used to control motor reverse operation via the VFD:

| | | ❶ | ❷ | ❸ | ❹ | ❺ | ❻ | ❼ | ❽ | ❾ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | START/STOP control via: | | | | | | | | |
| | **Parameter settings** | **HMI** | **HMI** | **DCS** | **DCS** | **DI** | **DI** | **DI** | **DI** | **DI** |
| Release | *Release: VFD reverse = Enable* | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Operating mode | *Operating mode = Local control (HMI)* | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *Operating mode = Remote control (DCS)* | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | *Operating mode = Remote control (DI)* | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| DI signal type für *Remote control (DI)* | *Remote START/STOP: DI mode = Level signal* | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | *Remote START/STOP: DI mode = Pulse signal* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| Setpoint setting | *Setpoint mode = Setpoint via HMI* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | *Setpoint mode = Setpoint via DCS* | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| | *Setpoint mode = Setpoint via DI* | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| | *Setpoint mode = Setpoint via AI* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | **Start motor reverse operation** | **HMI** | **HMI** | **DCS** | **DCS** | **DI** | **DI** | **DI** | **DI** | **DI** |
| START-conditions | Set frequency: negative value | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | HMI: *START* button | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | DCS-Start command | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | DI (-XS1:1,10) *Remote-Start/Stop signal* | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| | DI (-XS1:1,9) *Remote-Start/Stop signal* | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| ⇒ | **Motor starts reverse operation** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| | **Stop motor reverse operation** | **HMI** | **HMI** | **DCS** | **DCS** | **DI** | **DI** | **DI** | **DI** | **DI** |
| STOP-conditions | HMI: *STOP* button | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | DCS-Stop command | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | DI (-XS1:1,10) *Remote-Start/Stop signal* | 0 | 0 | 0 | 0 | x | x | x | x | x |
| | DI (-XS1:1,9) *Remote-Start/Stop signal* | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| ⇒ | **Motor stops reverse operation** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |

1: *corresponds to parameter setting* or *activated*
0: *does not correspond to the parameter setting* or *deactivated*
x: corresponds to *activated* or *deactivated*

*Tab. 5-1 Motor reverse – control variants*

❶ START/STOP control and setpoint setting via touchscreen (HMI)
❷ START/STOP control via touchscreen (HMI) and setpoint setting via DCS
❸ START/STOP control and setpoint setting via DCS
❹ START/STOP control via DCS and setpoint setting via touchscreen (HMI)
❺ START/STOP control and setpoint setting via digital inputs (DI: level signal)
❻ START/STOP control via digital inputs (DI: level signal) and setpoint setting via analog input (AI)
❼ START/STOP control and setpoint setting via digital inputs (DI: pulse signal)
❽ START/STOP control via digital inputs (DI: pulse signal) and setpoint setting via DCS
❾ START/STOP control via digital inputs (DI: pulse signal) and setpoint setting via touchscreen (HMI)

**❶ *START/STOP CONTROL AND SETPOINT SETTING VIA TOUCHSCREEN (HMI)***

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Local control (HMI)*
- *Setpoint mode = Setpoint via HMI*

Set frequency example:

- Motor forward run: *Set frequency (HMI) = 20 Hz*
- Motor reverse run: *Set frequency (HMI) = –20 Hz*

**❷ *START/STOP CONTROL VIA TOUCHSCREEN (HMI) AND SETPOINT SETTING VIA DCS***

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Local control (HMI)*
- *Setpoint mode = Setpoint via DCS*

Set frequency example:

- Motor forward run: *communication protocol (DCS) = 20 Hz*
- Motor reverse run: *communication protocol (DCS) = –20 Hz*

The following figure shows the function/time diagram for the variants ❶ and ❷ of a motor reverse operation:

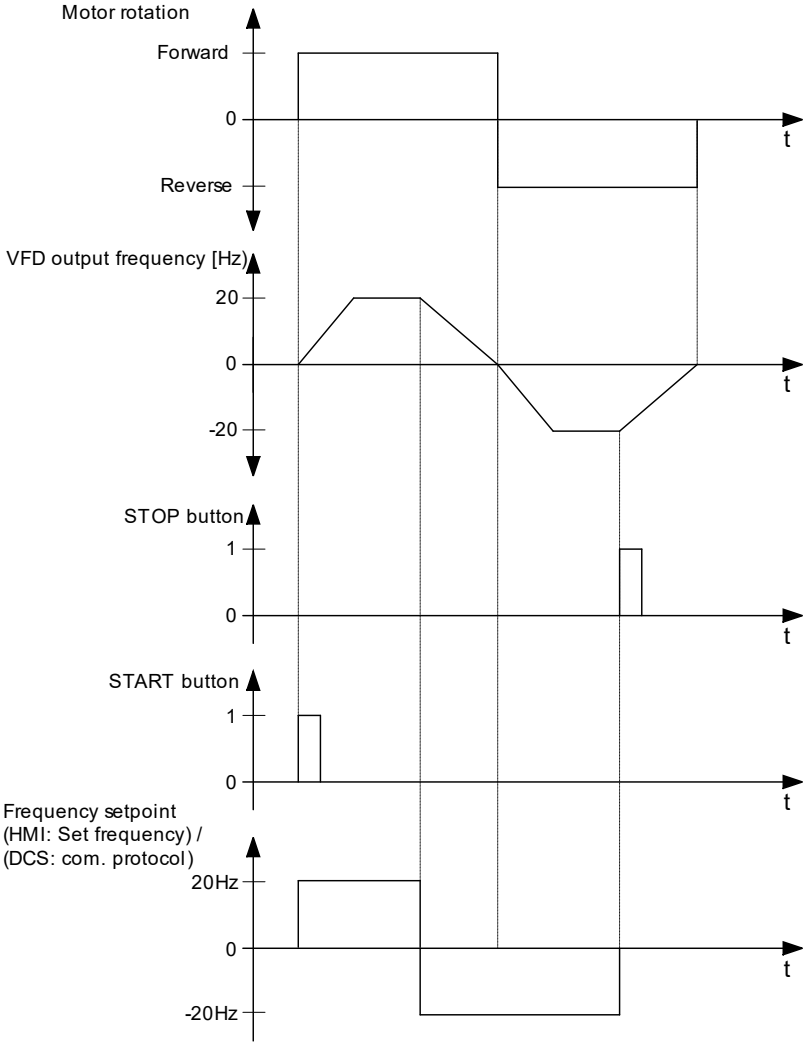



*Fig. 5-6 Motor reverse operation: variants ❶ and ❷*

**❸ *START/STOP CONTROL AND SETPOINT SETTING VIA DCS***

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Remote control (DCS)*
- *Setpoint mode = Setpoint via DCS*

Set frequency example:

- Motor forward run: *communication protocol (DCS) = 20 Hz*
- Motor reverse run: *communication protocol (DCS) = –20 Hz*

**❹ *START/STOP CONTROL VIA DCS AND SETPOINT SETTING VIA TOUCHSCREEN (HMI)***

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Remote control (DCS)*
- *Setpoint mode = Setpoint via HMI*

Set frequency example:

- Motor forward run: *Set frequency (HMI) = 20 Hz*
- Motor reverse run: *Set frequency (HMI) = –20 Hz*

The following figure shows the function/time diagram for the variants ❸ and ❹ of a motor reverse operation:

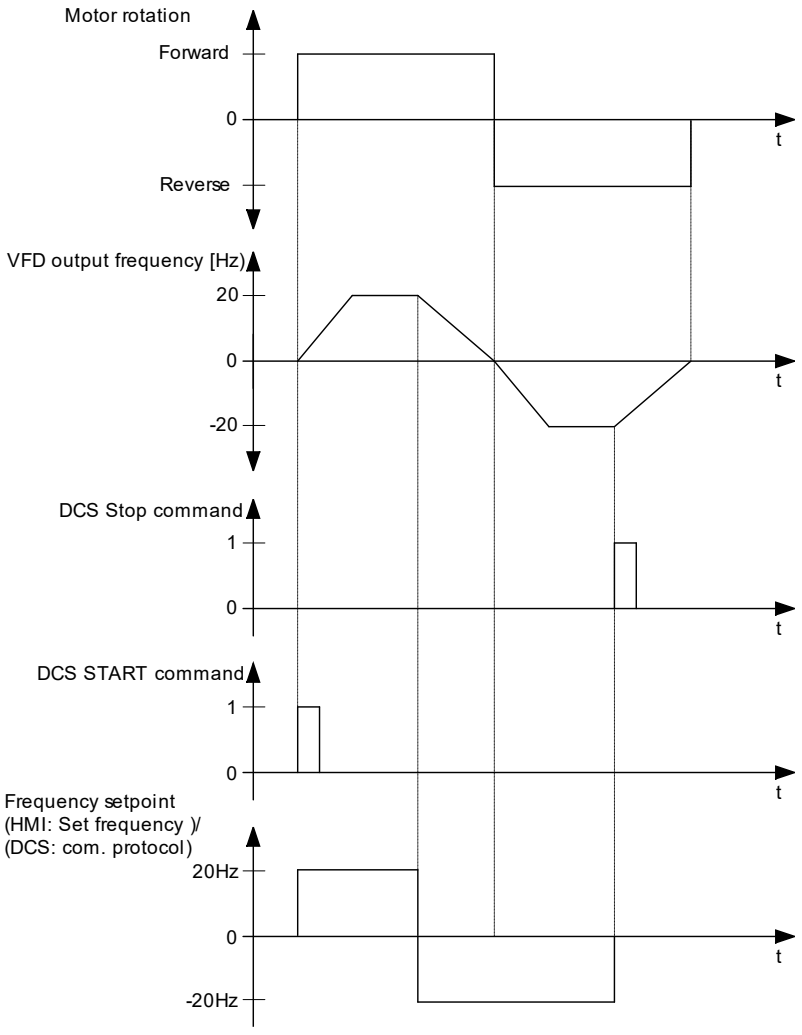



*Fig. 5-7 Motor reverse operation: variants ❸ and ❹*

**❺ START/STOP CONTROL AND SETPOINT SETTING VIA DIGITAL INPUTS (DI: LEVEL SIGNAL)**

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Remote control (DI)*
- *Remote START/STOP: DI mode = Level signal*
- *Setpoint mode = Setpoint via DI*

Set frequency example:

- Motor forward run: *Speed section 3* or *Speed section 7* (DI) = *20 Hz*
- Motor reverse run: *Speed section 3* or *Speed section 7* (DI) = *–20 Hz*

**❻ START/STOP CONTROL VIA DIGITAL INPUTS (DI: LEVEL SIGNAL) AND SETPOINT SETTING VIA ANALOG INPUT (AI)**

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Remote control (DI)*
- *Remote START/STOP: DI mode = Level signal*
- *Setpoint mode = Setpoint via AI*

Set frequency example:

- Motor forward run: *AI 1: f/n Setpoint (AI) = 20 Hz*
- Motor reverse run: *AI 1: f/n Setpoint (AI) = –20 Hz*

The following figure shows the function/time diagram for the variants ❺ and ❻ of a motor reverse operation:

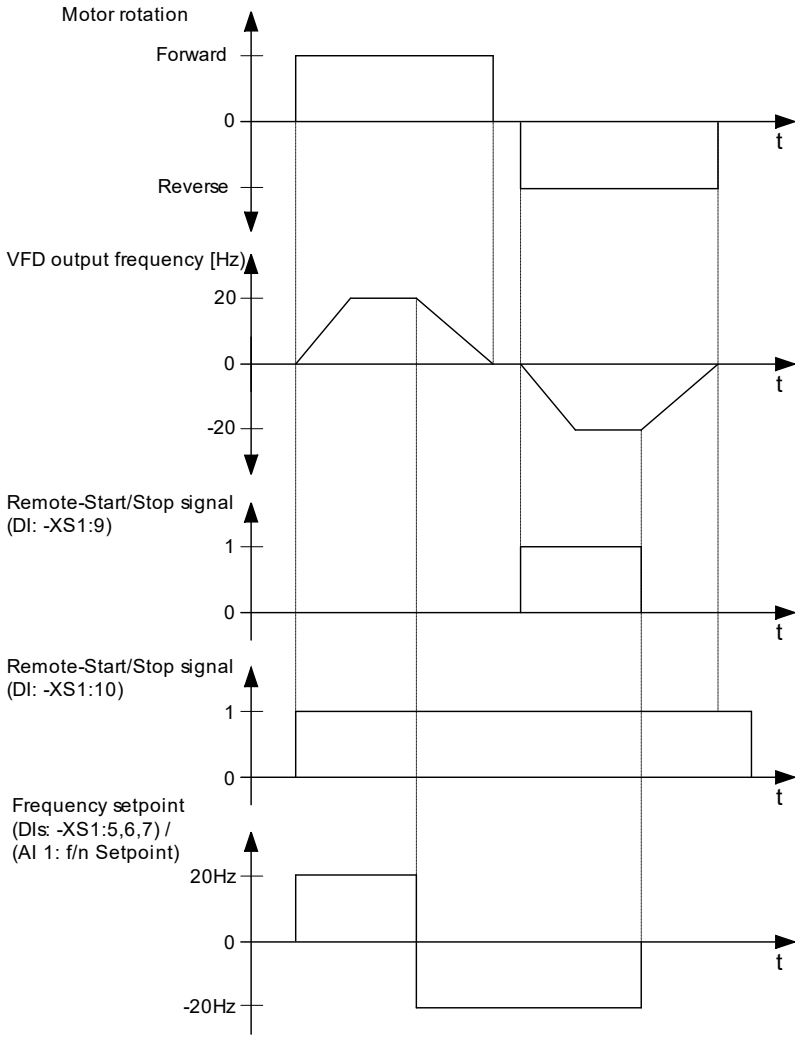



*Fig. 5-8 Motor reverse operation: variants ❺ and ❻*

**❼ START/STOP CONTROL AND SETPOINT SETTING VIA DIGITAL INPUTS (DI: PULSE SIGNAL)**

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Remote control (DI)*
- *Remote START/STOP: DI mode = Pulse signal*
- *Setpoint mode = Setpoint via DI*

Set frequency example:

- Motor forward run: *Speed section 3* or *Speed section 7* (DI) = *20 Hz*
- Motor reverse run: *Speed section 3* or *Speed section 7* (DI) = *–20 Hz*

**❽ START/STOP CONTROL VIA DIGITAL INPUTS (DI: PULSE SIGNAL) AND SETPOINT SETTING VIA DCS**

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Remote control (DI)*
- *Remote START/STOP: DI mode = Pulse signal*
- *Setpoint mode = Setpoint via DCS*

Set frequency example:

- Motor forward run: *communication protocol (DCS) = 20 Hz*
- Motor reverse run: *communication protocol (DCS) = –20 Hz*

**❾ START/STOP CONTROL VIA DIGITAL INPUTS (DI: PULSE SIGNAL) AND SETPOINT SETTING VIA TOUCHSCREEN (HMI)**

Parameter settings:

- *Release: VFD reverse = Enable*
- *Operating mode = Remote control (DI)*
- *Remote START/STOP: DI mode = Pulse signal*
- *Setpoint mode = Setpoint via HMI*

Set frequency example:

- Motor forward run: *Set frequency (HMI) = 20 Hz*
- Motor reverse run: *Set frequency (HMI) = –20 Hz*

The following figure shows the function/time diagram for the variants ❼, ❽ and ❾ of a motor reverse operation:

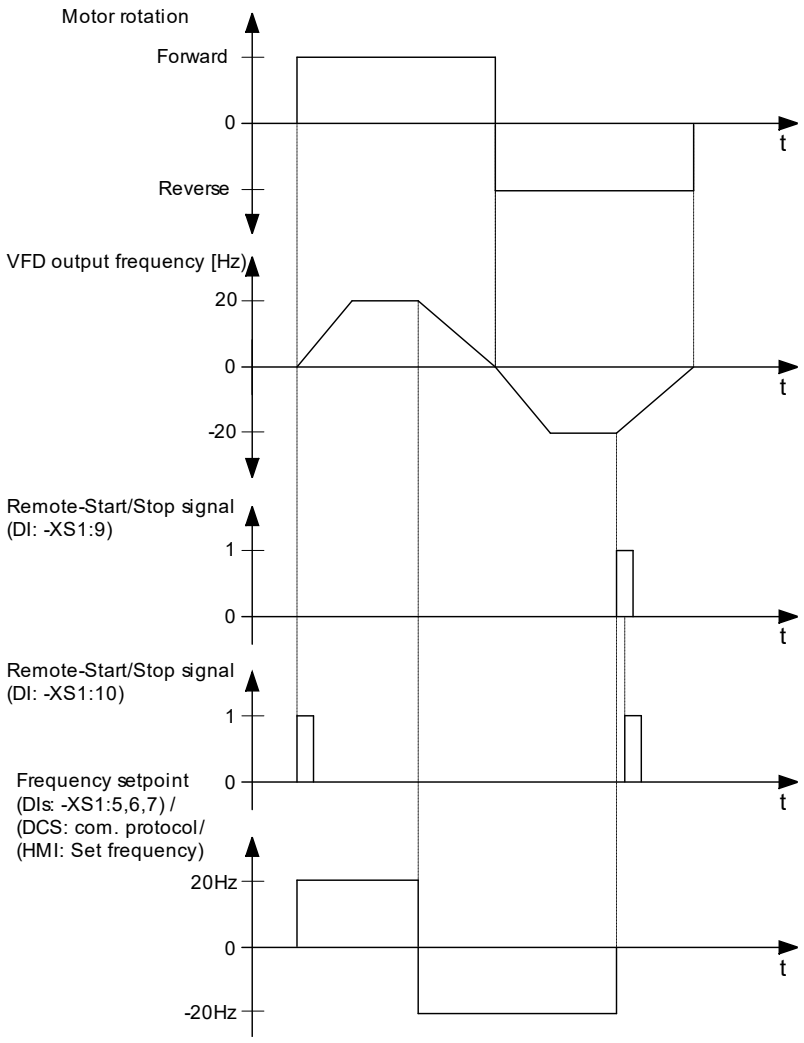



*Fig. 5-9 Motor reverse operation: variants ❼ or ❽ or ❾*

### 5.1.8 MV MAINS FAILURE (MV LOSS)

The VFD can be configured so that in the event of a mains voltage failure it either:

- *switches off* without time delay (instantaneously), or
- performs an *automatic restart* after mains return (MV restoration), or
- *continues operation* with the aid of kinetic buffering.

***INSTANTANEOUS VFD TRIPPING***

If parameter *Instantan. VFD Trip at MV loss* is set to *Enable*, the VFD switches off instantaneously in the event of a mains failure (MV loss).

***AUTOMATIC VFD RESTART AFTER MV LOSS***

With the parameter setting *Automatic start after MV failure = Enable*, the frequency inverter automatically performs a *restart* after the MV mains voltage returns.

The frequency inverter will only restart if the MV mains voltage returns within the time set in parameter *Max. permissible MV failure duration* and the *no STOP command* is active.

**NOTE**

With the parameter setting *Max. permissible MV loss duration = 100 s*, *no* VFD restart takes place.

***FAULT RIDE THROUGH (FRT) OPERATION***

The VFD does *not* switch off. The control of the VFD uses the kinetic rotational energy of the motor/load to compensate for the VFD's own losses. For this purpose, the output frequency of the VFD is lowered in a controlled manner feed the required energy into the VFD (regenerative operation of the motor).
The *maximum operating time* in case of MV mains failure depends on the *kinetic rotational energy* of the drive.

The frequency inverter only remains in operation for the time set in parameter *Max. permissible FRT duration* and as long as *no STOP command* is active.

**NOTE**

- FRT function: *Fault Ride Through* operation of the VFD
- With the parameter setting *Max. permitted FRT duration = 0 ms*, the FRT function is *disabled*.
- For FRT operation, you must ensure a *safe control voltage supply* (e.g., via a UPS).

The following table describes the relationship between the state of the VFD before and after the mains failure depending on the different parameter settings:

| VFD system status before MV loss | MV loss duration T1 | Parameter settings | VFD system status after MV loss |
|---|---|---|---|
| *VFD ready / VFD operation* | - | *Instantan. VFD Trip at MV loss = Enable* | *MV not ready* |
| *VFD ready* | T1 < T2 | *Instantan. VFD Trip at MV loss = Disable* | *VFD ready* |
| *VFD ready* | T1 > T2 | *Instantan. VFD Trip at MV loss = Disable* | *MV not ready, MV loss* |
| *VFD operation* | T1 < T2 | *Instantan. VFD Trip at MV loss = Disable; Automatic start after MV loss = Disable* | *VFD ready* |
| *VFD operation* | T1 < T2 | *Instantan. VFD Trip at MV loss = Disable; Automatic start after MV loss = Enable* | *VFD operation* |
| *VFD operation* | T1 > T2 | *Instantan. VFD Trip at MV loss = Disable; Automatic start after MV loss = Disable* | *MV not ready, MV loss* |

*Tab. 5-2 VFD system status before and after MV loss*

T1: MV loss duration

T2: Time slot for a *maximum permissible mains failure duration* in which the VFD may perform an automatic restart, provided that *no* STOP command is active (see parameter *Max. perm. mains failure duration*).

### 5.1.9 MOTOR OVERLOAD PROTECTION (THERMAL REPLICA)

To prevent motor damage due to overload or long-term overcurrent operation, the VFD protects the motor using a preset *inverse time motor thermal overload model*:

$$\int_{t_0}^{t} [(\frac{I}{I_N})^2 - 1]dt \geq k$$

where: I: Motor current
$I_N$: Motor rated current
t: Inverse overcurrent tripping time delay
k: Overload factor

When the *motor current I* exceeds the *motor rated current* $I_N$, the inverse time protection function is effective. The greater the *motor current I*, the shorter the *time delay t* until protection tripping (VFD trip).

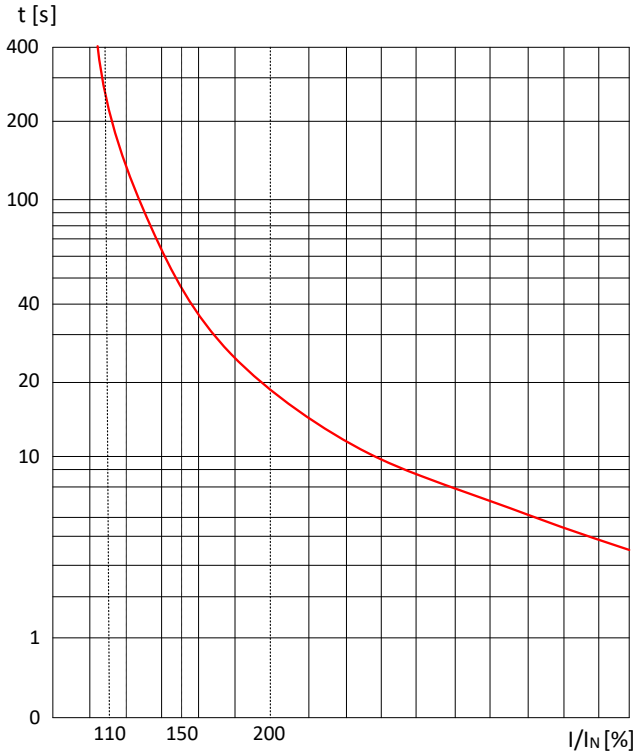



*Fig. 5-10 Inverse tripping time delay characteristics*

The following table provides information on the *maximum permissible overload duration* for the motor at *different overload levels*:

| Motor overload multiple $I/I_N$ [%] | Max. permissible motor overload duration t [s] |
|---|---|
| 110 | 251 |
| 120 | 120 |
| 130 | 76 |
| 140 | 55 |
| 150 | 42 |
| 200 | 18 |

*Tab. 5-3 Mapping between motor overload multiple and duration*

**NOTICE**

If the VFD output current *exceeds* 150 % of the VFD rated output current, the VFD will switch off before the *maximum permissible overload* of the motor is reached.

### 5.1.10 AUTOMATIC RAMP INTERVENTION

#### CURRENT CRITERION – OVERCURRENT

If, during the acceleration or deceleration process, the VFD output current *exceeds*

- the value set in parameter *Motor overload limit* or
- the preset *maximum permissible current limit value* (current pickup limit) which is 150 % of the VFD rated output current,

the VFD will pause the acceleration/deceleration process and hold its output frequency at the current value. Acceleration or deceleration resumes after the VFD output current drops below the *current reset limit.*

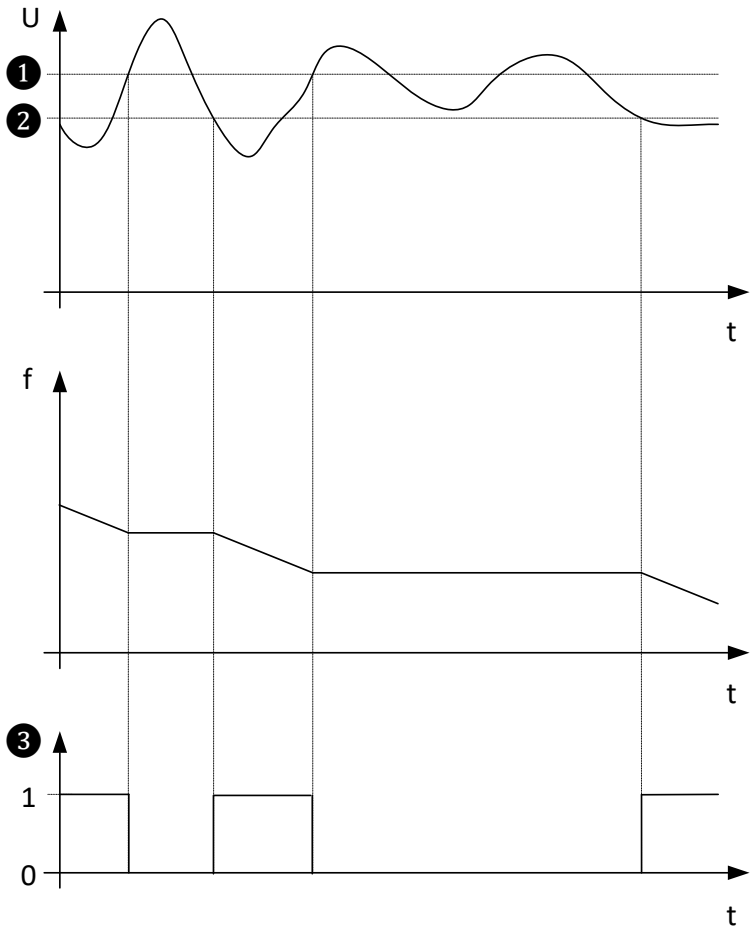



*Fig. 5-11 VFD ramp intervention: current criterion*

where: I: VFD output current
f: VFD output frequency

❶ Maximum permissible current limit
❷ Current reset limit
❸ Motor stop: acceleration process (1: active; 0: inactive)
❹ Motor stop: deceleration process (1: active; 0: inactive)

**NOTE**

The *maximum permissible current limit* and the *current reset limit* are fixed in the VFD. You cannot change these settings.

### VOLTAGE CRITERION – OVERVOLTAGE

When the VFD is *decelerating*, excessive load inertia or short deceleration time will cause the *DC bus voltage* to rise and the VFD will trip on *power cell overvoltage*.

To avoid this, the VFD continually monitors the *DC bus voltage* of the power cells.

If DC bus voltage *exceeds* the preset *maximum permissible DC bus voltage limit* for the power cells, the VFD pauses deceleration. When the DC bus voltage of the power cell is *below* the preset *DC bus voltage reset limit*, deceleration resumes.

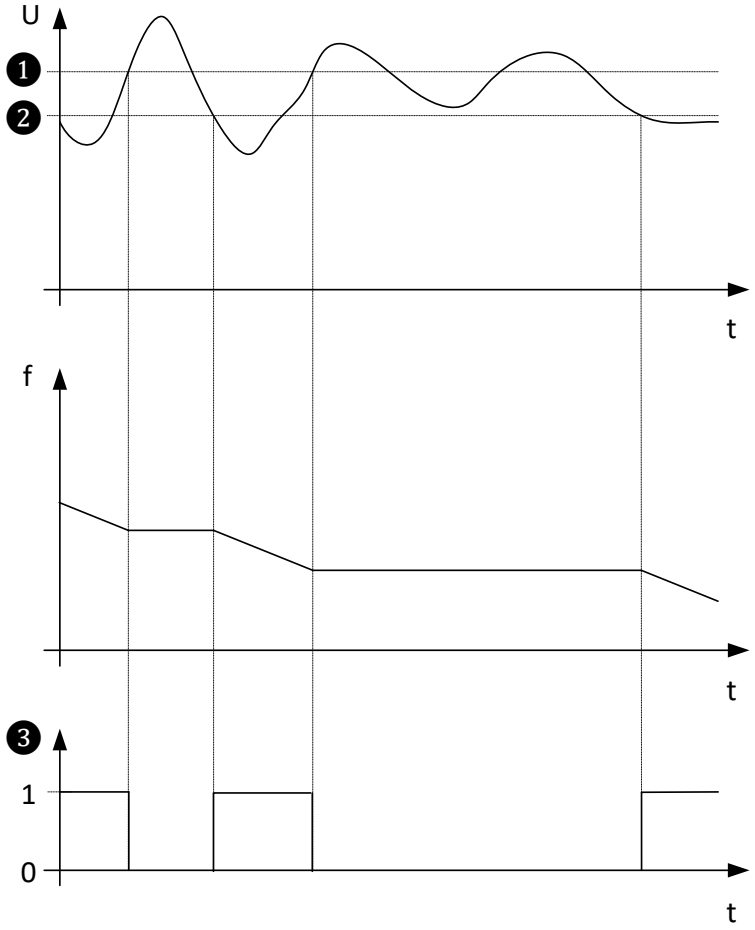



*Fig. 5-12 VFD ramp intervention: voltage criterion*

where: U: Power cell DC bus voltage
f: VFD output frequency
1 Maximum permissible DC bus voltage limit
2 DC bus voltage reset limit
3 Motor stop: deceleration process (1: active; 0: inactive)

**NOTE**

- The *maximum permissible DC bus voltage limit* and the *DC bus voltage reset limit* are fixed in the VFD. You cannot change these settings.

- For setting options, see parameters *Motor overexcitation gain* and *Motor overexcitation as of frequency.*

### 5.1.11 BYPASSED OPERATION (VFD BYPASS)

The VFD can be completely bypassed if required, to allow critical applications to continue operating even if the VFD is damaged. After switching off the defective VFD, the motor coasts to stop. When the VFD is bypassed, the motor operates directly from the incoming line (direct online, DOL). The minimum waiting time before restarting depends on the motor size and is typically between 250 and 750 ms. Ensure that the motor residual voltage has dropped to minimum to prevent switching into phase opposition.

The VFD can be bypassed either manually or automatically.

**NOTE**

VFD bypass function requires additional hardware (bypass cabinet).

### 5.1.12 BYPASSED OPERATION (POWER CELL BYPASS)

The power cells of each phase are connected in series. If a power cell fails, the defective cell can be bypassed (short-circuiting the output of the power cell with respect to terminals L1 and L2) to maintain the operation of the VFD.

#### CONTACTOR BYPASS OR IGBT BYPASS

Defective power cells can be bypassed (integrated cell bypass). Depending on the design of the power cells, you can use either:

- an integrated *contactor bypass* or
- an integrated *IGBT bypass*

to bypass a defective cell.

***CONTACTOR BYPASS*** For the power cells with protection bypass, normally open contacts (NO) of protection bypass are connected parallel to the output of each power cell (connections L1 and L2) (refer to figure "Fig. 3-41 Electrical schematic diagram of a power cell").

***IGBT BYPASS*** For the power cells with IGBT bypass, two series of connected IGBTs are connected parallel to the output of each power cell (L1 and L2). See "Fig. 3-41 Electrical schematic diagram of a power cell".

If the VFD detects a power cell failure, it immediately blocks the H-bridge IGBT outputs of the defective power cell and sends an actuation signal to the corresponding contactor bypass or IGBT bypass. The VFD can then continue system operation uninterrupted either:

- using the *Neutral point shift* function with reduced power, or
- with the implementation of n+1 power cells (depending on VFD equipment) without power reduction

## NEUTRAL POINT SHIFT

*CONSEQUENCES OF A POWER CELL FAILURE*

**NOTE**

- Only the defective power cell is bridged.
- Bridging of a single power cell leads to voltage unbalance at the VFD output.
- To compensate for such effects on the output voltage, the MVH 2.0 uses the *Neutral point shift* function.
- To use the *Neutral point shift* function, power cells must be equipped with either a *contactor bypass* or an *IGBT bypass*.

Bypassing a faulty power cell does not affect the VFD's current output capacity but it does reduce the voltage output on the affected phase.

When a power cell fails, only that cell is bypassed. All other power cells continue to work normally to maximize the voltage output capacity. The zero offset function realigns the zero point of the VFD output voltage. Adjusting the phase angles of the phase voltages at the VFD output with respect to each other restores the symmetry of the phase voltages. Although the number of power cells operating in each phase is different and the phase voltages at the VFD output are unbalanced, the phase voltages are symmetrical, and the motor may continue to operate without risk.

*INTERFERENCE-FREE, SYMMETRICAL VOLTAGE SYSTEM*

The following figure shows the example of a symmetrical voltage system in operation with *five cascaded power cells* per phase. All power cells operate without interference. The phase shift of the individual phase voltages to each other is 120 °.

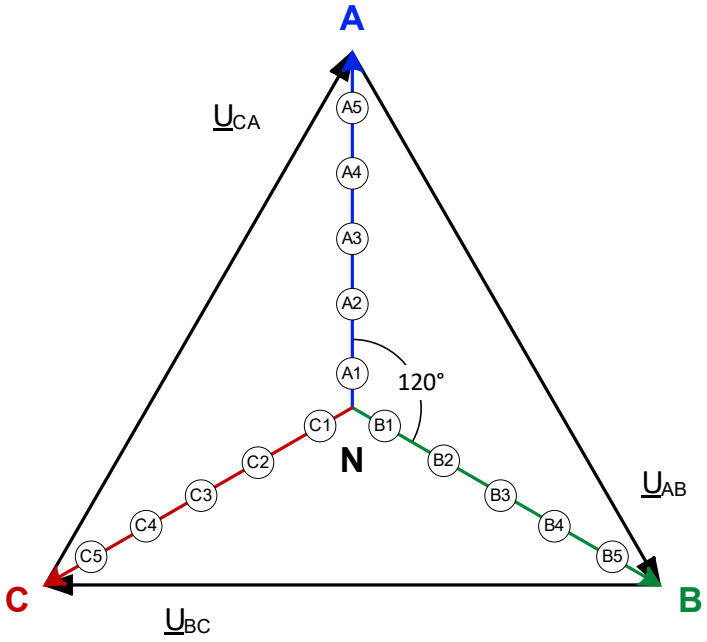



*Fig. 5-13 Phase angle of a 5-stage VFD - Interference-free operation*

*UNSYMMETRICAL VOLTAGE SYSTEM*

If a power cell fails and is bypassed, an *unbalanced* voltage system is created at the VFD output, as the magnitude of the *affected phase voltage* is reduced.

The following figure shows the *unbalanced* voltage system with a defective, but bridged, power cell in phase A.

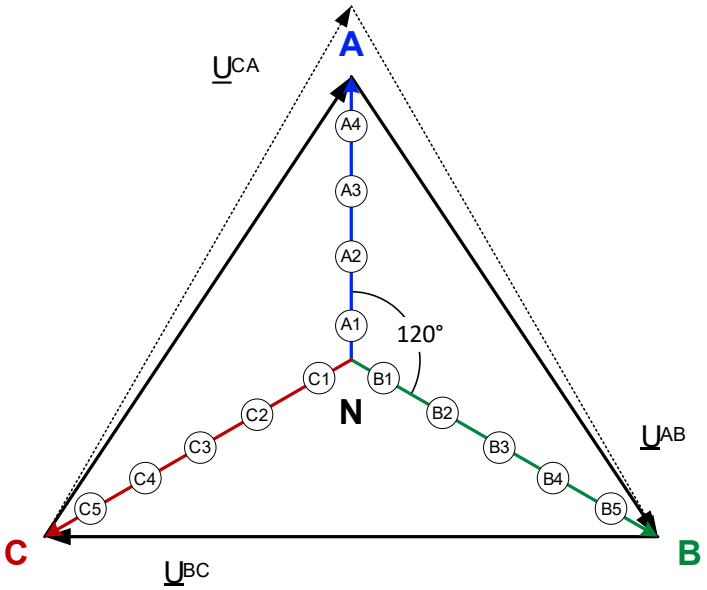



*Fig. 5-14 Phase angle of a 5-stage VFD - faulty and bridged power cell in phase A*

***BALANCING THE VOLTAGE UNBALANCE***

To compensate for the voltage unbalance caused by the lower magnitude of phase voltage A, the MVH 2.0 uses an algorithm to *shift the star point* accordingly.

In the above example of a 5-stage VFD, 14 of the 15 power cells are still in operation.

The phase angles of the phase voltages are adjusted so that:

- the phase angle difference between the phase voltages $\underline{U}_{NA}$ and $\underline{U}_{NB}$ as well as $\underline{U}_{NA}$ and $\underline{U}_{NC}$ is 126.4 °, and
- the phase angle difference between the phase voltages $\underline{U}_{NB}$ and $\underline{U}_{NC}$ is 107.2 °.

This phase shift leads to a *symmetrical* voltage system at the VFD output, which still corresponds to 92.9 % of the VFD's rated voltage regarding the magnitude of line-to-line voltages.

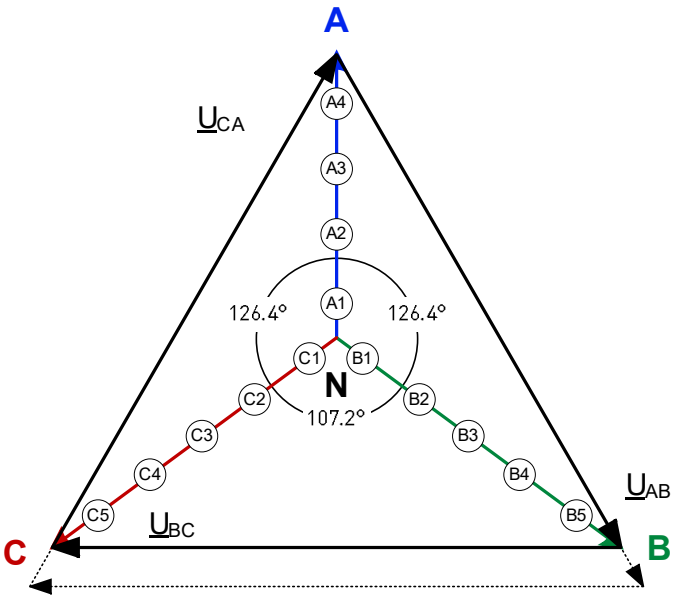



*Fig. 5-15 Phase angle of a 5-stage VFD - Application of "Neutral point shift" function*

**NOTE**

- There is no power reduction at speeds up to 92.9 % of the rated motor speed.
- At speeds > 92.9 % of the rated motor speed, the maximum motor torque is reduced as a quadratic function of the motor voltage.
- If the motor is designed to insulation class B/F, a continued operation with increased motor current is also possible under rated load.

## REDUNDANT CELL BYPASS (N+1)

All power cells of the VFD are equipped with an *IGBT or contactor bypass unit*. Each phase has an *additional (redundant) power cell* that also contributes to the VFD output voltage during VFD operation. If a power cell fails *during operation*, the control unit sends corresponding control signals to the *integrated bypass units* of the *corresponding cell number, in all three phases*. The redundant power cell means that the *full level of VFD output voltage* is still available.

# 6 MAINTENANCE

**WARNING**

Danger due to electric shock!

Dangerous residual voltage is still present at input terminals R, S, T on the power cell even after the VFD has been switched off!

- *Do not* perform troubleshooting and maintenance on the VFD with power on.
- Ensure you power off the VFD before opening the cabinet door and follow all lock-out/ tag-out safety procedures.
- Apply the five safety rules of electrical engineering (see *Five safety rules of electrical engineering*).
- To prevent personal injury caused by residual voltage on the main circuit capacitors, wait at least 10 minutes after power shutdown or failure, then confirm that the power cell voltage indicator is off before performing maintenance, inspection or repair.
- Only qualified electrical maintenance personnel should perform maintenance, inspection or replacement of parts.

## 6.1 ROUTINE INSPECTION

You must perform the routine inspection every year.

*ROUTINE INSPECTION SCHEDULE*

| Test object | Test criterion | Tool | Assessment criterion |
|---|---|---|---|
| Operating environment | Temperature | • Thermometer | • -5 ... +40 °C<br>• Derate VFD for use between 40 ... 50 °C, reduce rated output current by 1 °C. |
| | Humidity | • Hygrometer | • 5 ... 95 Hz non-condensing |
| | • Dust<br>• Grease<br>• Water and drips | • Visual inspection | • No dust<br>• No grease<br>• No water leaks |
| | Vibration | • Dedicated tester | • 0.15 mm, 9 ... 58 Hz, max. 3 m/s$^2$ |
| | Gas | • Dedicated tester,<br>• Sniff,<br>• Visual inspection | • No odor,<br>• no abnormal chemical smell or smoke |
| VFD | Heat | • Dedicated tester,<br>• Thermometer | • Outlet temperature is normal |
| | Sound | • Dedicated sound meter,<br>• Hearing | • No abnormal sounds, vibration, or squeaks |
| | Gas | • Sniff,<br>• Visual inspection | • No odor,<br>• No abnormal chemical smell or smoke |
| | Outward appearance | • Visual inspection | • Cabinets and doors are intact, without defects |
| | Cooling duct | • Visual inspection | • No dirt or other foreign materials blocking the air duct |
| | Input current | • Ammeter | • Within normal working range (see nameplate) |

| Test object | Test criterion | Tool | Assessment criterion |
|---|---|---|---|
| | Input voltage | • Voltmeter | • Within normal working range (see nameplate) |
| | Output current | • Ammeter | • Within normal working range or allowed short-term overload range |
| | Output voltage | • Voltmeter | • In the rated range for connected motor |
| Motor | Heat | • Dedicated tester,<br>• Thermometer | • No abnormal high temperature<br>• No overheating<br>• No burning odor |
| | Sound | • Dedicated sound meter,<br>• Hearing | • No abnormal sound or vibrations |
| | Vibration | • Dedicated tester | • No abnormal vibration |

*Tab. 6-1 Routine Inspection schedule*

## 6.2 REGULAR MAINTENANCE

You must perform the following maintenance work regularly, depending on the conditions of use of the VFD.

**NOTE**

- The regular maintenance interval is every *three* to *six* months.
- If the VFD is in a dusty environment, clean or change the filter regularly.
- Record the running condition of the VFD (see table "Tab. 6-3 VFD run record"). When a fault trip occurs, record the fault condition, identify the cause, and resolve the issue before powering on again.

***REGULAR MAINTENANCE SCHEDULE***

| Test object | Test criterion | Tool | Assessment criteria |
|---|---|---|---|
| VFD | • Main circuit terminals | • Screwdriver<br>• Wrenches<br>• Torque wrench<br>• Visual inspection | • Bolts and screws properly tightened,<br>• No damage to the cable or lugs |
| | • PE/Ground terminals | • Screwdriver<br>• Wrenches<br>• Torque wrench<br>• Visual inspection | • Screws tightened,<br>• No damage to the cable |
| | • Control circuit terminals | • Screwdriver<br>• Torque screwdriver | • Wires inserted,<br>• Screws properly torqued,<br>• No damage to the wires or cables |
| | • Internal connection cables<br>• Connections | • Screwdriver<br>• Torque screwdriver | • No damage to the wires or cables<br>• Screws properly torqued |
| | • Mounting screws | • Screwdriver<br>• Sleeve | • Sleeve fastening |
| | • Dust/dirt | • Vacuum cleaner<br>• Compressed air | • No dust, dirt, or fibres |

| Test object | Test criterion | Tool | Assessment criteria |
|---|---|---|---|
| | • Foreign matter | • Visual inspection | • No foreign matter in any cabinet or duct |
| Motor | • Insulation test | • Insulation tester | • No abnormal readings |

*Tab. 6-2 Regular maintenance schedule*

***VFD SWITCH-ON TEST AND RUN RECORD***

If the VFD is taken out of operation for a long period of time, perform a *switch-on test every six months*. The switch-on time for this test should not be less than one hour.

If the VFD is *not operated* for more than *six months*, we recommend to slowly *precharge* the power cells using the 400 V AC auxiliary winding of the transformer. Slowly increase the voltage to the rated voltage of the power cells via a voltage regulator.

**NOTE**

When a *fault trip* occurs, record the fault condition, identify the cause and resolve the issue before powering on again.

Record the *operating status* of the VFD in accordance with the following *run record*.

| Record time | Indoor temperature [°C] | Transformer temperature [°C] | Temperature cell cabinet [°C] | RUN frequency [Hz] | VFD output current [A] | VFD output voltage [V] | Fault type and description |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

*Tab. 6-3 VFD run record*

## 6.3 MAINTENANCE OF SPARE POWER CELLS

For power cells with *electrolytic capacitors*, energise and operate the spare power cells every six months to prevent the capacitors from drying out. For the spare cells, make sure that the DC bus capacitors are gradually precharged before installation and connection in the inverter. In doing so, slowly raise the voltage at terminals R, S, T to nominal voltage via a voltage regulator.

# 7 TROUBLESHOOTING

**WARNING**

Danger due to electric shock!

Dangerous residual voltage is still present at input terminals R, S, T on the power cell, even after the VFD has been switched off.

- *Do not* perform troubleshooting and maintenance on the VFD with power on.
- Ensure you power off the VFD before opening the cabinet door and follow all lock-out/ tag-out safety procedures.
- Apply the five safety rules of electrical engineering (see *Five rules of electrical engineering*).
- To prevent personal injury caused by residual voltage on the main circuit capacitors, wait at least 10 minutes after power shutdown or failure, then confirm that power cell voltage indicator is off before performing maintenance, inspection or repair.
- Only qualified electrical maintenance personnel should perform maintenance, inspection or replacement of parts.

## 7.1 ALARM/FAULT – CAUSES AND REMEDY

The MVH 2.0 has comprehensive fault monitoring and a complete protection mechanism. It generates corresponding messages on the detected fault events.

Events can be divided into two categories:

- *Alarm* events
- *Fault* events

***ALARM MESSAGES*** When an *alarm event* is active, the VFD will report the corresponding event message but continues to operate. The VFD can be turned on, started, or running.

***FAULT MESSAGES*** When a *fault event* occurs, the MV power will be removed immediately, the corresponding fault message will be recorded, and the system will be latched in the fault state.

***ALARM/FAULT INVESTIGATION*** Before seeking service support, you can first perform a self-inspection of the VFD system according to the alarm or fault message and the proposed solutions in the following sections.

For service support, contact AuCom or your local supplier.

### 7.1.1 ALARM MESSAGES

When an *alarm* event occurs, the system issues an alarm signal and displays the condition. The indicator light will blink.

The alarm condition is *cleared automatically* when the condition causing the alarm goes away.

When an *alarm* occurs before medium voltage is applied in the VFD, you can select *two options*. You can set this using parameter *VFD operation with active Alarm*:

- If set to *Enable*, medium voltage (MV) *can* be applied to the VFD.
- If set to *Disable*, medium voltage (MV) *will not* be applied to the VFD.

The following *alarm messages* are available:

| Alarm messages |
|---|
| Alarm: No feedback signal at Analog input AI 2 |
| Alarm: No setpoint signal at Analog input AI 1 |
| Alarm: Door lock |
| Alarm: Clean air filter |
| Alarm: Communication error control unit |
| Alarm: Excitation current difference > 10% |
| Alarm: Fan failure |
| Alarm: Fan failure loop |
| Alarm: Fan power supply |
| Alarm: Motor overload |
| Alarm: Cell bypass |
| Alarm: Cell cabinet overtemperature |
| Alarm: Door alarm cell cabinet |
| Alarm: Communication error HMI |
| Alarm: Door alarm transformer cabinet |
| Alarm: Transformer heat exchanger leakage |
| Alarm: Transformer overtemperature |
| Alarm: Water cooling |

*Tab. 7-1 Alarm list*

## ALARM MESSAGES – CAUSES AND REMEDIES

Use this table to *troubleshoot* when the VFD reports an *alarm* event.

| Alarm message | Possible cause | Remedy |
|---|---|---|
| *Alarm: No feedback signal at Analog input AI 2* | No analogue signal for the speed setpoint | • Measure whether an analogue signal is present.<br>• Check the wiring of the analogue input and correct as necessary. |
| | Power supply failure | • Measure the voltage at the power supply and correct it if necessary. |
| *Alarm: No setpoint signal at Analog input AI 1* | No analogue signal for the speed setpoint | • Measure whether an analogue signal is present.<br>• Check the wiring of the analogue input and correct as necessary. |
| | Power supply failure | • Measure the voltage at the power supply and correct it if necessary. |
| *Alarm: Door lock* | Door contact switch does not provide a signal when the cabinet door is closed | • Check the correct operation of the door contact switch and replace if necessary.<br>• Check the correct alignment of the door contact switch and adjust if necessary.<br>• Check the wiring of the door contact switch and correct as necessary. |

| Alarm message | Possible cause | Remedy |
|---|---|---|
| | Defective digital input (DI) of the I/O interface board | • Contact AuCom. |
| *Alarm: Clean air filter* | Filters are dirty and/or clogged | • Check by holding a piece of paper in front of the filters. If the paper is not held by the suction air flow, the filters are dirty or clogged and should be cleaned. |
| | Too short setting of the time interval of the parameter *Filter cleaning interval* | • Increase parameter setting value. |
| *Alarm: Communication error control unit* | Faulty communication line between main processor board AP4 and I/O interface unit | • Ensure that the network cable is plugged in correctly.<br>• Check network cable and replace if necessary. |
| | I/O interface unit failure | • Check the polarity of the connected power supply and correct as necessary.<br>• I/O interface unit is defective ⇒ Contact AuCom. |
| | Main processor board AP4 failure | • Measure the voltage at the power supply unit of the assembly ⇒ The measured value must be in the range of 24 V DC ± 20 %. Correct voltage supply if necessary.<br>• Main processor board AP4 is defective ⇒ Contact AuCom. |
| | The software versions of the main processor board AP4 and I/O interface unit are not compatible | • Contact AuCom. |
| *Alarm: Excitation current difference > 10%* | *Excitation current difference limit value = 10 %* | |
| | Incorrect parameter settings of the excitation system | • Correct parameter settings. |
| | • Incorrect parameter setting of *Analog input AI 3* (feedback of the exciter current actual value)<br>• Defective *Analog input AI 3*<br>• Wire break of *Analog input AI 3* | • Check whether the difference between the supplied excitation current and the feedback excitation current value is above 10 %, correct as necessary.<br>• Correct parameter setting.<br>• Check wiring of *Analog input AI 3* and correct as necessary. |
| *Alarm: Fan failure* | Medium voltage is not being applied to the VFD and parameter *Manual fan control* is set to *Stop*. | • When medium voltage is applied to the VFD, the fans will activate and *Alarm: Fan failure* will automatically clear. |
| | Cabinet fan wiring error or fault | • Ensure the fan fault signal cable connection is correct. |
| | If parameter *VFD operation with active Alarm* is set to *Enable* and the fans are not running an *Alarm: Fan failure loop* will occur | • Set parameter *VFD operation with active Alarm* = *Disable* and set parameter *Manual fan control* = *Start* |

| Alarm message | Possible cause | Remedy |
|---|---|---|
| *Alarm: Fan failure loop* | Motor circuit breaker for the fan has tripped | • Check the motor for possible short circuits in the windings or earth faults and replace the fan if necessary<br>• Check the fan filter for dirt and replace if necessary. |
| | Temperature in the fan motor has exceeded the temperature pickup value | • Check the fan for ease of movement and replace it if necessary.<br>• Check the fan filter for dirt and replace if necessary. |
| *Alarm: Fan power supply* | Fan power circuit breaker or thermal relay has tripped | • Check the circuit breaker and the thermal relay are operational and replace if necessary.<br>• Ensure that there is no fan overload condition. |
| | Fan contactor does not switch | • Check the wiring of the fan contactor for errors and correct as necessary.<br>• Check the correct operation of the fan contactor and replace if necessary. |
| | Faulty fan auxiliary contacts | • Correct or replace fan. |
| *Alarm: Motor overload* | Motor current has exceeded limit of current protection function | • If the VFD is operating in an overloaded state, reduce the load, then observe the output current |
| | Set acceleration time is too short | • Increase the value of *Acceleration ramp* . |
| | Set deceleration time is too short | • Increase the value of *Deceleration ramp* . |
| | Incorrect parameter settings for motor rated current and/or motor idle current | • Correct the settings of parameters *Motor rated current* and *Motor idle current.* |
| | Mechanical load is too high or has the motor stalled | • Reduce load or solve mechanical problems. |
| | The performance class of the VFD does not meet the requirements of the application | • Check that the rated current of the VFD model is suitable for the load characteristics of the motor; contact the manufacturer if necessary. |
| *Alarm: Cell bypass* | Fuse has tripped | • Replace power cell. |
| | Cell bypass IGBT fault | • Replace power cell. |
| | Fibre optic fault | • Replace power cell. |
| | Cell bypass contactor fault | • Replace power cell. |
| | Power cell overheated | • Replace power cell. |
| | Too much dust in the power cell | • Replace power cell. |
| *Alarm: Cell cabinet overtemperature* | *Temperature limit value = 55 °C* | |
| | Failure of one or more fans | • Check whether the fan circuit breaker has tripped.<br>• Check the correct operation of the fan contactor and the thermal relays and replace if necessary. |

| Alarm message | Possible cause | Remedy |
|---|---|---|
| | Filters are dirty and/or clogged | • Check by holding a piece of paper in front of the filters. If the paper is not held by the suction air flow, the filters are dirty or clogged and should be cleaned. |
| | VFD has been operated in an overloaded state for a long time | • Reduce the load on the VFD output and observe the temperature displayed on the touchscreen. |
| | Ambient temperature is too high | • Reduce the ambient temperature by increasing the site air-conditioning/ cooling. |
| *Alarm: Door alarm cell cabinet* | Door contact switch does not provide a signal when the cabinet door is closed | • Check the correct operation of the door contact switch and replace if necessary.<br>• Check the correct alignment of the door contact switch and adjust if necessary.<br>• Check the wiring of the door contact switch for faults and correct as necessary. |
| | Defective digital input (DI) of the I/O interface board | • Contact AuCom. |
| *Alarm: Communication error HMI* | Missing / insufficient power supply 24VDC for the operating unit (HMI) | • Check for 24 V DC supply to rear connector of touchscreen. |
| | Faulty network line for communication with the operating unit (HMI) | • Ensure that the network cable is plugged in correctly.<br>• Check network cable and replace if necessary. |
| | Defective interface on the operating unit (HMI) | • Contact AuCom. |
| *Alarm: Door alarm transformer cabinet* | Door contact switch does not provide a signal when the cabinet door is closed | • Check the correct operation of the door contact switch and replace if necessary.<br>• Check the correct alignment of the door contact switch and adjust if necessary.<br>• Check the wiring of the door contact switch and correct as necessary. |
| | Defective digital input (DI) of the I/O interface board | • Contact AuCom. |
| *Alarm: Transformer heat exchanger leakage* | Heat exchanger leaks | • Contact AuCom. |
| | Other cause of water ingress detected by visual inspection | • Eliminate the identified cause of water ingress. |
| *Alarm: Transformer overtemperature* | *Temperature limit value = 95 °C* | |
| | Incorrect parameter setting for temperature limit value | • Correct parameter setting. |
| | Faulty temperature sensor | • Check temperature sensor and replace if necessary. |
| | Failure of one or more fans | • Check whether the fan circuit breaker has tripped. |

| Alarm message | Possible cause | Remedy |
|---|---|---|
| | | • Check the correct operation of the fan contactor and the thermal relays and replace if necessary. |
| | VFD has been operated in an overloaded state for a long time | • Reduce the load on the VFD output and observe the temperature displayed on the touchscreen. |
| | Ambient temperature is too high | • Reduce the ambient temperature by increasing the site air-conditioning/ cooling. |
| *Alarm: Water cooling* | Cooling water temperature is too high | • Check parameter settings and correct as necessary.<br>• Check whether the external cooling circuit is switched on and switch it on if necessary. |
| | Conductivity is too high | • Check whether the conductivity value exceeds the set value.<br>• Ensure the internal water deionization process is operating normally. |
| | Cooling water level is too low | • Check the cooling circuit for leaks and correct as necessary.<br>• Refill cooling water. |
| | Faulty wiring of the feedback signals | • Check the wiring of the feedback signal lines and correct as necessary. |

*Tab. 7-2 Alarm events – Causes and remedy*

### 7.1.2 FAULT MESSAGES

When a fault occurs, the VFD system issues a *fault message* indicating the *fault condition* and commands the medium voltage breaker or contactor to open. At the same time, the VFD records the failure. The drive will remain in *fault state* until reset. The VFD will change to a *ready status* after troubleshooting and resetting of the fault is complete.

The following *fault messages* are available:

| Fault messages |
|---|
| Fault: Bypass power supply |
| Fault: VFD cabinet overtemperature |
| Fault: Power cell bypass unit |
| Fault: VFD control unit not ready |
| Fault: Test mode active - MV supply not allowed! |
| Fault: Excitation system |
| Fault: External Fault |
| Fault: Fibre optics (FO) |
| Fault: Power cell fuse failure |
| Fault (FO): Receive (RX) |
| Fault (FO): Transmit (TX) |
| Fault: MV mains failure (MV loss) |
| Fault: IGBT power cell |
| Fault: Incorrect input power display value |
| Fault: VFD input ground fault |
| Fault: VFD input phase unbalance |
| Fault: I/O interface unit not ready |
| Fault: Low frequency vibration while starting up |
| Fault: VFD control unit version error |
| Fault: Motor overcurrent |
| Fault: VFD output ground fault |
| Fault: VFD overvoltage |
| Fault: Parameter setting error |
| Fault: Door alarm cell cabinet |
| Fault: Power cell |
| Fault: Power cell overtemperature |
| Fault: Power cell overvoltage |
| Fault: Power cell power supply |
| Fault: System overspeed |
| Fault: VFD output phase unbalance |
| Fault: Transformer overtemperature |
| Fault: Door alarm transformer cabinet |
| Fault: VFD instantaneous trip at power on |
| Fault: VFD overcurrent |
| Fault: VFD start failure |

*Tab. 7-3 Fault list*

## VFD TRIP ANALYSIS

When a VFD trip occurs, the HMI displays the corresponding *fault message*. This information allows the operator to take appropriate action to clear the fault.

The flowchart below provides a procedure to analyse the cause of a VFD trip.

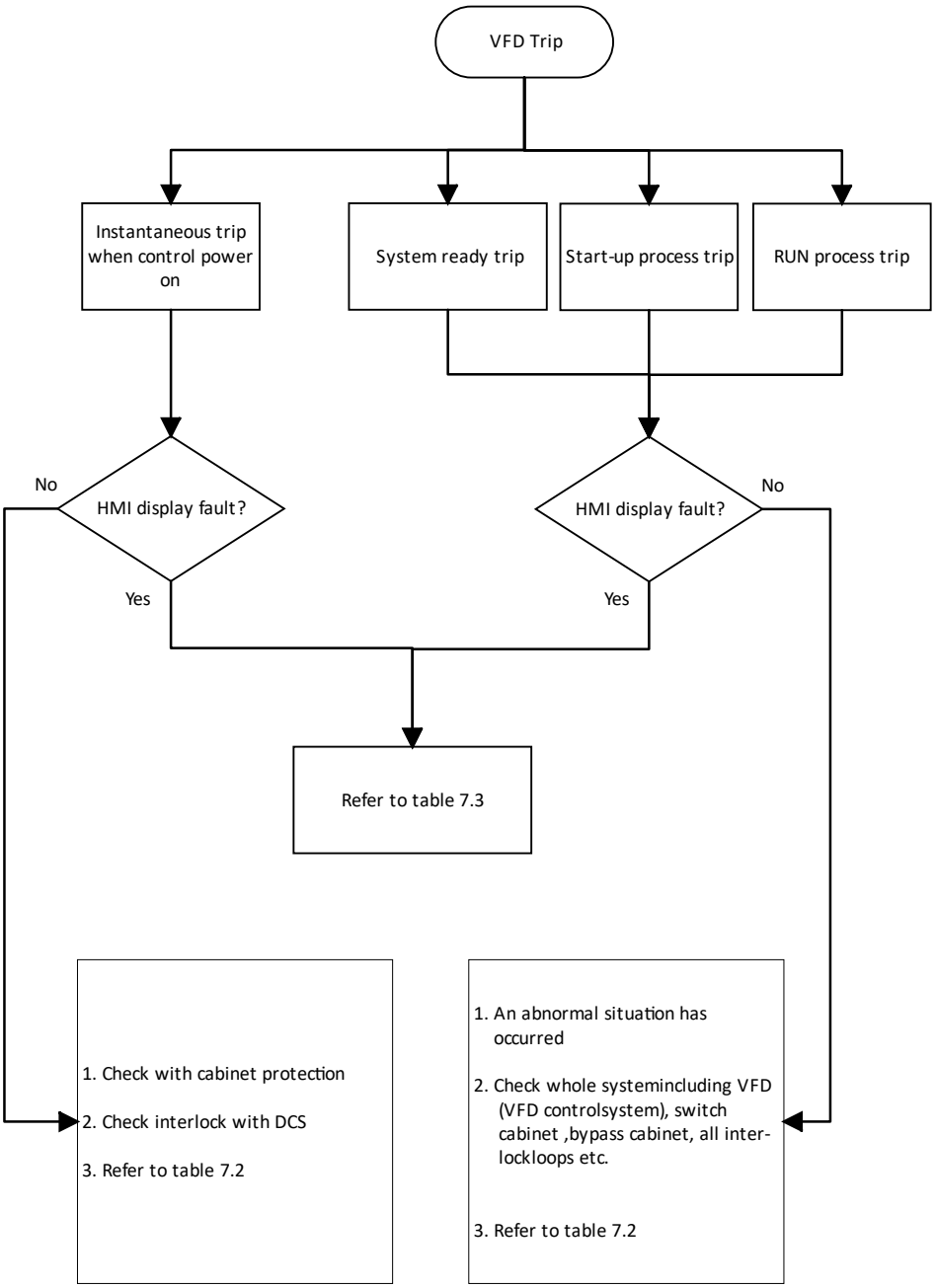



*Fig. 7-1 VFD trip: Procedure for fault analysis*

Before switching on the VFD, perform the following checks.

| Item | | To check |
|---|---|---|
| VFD & accessory equipment | Switch cabinet (Synchronous transfer) | • Check that the primary power wiring L1, L2, L3 in the switch cabinet is properly terminated.<br>• Is the circuit-breaker switched on? |
| | Primary cable inlet | • Check that the wiring from the synchronous transfer cabinet to the VFD is correct. |
| | Interlock wiring & control power | • Check if cabinet control loop power supply is operating normally.<br>• Check if MV interlock switch wiring is correct. |
| | VFD | • Check if the primary wiring from the transformer cabinet to the cell cabinet is correct.<br>• Check if VFD parameters are set correctly.<br>• Is the VFD status *MV not ready*?<br>• Check whether fault indicator is on.<br>• Resolve fault condition before attempting to energize. |
| Load equipment | Primary winding | • Check if wiring from VFD to motor is correct. |
| | Motor | • Check load.<br>• Check if the motor rotation is mechanically blocked.<br>• Check if it runs normally at rated frequency. |
| | Load | • Check if motor or load cooling is operating normally. |
| File record | Project-specific parameters | • Check if correct project parameters are set. |

*Tab. 7-4 Check before VFD power on*

## FAULT MESSAGES – CAUSES AND REMEDIES

Use this table to *troubleshoot* when the VFD reports a *fault* message.

| Fault message | Possible cause | Remedy |
|---|---|---|
| *Fault: No motor run at start signal* | DI *External VFD release* (terminals -XS1:1,8) not active | • Check input wiring of the DI for errors, and correct as necessary. |
| | The reset signal inputs are held in the active reset state | • The reset signals, after being used to reset the VFD, must return to their non-reset level otherwise the drive will not accept a run command. |
| *Fault: VFD cabinet overtemperature* | *Temperature limit value = 60 °C* | |
| | Fan power circuit breaker or thermal relay has tripped | • Check the circuit breaker and the thermal relay are operational and replace if necessary.<br>• Ensure that there is no fan overload condition. |
| | Filters are dirty and/or clogged | • Check by holding a piece of paper in front of the filters. If the paper is not held by the suction air flow, the filters are dirty or clogged and should be cleaned. |
| | VFD has been operated in an overloaded state for a long time | • Reduce the load on the VFD output and observe the temperature displayed on the touchscreen. |
| | Ambient temperature is too high | • Reduce the ambient temperature by increasing the site air-conditioning/cooling. |
| | Faulty analogue input (AI 3) on the I/O interface board | • Contact AuCom. |
| *Fault: Power cell bypass unit* | Bypass contactor is damaged | • Contact AuCom. |
| | Faulty power supply to the power cell gate drive board | • Contact AuCom. |
| *Fault: VFD control unit not ready* | Faulty connection between the control unit and the I/O interface unit | • Check wiring and correct as necessary. |
| *Fault: Test mode active – MV supply not allowed!* | Missing signal for *MV not ready* (HV OFF) at the connection terminals -XS3:1,4 of the I/O interface unit. | • Missing signal for MV not ready (HV OFF) at the connection terminals -XS3:1,4 of the I/O interface unit!<br>• Check wiring and correct as necessary. |
| | Faulty interlock protection for MV switching element | • Check wiring and correct as necessary. |
| *Fault: Excitation system* | Error in the field excitation system | • Check excitation system for errors and correct as necessary. |
| | Active digital input *Excitation system fault* at terminals -XS2T:1,5 of the I/O interface unit | • Check wiring and correct as necessary.<br>• Check external contact for DI Excitation system fault and correct as necessary. |

| Fault message | Possible cause | Remedy |
|---|---|---|
| *Fault: External fault* | VFD trip by optional motor protection device or - if included - by upstream protection system | • DI *External fault 1* is active (terminals: -XS2:1,10)<br>⇒ Determine cause of external trip and correct as necessary.<br>• DI *External fault 2* is active (terminals: -XS2:1,9)<br>⇒ Determine cause of external trip and correct as necessary. |
| | VFD trip by *EMERGENCY OFF* | • DI *EMERGENCY-OFF* is active (terminals: -XS3:1,5)<br>⇒ Check whether one of the EMERGENCY STOP switches is actuated.<br>⇒ Determine and eliminate the cause and restore the EMERGENCY STOP signal chain.<br>⇒ Reset safety relay. |
| *Fault: Fibre optics (FO)* | Faulty control board of a power cell | • Contact AuCom. |
| | Fibre optic (FO) cables for sending (TX) and receiving (RX) are swapped | • Check the fibre optic (FO) connections and correct as necessary. |
| | Dust inside the fibre optic (FO) connector | • Remove dust with a dust-free cloth or canned compressed air. |
| | Poor contact between the fibre optic (FO) plugs and receivers | • Check whether the fibre optic (FO) plug is firmly in place and correct as necessary. |
| | Optical fibre is broken or bent too much | • Compare relative fibre brightness to any adjacent cell.<br>• Visually inspect the entire length of the fibre optic cable for cable breakage or severe kinks and replace if necessary. |
| | Fibre optic connector is damaged | • Replace the fibre optic connector or the entire fibre optic cable including the connector. |
| | Power cell board is too dusty, causing the power cell to falsely report a failure | • Remove dust from the board and power cell. |
| | The fault message can be related to a defective power cell if there are additional fault messages regarding defective power cells. | • Contact AuCom. |
| | Faulty fibre receiver board | • Contact AuCom. |
| *Fault: Power cell fuse failure* | A phase loses input power | • Check the wiring of the incoming power. Use adequate and safe MV measurement techniques, measure the input voltage to ensure that all three phases are present.<br>• Correct as necessary. |
| | Abnormal power outage | • Identify the cause of any abnormal power outage and correct as necessary. |
| | Power cell incoming cables are loose or disconnected | • Check the input line for correct connection to the power cell and correct as necessary. |

| Fault message | Possible cause | Remedy |
|---|---|---|
| | Fuse is open or blown | • Contact AuCom. |
| | VFD cabinet is not properly grounded | • Check the earthing connection of the VFD cabinet.<br>• Measure the earthing resistance of the VFD cabinet (⇒ it must be less than or equal to 0.1 Ω).<br>• If the measured resistance value is greater than 0.1 Ω, take appropriate corrective measures. |
| | Power cell board is too dusty, causing the power cell to falsely report a failure | • Remove dust from the board and power cell. |
| *Fault (FO): Receive (RX)* | Optical fibre (RX) is broken or bent too much | • Compare relative fibre brightness to any adjacent cell.<br>• Visually inspect the entire length of the fibre optic cable for cable breakage or severe kinks and replace if necessary. |
| *Fault (FO): Transmit (TX)* | Optical fibre (TX) is broken or bent too much | • Compare relative fibre brightness to any adjacent cell.<br>• Visually inspect the entire length of the fibre optic cable for cable breakage or severe kinks and replace if necessary. |
| *Fault: MV mains failure (MV loss)* | Mains-side power failure during VFD operation | • Check for any abnormal situation on the site power grid. |
| | Incorrect setting of parameter *Max. permitted FRT duration* | • Check parameter setting and correct as necessary. |
| *Fault: IGBT power cell* | Power cell voltage detection board is damaged | • Check power cell voltage detection board and the detection board resistance wiring, correct as necessary. |
| | Transient load (load peak) | • Find the cause of the load jump and correct as necessary. |
| | The VFD output ground wire has been removed | • Restore the proper grounding of the VFD output. |
| | The motor insulation is damaged | • Measure the connection cable and motor to verify the motor winding insulation is within the allowed range. |
| | The motor load has stalled | • Clear the mechanical fault |
| | The VFD cabinet is not properly grounded | • Check the earthing connection of the VFD cabinet.<br>• Measure the earth resistance of the VFD intra cabinet (⇒ it must be less than or equal to 0.1 Ω).<br>• If the measured resistance value is greater than 0.1 Ω, take appropriate corrective measures. |
| | Power cell control board is too dusty, causing the power cell to falsely report a failure | • Remove dust from the control board and power cell. |
| *Fault: Incorrect input power display value* | Incorrect setting of parameter *VFD input: Rated CT prim. current* | • Check parameter setting and correct as necessary. |

| Fault message | Possible cause | Remedy |
|---|---|---|
| | Relay KA1 is open | • Ensure relay KA1 is operational and replace if necessary.<br>• Check wiring of relay KA1 and correct as necessary. |
| | Incorrect phase sequence of the voltages and currents at the VFD input | • Check the wiring at the VFD input and correct as necessary. |
| *Fault: VFD input ground fault* | Incorrect input power wiring or grounding of the transformer | • Check the VFD's main circuit wiring and correct as necessary.<br>• Perform a dielectric test on the main transformer line to ground, then compare the result with values from the transformer supplier. |
| | The input cable insulation is damaged | • Measure the insulation resistance of the input cable.<br>• Verify that it is within the allowed range. |
| | The lightning arrestors (if installed) are damaged | • Replace lightning arrestors.<br>• After replacing the lightning arrestors, perform an insulation resistance test ("megger") to verify the transformer is still healthy. |
| *Fault: VFD input phase unbalance* | There is an actual input power system voltage imbalance | • Measure the input voltage using proper and safe MV measurement techniques.<br>• Find the cause of the imbalance and correct as necessary. |
| | The software versions of the VFD main processor and I/O interface unit are not compatible | • Contact AuCom. |
| | The signal board I/O sampling resistances do not match. | • Contact AuCom. |
| *Fault: I/O interface unit not ready* | Lack of control voltage at -XS16 | • Check the connection wiring of the lower terminal board of the I/O interface unit and correct as necessary.<br>• Supply voltage to terminal strip -XS16 of the lower terminal board. |
| *Fault: Low frequency vibration while starting up* | The torque at the VFD output is insufficient at low frequency. | • Adjust the setting of the *Torque boost gain* parameter.<br>• Check the curves of the voltages and currents at the VFD output. |
| | Phase failure or open contact in one phase at the VFD output | • Check the connections of the VFD output and correct as necessary. |
| | VFD is in current-limiting operation | • Adjust the setting of parameter *Motor overload limit*. |
| | Incorrect setting of parameter *Acceleration ramp* | • Check parameter setting and correct as necessary. |
| | Fault message of a power cell | • Contact AuCom. |
| | Vibration of the mechanical load | • Check mechanical load and eliminate cause of vibrations. |

| Fault message | Possible cause | Remedy |
|---|---|---|
| *Fault: VFD control unit version error* | Parameters are not yet uploaded | • Upload parameters: the fault message is then automatically cleared. |
| | Software programme versions are not compatible | • Contact AuCom. |
| *Fault: Motor overcurrent* | *Protective function setting range: 110 – 150 % of VFD rated output current* | |
| | Incorrect settings of the motor parameters | • Check settings of *Motor parameter 1* or *Motor parameter 2* and correct as necessary. |
| | Abnormal, mechanical load | • Check mechanical load and correct mechanical fault as necessary. |
| *Fault: VFD output ground fault* | VFD output is short-circuited to ground | • Check whether the VFD output terminal wiring and motor connections are correct and undamaged and correct as necessary. |
| *Fault: VFD overvoltage* | Deceleration time is too short for a high inertia load | • Check settings of parameter *Deceleration ramp* and correct as necessary. |
| | Incoming line voltage is too high | • Reduce the secondary transformer voltage via the primary-side tap changer of the multi-level transformer gate. |
| | Unstable vector control | • Improve tuning of the vector and related PI-controllers for *magnetic flux* and *speed.* |
| *Fault: Parameter setting error* | The parameter settings of *VFD type* are incorrect when control mode is *synchronous vector control*. | • Check parameter settings and correct as necessary. |
| *Fault: Door alarm cell cabinet* | *Precondition:* This fault message is only activated for the parameter setting *Open cabinet door: Fault selection = Fault.* | |
| | At least one of the doors of the cell cabinet has been unlocked while the VFD was switched on. | • Check that all doors of the cell cabinet are properly closed and locked. |
| | At least one door contact switch is faulty | • Check door contact switch and replace if necessary. |
| *Fault: Power cell overtemperature* | *Temperature limit value = 85 °C* | |
| | Cooling fans do not work properly | • Check by holding a piece of paper in front of the filters. If the paper is not held by the suction air flow, the filters are dirty or clogged and should be cleaned. |
| | Filters are dirty and/or clogged | |
| | The power cell overheating has damaged the internal sensor | • Contact AuCom. |
| | VFD has been operated in an overloaded state for a long time | • Reduce the load on the VFD output and observe the temperature displayed on the touchscreen. |
| | Ambient temperature is too high | • Reduce the ambient temperature by increasing the site air-conditioning/cooling. |
| | *Overvoltage protection pickup value = 1190 V* | |

| Fault message | Possible cause | Remedy |
|---|---|---|
| *Fault: Power cell overvoltage* | Deceleration time is too short | • Increase setting value of parameter *Deceleration ramp*.<br>• Adjust value of parameter *Motor overexcitation gain* to reduce regeneration. |
| | The pickup limit of overvoltage protection has been exceeded | • Check the voltage at the power cell inputs and, if necessary, reduce the secondary transformer voltage via the primary tap changer of the multi-level transformer. |
| | Current in VFD output oscillating | • Adjust the speed ratio system parameters: *PI-contr. (speed): P-gain* and *PI-contr. (speed): I-time*). |
| | Faulty *Hall sensors* for current measurement | • Check wiring of the hall sensor and correct as necessary.<br>• Ensure the hall sensors are intact. |
| | Motor consumes high reactive power. | • Contact AuCom. |
| | There is an unbalanced or overhauling load | • Check load and correct as necessary. |
| *Fault: Power cell power supply* | Defective power cell module | • Contact AuCom. |
| *Fault: System overspeed* | Parameter *VFD type* and *common control parameters* are set incorrectly | • Contact AuCom. |
| *Fault: VFD output phase unbalance* | The output voltage of a power cell is too low | • Determine the defective power cell via *Power cell status* menu.<br>• Replace power cell.<br>• Contact AuCom. |
| | The software versions of the VFD main processor and I/O interface unit are not compatible | • Contact AuCom. |
| | Faulty motor wiring | • Ensure the VFD output terminal wiring and motor connections are correct and undamaged. |
| | Motor windings are damaged (shorted or open) | • Check the motor for damage and correct as necessary. |
| *Fault: Transformer overtemperature* | *Temperature limit value = 150 °C* | |
| | Incorrect temperature limit setting | • Check parameter setting and correct as necessary. |
| | Filters are dirty and/or clogged | • Check by holding a piece of paper in front of the filters. If the paper is not held by the suction air flow, the filters are dirty or clogged and should be cleaned. |

| Fault message | Possible cause | Remedy |
|---|---|---|
| | Failure of one or more fans | • Check whether the fan circuit breaker has tripped.<br>• Check the correct operation of the fan contactor and thermal relays and replace if necessary.<br>• Check wiring of the fan circuit and correct as necessary. |
| | VFD has been operated in an overloaded state for a long time | • Reduce the load on the VFD output and observe the temperature displayed on the touchscreen. |
| | Ambient temperature is too high | • Reduce the ambient temperature by increasing the site air-conditioning/cooling. |
| *Fault: Door alarm transformer cabinet* | *Precondition:*<br>This fault message is only activated for the parameter setting *Open cabinet door: Fault selection = Fault.* | |
| | At least one of the doors of the transformer cabinet has been unlocked when the VFD is switched on. | • Check that all doors of the cell cabinet are properly closed and locked. |
| | At least one door contact switch is faulty | • Check door contact switch and replace if necessary. |
| *Fault: VFD instantaneous trip at power on* | The safety earthing of the main circuit was not removed before commissioning. | • Remove safety grounding before energizing the VFD. |
| | Incorrect connection of the VFD ground | • Ensure the main circuit ground wire is connected properly and a low impedance earth ground is present. |
| | The protection settings for the power cabinet are set too low | • Adjust the protection value of the power cabinet according to the site's supply capability. |
| | There is an excessive inrush current to the transformer | • Contact AuCom. |
| *Fault: VFD overcurrent* | *Pickup limit value = 150 % of the VFD output rated current* | |
| | Transient load (load peak) | • Find the cause of the load jump and correct as necessary. |
| | Incorrect settings of parameters *Start Frequency*, *Acceleration ramp* and/or *Motor overexcitation gain* | • Check parameter settings and correct as necessary. |
| | Faulty wiring of the VFD output circuit | • Check wiring for errors and correct as necessary. |
| | Parameter *VFD type* is set to *ASYNC Motor VC without sensor* without first using the motor *parameter identification* feature | • Identify the motor parameters in the correct order of *parameter identification.* |
| | If the control mode uses an encoder: there is a wiring error with the encoder | • Check the encoder signal wiring and correct as necessary. |
| | The diode on the output voltage detection board is damaged | • Contact AuCom. |
| | Distorted waveform of the VFD output current | • Adjust the settings of parameter *PI-controller: Speed P-gain*. |

| Fault message | Possible cause | Remedy |
|---|---|---|
| | Motor insulation is damaged | • Measure the connection cable, ensure the motor winding insulation is within the allowed range. |
| | Faulty wiring of the Hall sensors' circuit | • Check the wiring of the Hall sensors' circuit and correct as necessary.<br>• Measure the voltage at each Hall sensor and check that the voltage is within the permissible range in each case.<br>• Contact AuCom. |
| | Deceleration time is too short | • Increase the value of parameter *Deceleration ramp*. |
| | Acceleration time is too short | • Increase the value of parameter *Acceleration ramp*. |
| | Faulty power cell(s) | • Contact AuCom. |
| | The motor or auxiliary machinery has stalled | • Replace the motor or auxiliary machinery if damaged or clear the mechanical fault. |
| | Start frequency is set too high | • Decrease setting value of *Start Frequency* parameter. |
| | Torque boost gain is set too large | • Decrease setting value of *Torque boost gain* parameter. |
| | Faulty wiring of the lightning arrestors' circuit, if applied | • Ensure the peripheral electrical equipment wiring at the output of the VFD is correct (as per factory specifications). |
| | The performance class of the VFD does not meet the requirements of the application | • Check that the rated current of the VFD model is suitable for the load characteristics of the motor. Contact AuCom. |

*Tab. 7-5 Fault events – Causes and remedy*

## 7.2 REPLACEMENT

### 7.2.1 POWER CELL REPLACEMENT

All the power cells in the cell cabinet have the same electrical and mechanical properties. If a failure caused by a malfunction of power cell is identified, the faulted power cell can be replaced with a new cell with the same specification.

**WARNING**

Danger due to electric shock!

Dangerous residual voltage is still present at input terminals R, S, T on the power cell, even after the VFD has been switched off.

- *Do not* perform troubleshooting and maintenance on the VFD with power on.
- Ensure you power off the VFD before opening the cabinet door and follow all lock-out/ tag-out safety procedures.
- Apply the five safety rules of electrical engineering (see *Five rules of electrical engineering*).
- To prevent personal injury caused by residual voltage on the main circuit capacitors, wait at least 10 minutes after power shutdown or failure, then confirm that power cell voltage indicator is off before performing maintenance, inspection or repair.
- Only qualified electrical maintenance personnel should perform maintenance, inspection or replacement of parts.

**NOTE**

- Make sure that the replacement power cells have the two fibre optic rubber plugs inserted into the TX/RX connectors to prevent dust from contaminating the fibre optic transceivers.
- After replacement, contact your supplier with regard to power cell repair.
- For the spare cells with electrolytic capacitors, make sure that the DC bus capacitors are gradually precharged before installation and connection in the inverter. In doing so, the voltage at terminals R, S, T must be slowly raised to nominal voltage via a voltage regulator.

**INSTRUCTION – Replacing a defective power cell**

*START* *USER LEVEL:* **(Standard)**

**STEP 1:** Stop the VFD and take it out of service.

**STEP 2:** Apply the five safety rules of electrical engineering.

**STEP 3:** Switch off the MV supply. Depending on the configuration,

- either open the disconnect/earthing switch,
- pull out the MV switchgear dolly, or
- isolate the VFD using the isolation knife-switch in the bypass cabinet (if equipped with a bypass cabinet).

**STEP 4:** Lock out the local or remote MV switch and connect the cabinet's grounding switch (if supplied).

**STEP 5:** Move the disconnect/earthing switch to the disconnect/earthing position and secure it against being switched on again.

**STEP 6:** Wait at least 10 minutes after MV power is removed. All cell indicator lights must be off.

**STEP 7:** Unlock and open the cabinet door.

**STEP 8:** Check that all voltage indicators (LEDs) on the power cells have gone out and wait for them to go out if necessary.

**STEP 9:** Unplug the TX, RX fibre optic plugs from the faulty power cell.

**STEP 10:** Disconnect the R, S and T terminals of the faulty power cell and remove the input power cable.

**STEP 11:** Disconnect L1 and L2 connections at the output of the defective power cell and remove the connecting leads to the adjacent power cells.

**STEP 12:** Remove the screws connecting the faulty power cell to its mounting track.

**STEP 13:** Pull out the faulty cell along its track, handle cell with care.

**STEP 14:** Remove the fibre optic rubber stoppers from the new power cell and place the plugs into the faulted cell fibre optic connections.

**STEP 15:** Install the replacement cell, tighten mounting hardware, and wire in reverse order of removal.

**STEP 16:** Re-power the VFD. Verify proper operation.

***END***

# 8 TRANSPORT, STORAGE, AND INSTALLATION

## 8.1 RECEIVING INSPECTION

Upon receiving the MVH 2.0 product:

- Confirm the exterior packaging of the VFD is in good condition.
- Unpack and confirm the cabinet surface of the VFD is in good condition and verify that there are no broken or shifted internal components.
- Check the packing list to confirm all components are received.

**CAUTION**

If there is any damage to the VFD, refuse shipment and immediately contact the carrier.

## 8.2 STORAGE

The VFD should be stored in a ventilated room, with a temperature between -40 °C and 70 °C and with a non-condensing humidity no higher than 90 %.

## 8.3 TRANSPORT

With proper packing, the MV VFD may be transported by airplane, truck, train, ship etc.

**CAUTION**

- During transportation, do not expose the VFD to rain, extended direct sunlight, dirt, high vibration, or impact, invert the cabinet, or lay it on one side.
- Be aware of height limitations before and during movement of the equipment to its final position.
- Any cranes or lifting rigging should be of higher capacity than the weight of the MVH 2.0.

### 8.3.1 HANDLING DURING TRANSPORT

There are several acceptable methods for handling the VFD cabinets:

- Overhead crane lifting
- Hand chain hoist lifting
- Roller lifting
- High-capacity fork truck

### *USING AN OVERHEAD CRANE OR A HAND CHAIN HOIST*

**CAUTION**

- Confirm that the cables are of sufficient length and strength to support the load.
- *Do not* lift with cables directly on the lifting eyes. Use of a spreader bar is mandatory to prevent cabinet deformation damage!

### *USING ROLLERS*

The use of rollers is suitable for narrow spaces where no crane or hand chain hoist can be used. Lay several rollers on the ground one by one, place the cabinet on the rollers and use a crowbar to move the rollers to the installation position.

**CAUTION**

- To avoid cabinet damage when any cabinet is hoisted, you must use all four rings at the same time.
- When lifting the power cell cabinet, the angle between the rope and the cabinet must not be less than 60 °. Use a spreader bar to distribute the load.
- When lifting the transformer cabinet, use the transformer's own core lift rings. *Do not* lift by the transformer cabinet body (see the following figure *Schematic diagram of cabinet hoists*). If there are multiple fans installed on the top of the transformer cabinet, remove the fans before the transformer is hoisted and reinstall these after the unit is put into its final position.
- Be careful when connecting the lifting apparatus to the inside of the transformer cabinet. *Do not* touch the transformer coils or insulation. Prevent foreign objects or materials from falling into the cabinet. While lifting the transformer, ensure the lifting angle does not deform the fan or cover plate.
- The cabinet must be placed on a flat surface to ensure proper alignment and normal opening and closing of the cabinet doors.
- Follow all local lifting safety requirements. When the cabinet is lifted, *do not* stand under the suspended equipment.
- To lift into position all-in-one cabinets, use slings through the forklift tubes (located at the bottom of the cabinet) in conjunction with spreader bars (above the cabinet). Failure to use top spreaders bars will result in door and air filter damage.

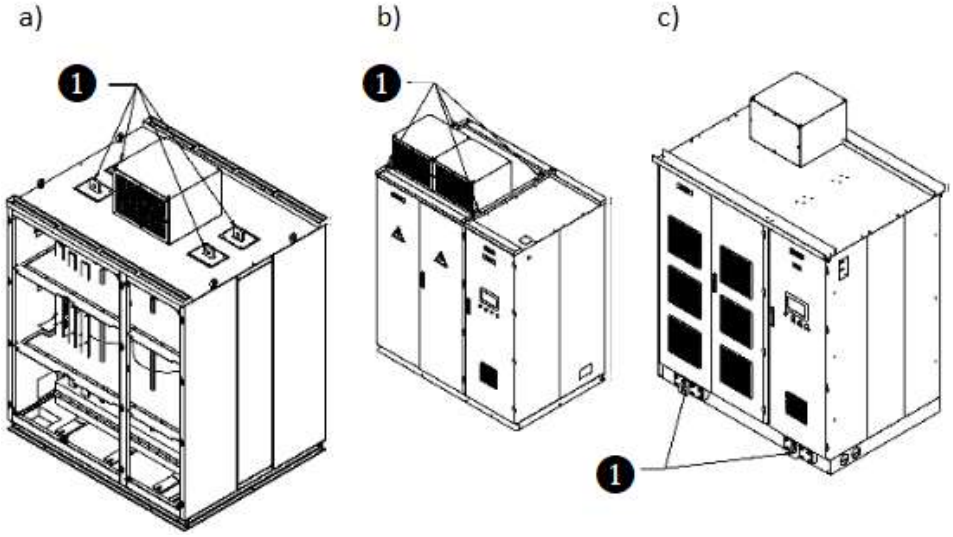



*Fig. 8-1 Schematic diagram of cabinet hoists:*
*a) Transformer cabinet – top hoist*
*b) Cell cabinet – top hoist*
*c) Cell cabinet – bottom hoist*

1 Lifting hoist

### *COOLING THE VFD CABINET*

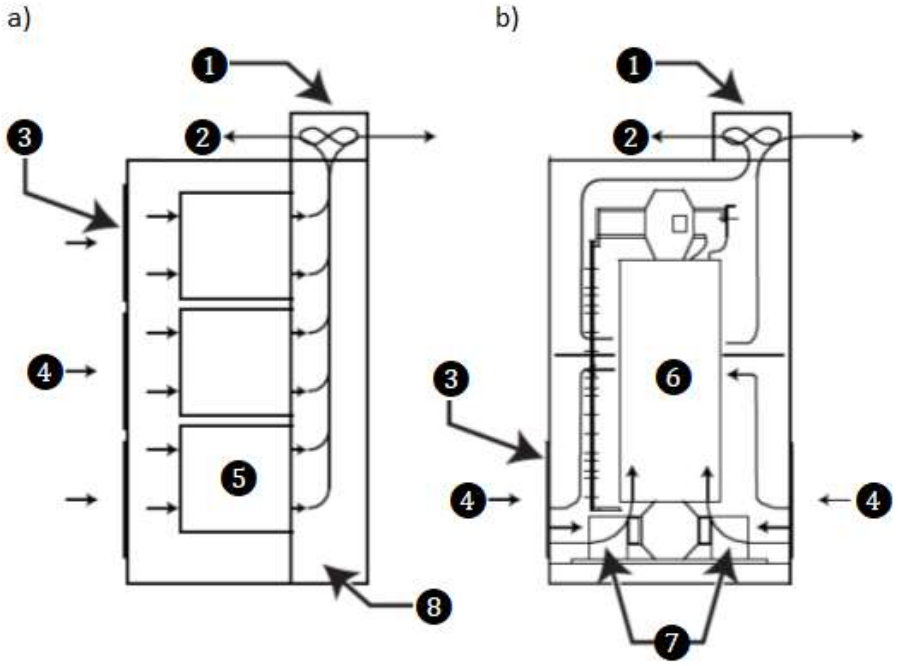



*Fig. 8-2 Cooling air flow paths in the various cabinet types – Example: 6 kV VFD:*
*a) Control/feeder cabinet and cell cabinet*
*b) Transformer cabinet*

1 Centrifugal fan
2 Air outlet
3 Filter (front)
4 Air inlet (front)
5 Power cells
6 Multi-level transformer
7 Bottom fan
8 Independent air duct

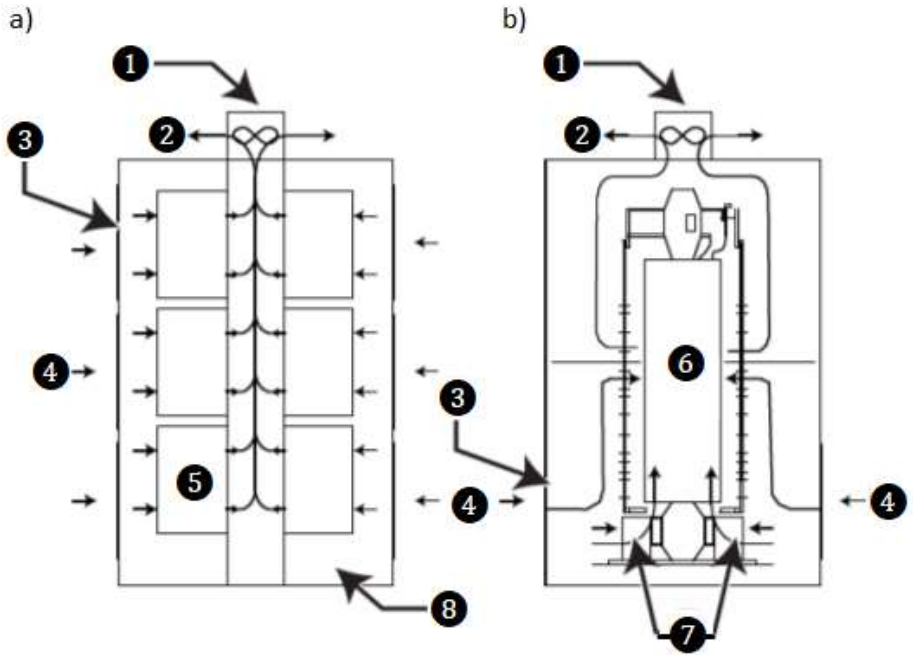



*Fig. 8-3 Cooling air flow paths in the various cabinet types – Example: 11 kV VFD:*
*a) Control/feeder cabinet and cell cabinet*
*b) Transformer cabinet*

1. Centrifugal fan
2. Air outlet
3. Filter (front)
4. Air inlet (front)
5. Power cells
6. Multi-level transformer
7. Bottom fan
8. Independent air duct

In case of high ambient temperatures or poor ventilation, it may be necessary to install a circulation fan or industrial air conditioning. To reduce the ambient temperature of the VFD, a concentrated ventilation duct can be installed by the customer. The hot air can be ejected outdoors by the centrifugal blower through the ventilation duct. The concentrated ventilation duct is directly connected to cooling blowers on the top of the cabinet (see Fig. 8-4Air-water cooling schemes:
a) Air/water cooling
b) Air cooling).

The ventilation system must be designed so that it does not create any airflow restriction on the VFD cooling system. Also, if circulating outside air, care must be taken to prevent debris from clogging the air filters.

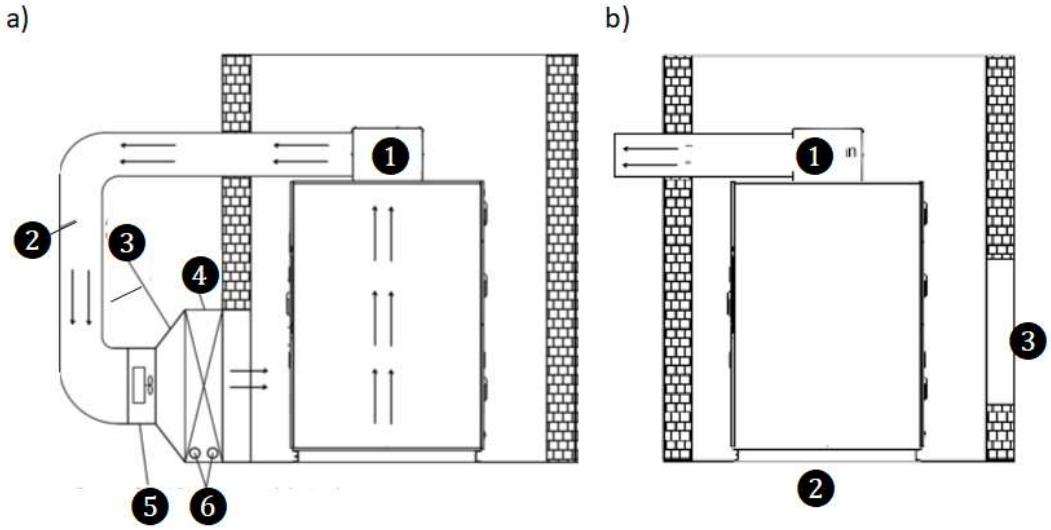



*Fig. 8-4 Air-water cooling schemes:*
*a) Air/water cooling*
*b) Air cooling*

1. Top fan
2. Air duct
3. a) Air duct soft connection
   b) Air inlet (area > total area of all fan outlets)
4. Heat exchanger
5. Booster fan
6. Cooling water inlet/outlet

## 8.4 INSTALLATION

***SET UP THE VFD CABINET***

For safety and ease of the cable routing, it is recommended that the cabinets be installed over a cable duct, see Cable channel/duct on page 100. The VFD needs proper support when located on top of a cable duct.

The bottom of the VFD is made of 10# channel steel. (For rated powers larger than or equal to 2146 PS/1600 kW, it is made of 16# channel steel. For rated powers larger than 5364 PS/4000 kW, it is made of 18# joist steel.) Select the correct support according to the VFD weight.

From front view, the transformer cabinet and cell cabinet are arranged from left to right. Both the transformer cabinet and cell cabinet are fastened together by bolts to form a complete system.

The VFD should be installed on a stable base and solidly earth grounded. The shield of the transformer and its terminals should be earth grounded. The earthing resistance should be kept below 4 Ω. Each cabinet connects with each other as a complete system.

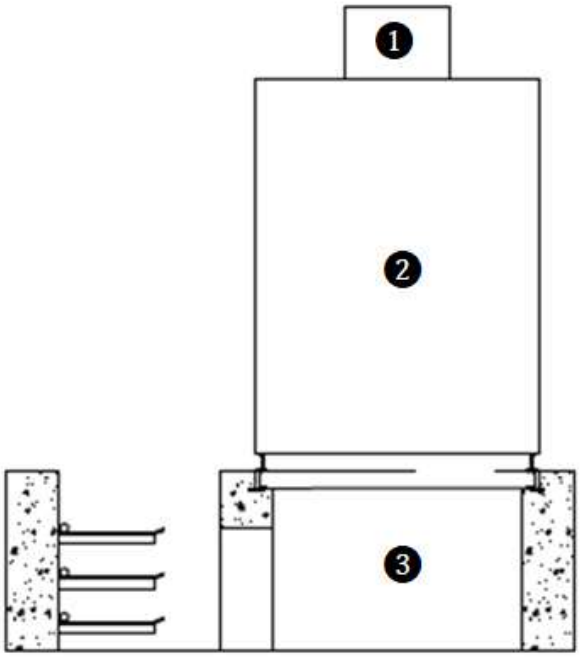



*Fig. 8-5 Cable channel/duct*

1. Top fan
2. VFD cabinet
3. Cable channel

### *ADDITIONAL, OPTIONAL CABINETS*

Depending on the application, accessory cabinets maybe be provided:

- A *bypass cabinet* is used to switch the motor connection from VFD output to line frequency.
- A *synchronous transfer system* is used to switch the VFD output to control up to two motors.
- A *precharge cabinet* is used for limiting the inrush currents of high power VFD systems.

**NOTE**

If the selected accessories include bypass cabinet, precharge cabinet etc., the actual position of the cabinet is according to the specific project drawings.

# 9 DISPOSAL

If the MVH 2.0 frequency inverter is decommissioned permanently, observe the following preparatory measures for the proper and environmentally friendly disposal of the product.

***SAFETY INSTRUCTIONS***

Always follow the safety instructions in chapter *Safety* when carrying out any work.

***ELECTRICAL AND ELECTRONIC COMPONENTS***

**DISPOSAL NOTE**

- Assemblies of the VFD containing electrical or electronic components must be disposed of in accordance with *Directive 2012/19/EU*.
- *Non-EU countries:* Waste electrical equipment must be disposed of in accordance with the locally applicable legal regulations.
- Never dispose of old electrical appliances with household waste. .

***REACH- REGULATION***

*Information on article 33*

The following substance of very high concern on the REACH Candidate List of 14 June 2023 is present in this product at a concentration of more than 0.1 % by weight:

- Lead; CAS number: 7439-92-1; EC number: 231-100-4

According to the current state of knowledge, it can be assumed that the above-mentioned substance does not pose a risk if this product is used and disposed of as intended.

***NON-ELECTRICAL COMPONENTS***

Assemblies of the VFD that do not contain electrical components, such as control cabinet equipment, control cabinet enclosures, cabinet doors, etc., must be disposed of in accordance with local regulations. For this purpose, contact your recycling partner or the local authorities.

***PACKAGING***

The materials used for the packaging of the MVH 2.0, such as wood, PVC, and plastic, are recyclable. Contact your recycling partner or local authorities for more information.

# 10 SPARE PARTS

The use of spare parts and accessories not specified by AuCom may result in material damage to the product.

- You mut only use spare parts and accessories specified and approved by AuCom.

*ORDERING INFORMATION*

A range of spare parts and accessories are available for the MVH 2.0 Series frequency inverters, such as:

- Power cells
- Medium voltage fuses
- Power cell low voltage fuses
- Filter inserts for the inlets of the cooling ducts of the VFD cabinet, and
- others

For orders, contact AuCom MCS GmbH & Co. KG or your local supplier.

(For the ordering contact details, see chapter *Introduction* in this manual)

# INDEX

## New Zealand

123 Wrights Road, PO Box 80208, Christchurch 8440. New Zealand

T +64 3 338 8280 F +64 3 338 8104

## China

203-1 JH Plaza, 2008 Huqingping Road, Shanghai 201702, China

T +86 21 5877 5178 F +86 21 5877 6378

## Germany

Borsigstraße 6, 48324 Sendenhorst, Germany

T +49 2526 93880 0 F +49 2526 93880 100

## Middle East

Al Thanyah Fifth, Mazaya Business Avenue BB2, Jumeirah Lakes Towers, Dubai, UAE

T +971 4 430 7203

## North America

Benshaw, Inc

615 Alpha Drive, Pittsburgh, PA 15238, USA

T +1 412 968 0100 F +1 412 968 5415


RIGHT FROM THE START

AuCom MOTOR CONTROL SPECIALISTS