Variable frequency drive (VFD) Medium voltage 2.3kV – 13.8kV

User Manual

en

MVH 2.0 Series



RIGHT FROM THE START





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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	
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	Firmware – I/O Interface unit:	as of version 2.27.10
	Firmware – Operating unit (HMI):	as of version 2.27.10

CHANGE LOG

/ersion	Change	Initiator	Date
1.0.0	Initial version	AuCom, (FB)	26.10.2023
	/ersion 1.0.0	/ersion Change 1.0.0 Initial version	/ersion Change Initiator 1.0.0 Initial version AuCom, (FB)

Tab. 1-1MVH 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

In this user manual, safety and protection levels are classified as DANGER, WARNING, WARNINGS 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 bazard
	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.

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

NOTE





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

STADT	ISERIEVEL' Name"
SIARI	USER LEVEL: "INAME

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.

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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
1/0	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
Δφ	Phase angle difference
f	frequency
	el. current
n	speed
θ	temperature
Rs	stator resistance
U	el. voltage
≙	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
4	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 AUTHORISEDOnly 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 PROTECTIVEAt all times, you must observe the regulations on the use of personal protective equipmentEQUIPMENT(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 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	Modification or manipulation of the MVH 2.0 is not permitted.
DISCLAIMER	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

•	WA	ARNING
14	۶	Do not use the VFD if there is moisture in the VFD cabinet, parts are missing, or parts were damaged during unpacking.
	۶	If the packing list does not correspond to the model number indicated on the nameplate you <i>must not</i> install the VFD.
	۶	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

A WA		ARNING		
14	۶	Never connect the phases of the medium voltage (L1, L2, L3) to the VFD output terminals (2U, 2V, 2W).		
	۶	Electrical connections must only be made by qualified personnel and in accordance with the relevant standards for electrical work.		
	۶	Make sure that all power supplies and auxiliary voltages are switched off before wiring to avoid electric shock or fire.		
	\triangleright	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 <i>automatic start</i> 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.
۶	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

- 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

 \triangleright

- 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

.0M

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



B

4

Combined Transformer/Power cell cabinet



Connection/switching panel (MV)

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.



a) Front view b) Rear view

- 1 Transformer cabinet
- 2 Cooling fans
- 3 Power cell cabinet

7

- 4 Connection/switching panel (MV)
- Control panel with operating and display elements (e.g., operating unit (HMI) 6 with touchscreen (LV) 6
 - Optional cable entry for MV supply line from above (customer side)
 - Optional cable entry for MV motor feeder from above (customer side)





Typical separate VFD cabinet design: ADA-AuCom Double Access a) Front view b) Rear view



6

1 Transformer cabinet



3 Power cell cabinet

4 Connection/switching panel (MV)

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
- ۶ 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).



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

1	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 con	formity is issued under the sole responsibility of the manufacturer
Product identification:	MVH 2.0 (Full Drive); MVH 5 2.0 (Start Drive); MVH D 2.0 (Dual Drive)
All available design var	iants listed in the product code of 10/07/2023 are considered.
The object of the decla Union harmonisation le	ration described above is in conformity with the following relevant egislation(s):
2014/30/EU: DIRECTIV of 26 February 2014 or electromagnetic comp	E 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL the harmonisation of the laws of the Member States relating to atibility: Official Journal of the European Union L96/79, 29/03/2014
Conformity to the directive product in the following sta	is verified through total compliance with all the specifications applicable to the indards:
IEC-61800-3:2017: Adjustat methods	e speed electrical power drive systems - Part 3: EMC requirements and specific test
IEC-61800-4:2002: Adjustat specifications for a.c. power	ile speed electrical power drive systems - Part 4: General requirements; Rating r drive systems above 1 000 V a.c. and not exceeding 35 kV
IEC-61800-5-2:2016: Adjust Functional	able speed electrical power drive systems - Part 5-2: Safety requirements –
Signed for on behalf o	AuCom MCS Grablet & Co. KG CALLS
	Aucom ??



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. 2-2Norms 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
- ĝ Product standards (IEC)
 - Category of operational availability (LSC: Loss of service continuity)
 - QR code
- **4** 5 6 CE marking
- 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. 2-3Technical data on the nameplate

QR cope 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



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 2VFD model selection according to the type of motor used in the applicationOrdering 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 Manufaction

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



ORDERING IDENTIFIER 7

Selection of rated current at VFD output:

Rated current Irms**				
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 Irms < 250 A:

The VFD is supplied without any precharge system.

Rated VFD current 250 A ≤ Irms < 500 A: The VFD includes an integrated device for precharging the power cells.

Rated VFD current Irms ≥ 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.

- Г	
- 1	
- 1	
- 1	
- 1	

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

RANGE

2.2.1 FEATURES OF THE MVH 2.0

FUNCTIONS

MVH 2.0 VFDs are suitable for speed regulation and control of medium voltage threephase 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 Motor speed is controlled via an adjustable frequency range from 0 to 80 Hz.

Motor control methops • 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 SYSTEMThe 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 DYNAMICAutomatic determination of motor parameters, for the pre-assignment of controlPARAMETER IDENTIFICATIONparameters in case of missing motor data for idle start and start under load.

- *Motor reverse mode* Reverse the motor rotation direction via the VFD.
 - *Toraue 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 Set the maximum VFD output current to optimally adapt the VFD to the load. *CURRENT*



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	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 \geq 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 <i>alarm messages</i> or <i>fault messages</i> 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 <i>alarm message</i> gives information about the cause of an active issue that <i>does not</i> 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:



a) Double side service zone b) Single side service zone





Front maintenance space: >1600 mm

1 2 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 (-10% +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) ± 0.1 % (closed loop vector control) ± 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), Communication protocols: Modbus RTU, Profinet, Profibus DP (optional*), 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	\leq 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	

* Additional communication modules required!

Tab. 2-8 MVH 2.0 – Technical data

NOTE

1	
	<u> </u>

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.



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



MV mains voltage supply Multi-level transformer

Power cells Ax, Bx, Cx

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



U	MV mains voltage supply
2	Multi-level transformer
3	Power cells
4	VFD control system:
6	-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
1	Voltage measurement at VFD output
12	Transformer's 400 V AC auxiliary winding
B	11 kV motor
14	Distributed control system (DCS)
1 5	Signals of digital inputs and outputs (DI, DO)
16	Signals of analog inputs and outputs (AI, AO)

INPUT – 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:

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 \underline{U}_{NL} are formed:

- Phase A: $\underline{U}_{NA} = \underline{U}_{A} = \underline{U}_{A1} + \underline{U}_{A2} + \underline{U}_{A3}$
- Phase B: $\underline{U}_{NB} = \underline{U}_{B} = \underline{U}_{B1} + \underline{U}_{B2} + \underline{U}_{B3}$
- Phase C: $\underline{U}_{NC} = \underline{U}_{C1} + \underline{U}_{C2} + \underline{U}_{C3}$

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

- Phases A and B: <u>ULL</u> = <u>UAB</u>
- Phases B and C: <u>ULL</u> = <u>U</u>BC
- Phases C and A: <u>ULL</u> = <u>U</u>CA

VFD- Rated voltage [kV]	Cells per phase	Input voltage per cell [V]	Phase voltage U⊾ [V]	Line-to-line voltage U∟ [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	690	6350	11	19
13.8	12	690	7967	13.8	25

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

Tab. 3-1Power 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.





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
 - Cooling fans of the VFD cabinet
 - Frame of the combined power cell/transformer cabinet
 - VFD control/feeder panel
 - low voltage compartment (bulkheaded) for VFD control
 - Actuating access for MV disconnector/earthing switch
- 234567399123 VFD control unit
 - I/O interface unit
 - Base for VFD cabinet
 - Mechanical drive shaft for MV disconnector/earthing switch
 - MV disconnector/earthing switch
 - MV fuses
 - Cable duct for customer MV supply line
- Ă Main contactor
- ß Connection to motor feeder line





Fig. 3-12

7

ACC-AuCom Compact Cabinet a) Rear view b) Side view: combined power cell/transformer cabinet

- П Connection terminals for customer MV supply line
- 2 MV disconnector/earthing switch
- ğ Power cells for phases A, B and C
- Ă Multi-level transformer
- ğ Cable duct for customer MV supply line
- 6 Main contactor
 - 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
- Multi-level transformer
 - Frame of the power cell cabinet
 - Power cells on the front for phases A, B and C
 - VFD control/feeder panel
 - low voltage compartment (bulkheaded) for VFD control
 - Actuating access for MV disconnector/earthing switch
 - Optional cable entry: MV supply line from above (customer side)
 - Optional cable entry: Motor feeder line from above (customer side)
 - VFD control unit
 - I/O interface unit
- B Base for VFD cabinet









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

- 1 Optional cable entry: MV supply line from above (customer side)
 - Cable connection for MV supply line (customer side)
- MV disconnector/earthing switch
 Installation compartment for volta
 - Installation compartment for voltage measurement, power cell detection and precharge system resistors
 - Cable duct for customer MV supply line
- 5 Cable duct for c
 6 Main contactor
 7 Optional cable e

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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
- 34567890 Multi-level transformer
 - Frame of the power cell cabinet
 - Power cells on the front for phases A, B and C
 - VFD control/feeder panel
 - low voltage compartment (bulkheaded) for VFD control
 - Actuating access for MV disconnector/earthing switch
 - VFD control unit
 - I/O interface unit
- 1 Base for VFD cabinet

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NOTE

- The ADA cabinet type can also be equipped with an:
- optional cable entry: MV supply line from above (customer side) ≻
- \triangleright optional cable entry: Motor feeder line from above (customer side)











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

- 1 Cable connection: MV supply line (customer side)
 - MV disconnector/earthing switch
- **2** 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 6
 - 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





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 \triangleright 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).
- \geq 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 +24VDC potential is supplied to the DI connection terminal (switching logic of the DI: closed-circuit principle).



b) Door interlocked (vertical key position, closed contact) c) Door unlocked (horizontal key position, open contact)

LED indicator: Door interlocking release

1

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	(OFF)	LED off: no release signal
release	green 🔘	LED on: release signal enabled

As soon as at least one cabinet door is unlocked without an active release signal DOOR INTERLOCKING FAILURE (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.



b)



a)



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.





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 electromagnetic compatibility (EMC) and ensures trouble-free operation off the VFD.





EARTHING OF AUXILIARY COMPONENTS	All relevant, electrical auxiliary components must be connected to the base plate of the low voltage compartment 7 in the control/feeder panel. The base plate is connected to the earthing rail 6 via a fine-core earthing cable.
Motor feeder line	The shielding of the motor feeder line 10 must be earthed at the VFD via the earthing rail
Shielding	6 at the connection point 9 and connected to the motor housing 11 on the motor side.

SEPARATE EARTHING LINE BETWEEN MOTOR UND VFD The motor housing (2) must be connected to the earthing rail of the VFD (8) via a separate earthing line (13).



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.







Secondary windings

Another three-phase 400 VAC 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 VAC 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



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



Transformer star point



3

- Connection lines of secondary windings (R, S, T) to the power cells
- Current transformer in the transformer primary circuit



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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



3

VFD control unit Operating unit (HMI)

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



STRUCTURE AND FUNCTIONS



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.

INTERFACES AND



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.

"	VDICATION	ELEMENTS
AP1	AP2	AP3
XT6 XR6 XR7 XR7 XR7 XR7 XR8 XR8 XR8 XR8 XR8 XR8 XR8 XR8 XR8 XR8	XTE XRE XRE XRE XRE XRE XRE XRE XR	XTB XRV XRV XRV XRV XRV XRV XRV XRV XRV XRV

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

FO connections				S			
AP1 AP2		AP3		Description			
(Phase A) (Phase B)		(Phase C)					
A1	XT2	B1	XT2	C 1	XT2	Transmit:	Optical signal are sent to the respective 1st power cell A1, B1, C1.
	XR2		XR2		XR2	Receive	Optical signals from the 1st power cell are received.
Δ2	XT2	R2	XT2	C 2	XT2	Transmit:	Optical signal are sent to the respective 2nd power cell A1, B1, C1.
	XR2		XR2		XR2	Receive	Optical signals from the 2nd power cell are received.
A3	XT2	B3	XT2	C 3	XT2	Transmit:	Optical signal are sent to the respective 3rd power cell A1, B1, C1.
	XR2		XR2		XR2	Receive:	Optical signals from the 3rd power cell are received.
A4	XT2	B4	XT2	C4	XT2	Transmit:	Optical signal are sent to the respective 4th power cell A1, B1, C1.
	XR2		XR2		XR2	Receive:	Optical signals from the 4th power cell are received.
A5	XT2	B5	XT2	C5	XT2	Transmit:	Optical signal are sent to the respective 5th power cell A1, B1, C1.
	XR2		XR2		XR2	Receive:	Optical signals from the 5th power cell are received.
A6	XT2	B6	XT2	C6	XT2	Transmit:	Optical signal are sent to the respective 6th power cell A1, B1, C1.
	XR2		XR2		XR2	Receive:	Optical signals from the 6th power cell are received.
A7	XT2	B7	XT2	C 7	XT2	Transmit:	Optical signal are sent to the respective 7th power cell A1, B1, C1.
	XR2		XR2		XR2	Receive	Optical signals from the 7th power cell are received.
A8	XT2	B8	XT2	C8	XT2	Transmit:	Optical signal are sent to the respective 8th power cell A1, B1, C1.
	XR2		XR2		XR2	Receive:	Optical signals from the 8th power cell are received.
A9	XT2	B9	XT2	C9	XT2	Transmit:	Optical signal are sent to the respective 9th power cell A1, B1, C1.
	XR2		XR2		XR2	Receive:	Optical signals from the 9th power cell are received.
LED indicators					,	Descriptio	n
API		AP	2	APS	,		
LED blo LED: LED: LED: LED:	cks: 1 2 3 4					Operating RESET of A Power sup Bypass	indication AP1, AP2, AP3 modules ply of the module

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



NOTE 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:

- o the motor control algorithms,
- o the power cell fault diagnosis,
- o various real-time protections, and
- o communication with interface boards.

FPGA subsystem

The Field Programmable Gate Array (FPGA) coordinates:

- o the real-time communication with the DSP,
- o the communication with the power cells,
- o the carrier phase shifted PWM output, and
- o other logic functions.

INTERFACES AND INDICATION ELEMENTS



Interfaces	Description
CAN bus :	Communication with PC/notebook: IBS interface, software tool: <i>HC Tools</i>
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
ТХ	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

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



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.

- 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)*.

CES AND	Terminal	Description				
EMENTS	PE PGND 24VDC	Ground 24 V power supply: neg. potential 24V power supply: pos. potential				
	VCO	Positive +5 V or +2	potential for power supply of speed sensor: 24 V or 200 mA			
	AP AN	Speed se Speed se	nsor A+ nsor A-			
	BP BN	Speed sensor B+ Speed sensor B-				
	ZP ZN	Speed sensor Z+ Speed sensor Z-				
	PGND	Negative potential for speed sensor power supply				
	CLK+ CLK-	Output fo Output fo	or pos. clock signal + or neg. clock signal -			
	LED indicators	Descript	ion			
	LED-Block: LED: 1st line left LED: 2nd line right LED: 3rd line left LED: 4th line right	- 15 V +15 V +5 V +24 V				
	Terminal	Description				
	BACKOUT1	Spare output 1, NO contact				
	BACKOUT2	Spare output 2, NO contact				
	HV-OFF	Output:	+24 V DC signal <i>MV not ready</i> to the I/O interface unit (target terminal: -XS3:4). If medium voltage is not ready, then internal NO contact (AP5) will close (\Rightarrow +24 V DC at terminal <i>HV-OFF</i>)			
	DO-COM	Output:	Common pos. potential (+24 V DC) for digital outputs (DO) to the I/O interface unit (target terminal: -XS3:2)			
nit – noard AP5	PRDY	Output:	+24 V DC signal <i>Control unit ready</i> to the I/O interface unit (target terminal: -XS3:4). If control unit is ready, then internal NO contact (AP5) will close (\Rightarrow +24 V DC at terminal <i>PRDY</i>).			
	PENL	Input:	+24 V DC signal <i>I/O interface unit ready from</i> 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 (\Rightarrow +24 V DC at terminal <i>PENL</i>).			
	BACKIN	Spare inp	but			
	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 <i>AP1, AP2, AP3 RESET</i> 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 (\Rightarrow +24 V DC at terminal <i>PRST</i>).			

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





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



SIGNAL BOARD AP6

STRUCTURE AND FUNCTION

Terminals

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.

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. 3-5Signal board AP6 - Terminals

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

- 1		
- 1		_
- 1	_	_
- 1	_	_
- 1	_	_
- 1		
- 1	_	

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



Programmable logic controller (PLC)

lower terminal board with terminals for output signals

Upper terminal board with terminals for input 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 $0.15 \,\mu$ s. 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):	Internal communication to the operating unit (HMI)
RJ45	S7 protocol
9-pole SUB-D socket:	Communication to the VFD control unit (Main control board AP4):
PIN 3 PIN 8	RS485 communication interface, RS485A: RxD/TxD "high" level RS485 communication interface, RS485B: RxD/TxD "low" level

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

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

FIRMWARE AND PROGRAMThe PLC integrates a micro-SD card slot. You can perform program update and PLCUPDATEfirmware 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 TOThe following preconditions apply to the connection diagram with regard to theTHE CONNECTION DIAGRAMrepresented 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 ①, signals in the VFD cabinet, and excitation feedback signals. The 24 V+ power supply 仓 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 ①, ③ and ④ 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

1 2 3

4

6

- External control signal (Remote)
- Common terminal E24 V+
- External status and fault signals
- Galvanic decoupling (relays)
- 5 Internal signals from VFD system
 - Common terminal 1, power supply, temperature recording, and excitation
 - feedback

7 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*.


	NO	TE
\equiv	۶	Digita inputs
	\triangleright	Signal

- 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.

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

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
			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.
				 DI inactive (signal contact open): ⇒ The VFD output is blocked (e.g., the start command for the motor cannot be sent).
				NOTE: Digital outputs (DO) <i>MV Main switch ON 1</i> and <i>MV Main switch ON 2</i> remain switched on, independent of the signal status of DI <i>External VFD release.</i>
	7	Set frequency 1	Open-circuit principle/ Level signal	DIs are only effective for parameter setting: Setpoint mode = Setpoint via DI)
	6	Set frequency 2	Open-circuit principle/ Level signal	The setpoint frequency for the VFD output is set
	5	Set frequency 3	Open-circuit principle/ Level signal	Frequency setpoint setting is done according to a coding of the binary states (DI active/inactive) of the three DIs as well as <i>Speed section 3</i> or <i>Speed section 7</i> set in parameter <i>Setpoint via DI</i> .
	4	Switch-over operating mode	Open-circuit principle/ Level signal	DI is only effective for parameter setting <i>Release: Switch-over (DI) operating mode =Enable.</i>
				DI active (signal contact closed): → Operating mode: Remote control (DI)
				DI inactive (signal contact open): ⇒ Operating mode: Local control (HMI)
	3	External RESET	Open-circuit principle/ Pulse signal	This function corresponds to the function of the <i>RESET</i> button of the HMI.
				 DI active (signal contact closed): ⇒ All active fault messages are reset, provided their causes have been resolved.
				DI inactive (signal contact open): → no function
	10	External fault 1	Open-circuit principle/ Level signal	This function corresponds to the function of the <i>EMERGENCY STOP push button</i> on the cabinet door of the VFD control panel.
				DI active (signal contact closed): ⇒ MV mains supply is switched off (VFD main contactor)
				DI inactive (signal contact open): → no function
	9	External fault 2	Open-circuit principle, Level signal	The <i>External fault 2</i> function corresponds to the function of the <i>EMERGENCY STOP push button</i> on the cabinet door of the VFD control panel.
-XS2				DI active (signal contact closed): ⇒ MV mains supply is switched off (VFD main contactor)
102				DI inactive (signal contact open): → no function
	8	Synchronous transfer start	Open-circuit principle, Level signal	DI is only effective for parameter setting <i>Transfer release: VFD<->Grid = Enable.</i>
				DI active (signal contact closed): ⇒ Synchronous transfer process starts
				DI inactive (signal contact open): → no function
	7	Excitation system ready	Open-circuit principle, Level signal	Status signal from <i>external excitation system</i> (synchronous motors only).
				DI active (signal contact closed): ⇒ 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): → The external excitation system is not ready to start the excitation process
	6	Excitation system ON	Open-circuit principle, Level signal	Feedback signal from <i>external excitation system</i> (synchronous motors only).
				DI active (signal contact closed): → the external excitation field is in operation
				DI inactive (signal contact open): ⇒ the external excitation field is not in operation
	5	Excitation system fault	Open-circuit principle, Level signal	Fault signal from <i>external excitation system</i> (synchronous motors only).
				DI active (signal contact closed): ⇒ Fault in the external exciter field
				DI inactive (signal contact open): ⇒ 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.
				DI active (signal contact closed): ⇒ all circuit breakers of the fans are closed
				DI inactive (signal contact open): ⇒ at least one circuit-breaker has tripped
	3	Fans ON	Open-circuit principle/	Feedback that all fans are switched on.
			Level signal	DI active (signal contact open): ⇒ all auxiliary contacts of the fans' contactors are closed
				 DI inactive (signal contact closed): ⇒ at least one auxiliary contact of the fans' contactors is open
	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.
				DI active (signal contact closed): ⇒ all power cell cabinet doors are closed and locked
				DI inactive (signal contact open): ⇒ at least one power cell cabinet door is unlocked
				⇒ 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!
-XS3				⇒ 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.
				DI active (signal contact closed): ⇒ all transformer cabinet doors are closed and locked
				DI inactive (signal contact open): ⇒ at least one transformer cabinet door is unlocked
				⇒ for setting the parameters: Open cabinet door: Selection Alarm/Fault = Fault, the



Terminal	Terminal	DI name	DI switching logic/	Description of DI function
DIOCK	110.		Signal mode	
				message Fault: Door alarm transformer cabinet is issued and the VFD switches off!
				⇒ for setting the parameters: Open cabinet
				message Alarm: Door alarm transformer
				cabinet is issued; but the VFD remains in
				operation.
				NOTE: For transformer cabinets <i>without</i> 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.
				DI active (signal contact closed):
				⇒ at least one of the three transformer temperature sensors (PT100) reports an
				overtemperature: $\vartheta \ge 150 ^{\circ}\text{C}$
				⇒ the VFD switches off!
				DI inactive (signal contact open):
				\Rightarrow none of the three transformer temperature
				sensors (P1100) reports an overtemperature: $\vartheta < 150 ^{\circ}C$
				NOTE: If <i>no sensor</i> 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.
				DI active (signal contact closed):
				⇒ at least one of the three transformer temperature sensors (PT100) reports an
				overtemperature: $\vartheta \ge 95 ^{\circ}\text{C}$
				⇒ VFD remains in operation
				DI inactive (signal contact open):
				⇒ none of the three transformer temperature sensors (PT100) reports an overtemperature.
				$\vartheta < 95 ^{\circ}\text{C}$
				NOTE: If no sensor is used, terminal 7 must
				remain unconnected (open).
	6	RESET Door-Push button	Open-circuit principle/	DI active (signal contact closed):
			Level signal	⇒ All error messages are reset, provided that their causes have been resolved
				⇒ 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
				⇒ The VFD control unit is reset.
				DL inactive (signal contact open):
				\Rightarrow no function
	5	EMERGENCY OFF	Open-circuit principle/	The EMERGENCY STOP function is used to switch
			Level signal	off the medium voltage via an upstream main switching element when an EMERGENCY STOP
				switch is actuated.
				DI active (signal contact closed):
				⇒ An EMERGENCY STOP switch was actuated and the medium voltage was switched off via
				the upstream main switching element.
				DI inactive (signal contact open):
	4	MI pot ready	Open circuit prizziala /	⇒ no function
	4	ινιν ποι ι eady	Level signal	terminal: <i>Power supply module AP5</i> , terminal: <i>HV-OFF</i>



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

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

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

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

Tab. 3-8Upper 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 VAC/VDC and 8A 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 $\geq 250 \Omega$, max. input current 30 mA (max. input voltage 15 V).

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

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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 (2channel).
- Connection is made via the customer terminal block.

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

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



Terminal block	Terminal No.	DO name	Specification	D0 operating conditions
				 all power cells show power cell status <i>Normal</i> and all power cells show cell bypass unit status <i>Normal</i> and the VFD is put in operation by a START command. Relay contacts (NO) open as soon as the VFD switches off due to at least one of the above criteria or the motor is switched off by a STOP command. For parameter setting <i>VFD mode = Test</i> applies: Relay contacts (NO) close, once the following criteria are met: there is no active Fault and DI <i>EMERGENCY-OFF</i> is inactive and the VFD is put in operation by a START command. Relay contacts (NO) open as soon as the VFD switches off due to at least one of the above criteria or
	3 4 5 6	<i>MV Main switch ON 1</i> <i>MV Main switch ON 2</i>	8 A, 250 V AC 8 A, 250 V AC	 the motor is switched off by a STOP command. For parameter setting VFD mode = Operation applies: Relay contacts (NO) close, once the following criteria are met: there is no active Fault and DI EMERGENCY-OFF is inactive and all power cells show power cell status Normal and all power cells show cell bypass unit status Normal
				 Relay contacts (NO) open if none of the above criteria are met. For parameter setting <i>VFD mode = Test</i> applies: Relay contacts (NO) close once the following criteria are met: there is no active Fault and DI <i>EMERGENCY-OFF</i> is inactive Relay contacts (NO) open as soon as none of the above criteria are met.
	7 8 9 10	<i>MV Main switch OFF 1</i> <i>MV Main switch OFF 2</i>	8 A, 250 V AC 8 A, 250 V AC	 Relay contacts (NO) close as soon as VFD mode = Test is set or when VFD mode = Operation is set and at least one Fault is active.
				 when VFD mode = Operation is set and no Fault is active
	1 2	Fault (NO)	8 A, 250 V AC	 Relay contact (NO) closes once a <i>Fault</i> is active. Relay contact (NO) opens once no <i>Fault</i> is active and all Fault notifications are reset (HMI: button <i>RESET</i> or digital input: <i>External RESET</i> or <i>RESET command</i> via DCS-communication).
-XS13	3 4	Fault (NC)	8 A, 250 V AC	 Relay contact (NC) opens once a Fault is active. Relay contact (NC) closes once no Fault is active and all <i>Fault notifications</i> are reset (HMI: button <i>RESET</i> or digital input: <i>External RESET</i> or <i>RESET command</i> via DCS-communication).



Terminal block	Terminal No.	DO name	Specification	DO operating conditions
	5 6	Fan ON 1	8 A, 250 V AC	 Relay contacts (NO) close if VFD mode = Operation is set and DI Fans ON(-XS2:3) is active while the VFD is in operation, or if VFD mode = Test is set and fans are manually switched on using the START button in Functions parameters 3 menu
	7 8	Fan ON 2	8 A, 250 V AC	 Relay contacts (NO) open if VFD mode = Operation is set and DI Fans ON(-XS2:3) is inactive while the VFD is in operation, or if VFD mode = Test is set and fans are manually switched off using the STOP button in Functions parameters 3 menu
	9 10	Sync. motor: Excitation ON/OFF	16 A, 250 V AC	ON command to the external exciter panel to switch on excitation (synchronous motors only). Relay contact (NO) closes • depending on the settings in the Excitation system menu
	1 2	Remote control (DI) active	16 A, 250 V AC	This D0 is only effective for parameter setting Release: Switch-over (DI) operating mode= Enable: Relay contact (N0) closes • if DI Switch-over operating mode is active.
				Relay contact (NO) opens If DI <i>Switch-over operating mode</i> is inactive.
	3 4	Cabinet door open	16 A, 250 V AC	 Relay contact (NO) closes At least one cabinet door of the transformer or cell cabinet is unlatched/opened (DI <i>Door alarm cell cabinet</i> or DI <i>Door alarm trafo cabinet</i> is active)
				 Relay contact (NO) opens all cabinet doors of the transformer or cell cabinet are closed and latched (DI <i>Door alarm cell cabinet</i> or DI <i>Door alarm trafo cabinet</i> is inactive)
	5 6	<i>Cell cabinet overtempt. Alarm</i>	16 A, 250 V AC	 Relay contact (NO) closes if the sensor for temperature monitoring in the power cell cabinet (AI: -XS4:4,5,6) reports an overtemperature (∂ ≥ 55 °C).
-XS14				 Relay contact (NO) opens if the sensor for temperature monitoring in the power cell cabinet (AI: -XS4:4,5,6) reports no overtemperature (θ < 55 °C).
	7 8	Fan Alarm	16 A, 250 V AC	 Relay contact (NO) closes if at least one of the fans reports a malfunction (DI Alarm: Fan failure is active)
				 Relay contact (NO) opens provided that all fans are fault-free (DI Alarm: Fan failure is inactive).
	9 10	Trafo overtemp. Alarm	16 A, 250 V AC	This DO is only to be used in cooperation with an external temperature monitoring relay.
				 Relay contact (NO) closes if at least one of the three sensors for transformer temperature monitoring reports an overtemperature (ϑ ≥ 95 °C) (DI <i>Alarm: Trafo overtemp.</i> is active)
				 Relay contact (NO) opens provided that all three sensors for transformer temperature monitoring reports no overtemperature (θ < 95 °C) (DI <i>Alarm: Trafo overtemp.</i> is inactive)
Terminal	1 2	VFD ready	16 A, 250 V AC	For parameter setting VFD mode = Operation applies: Relay contact (NO) closes • provided that all self-check procedures of the VFD control system have been successfully completed and • medium voltage is switched on



Terminal block	Terminal No.	DO name	Specification	DO operating conditions
				 Relay contact (NO) opens if medium voltage is switched off (intended control command) or any <i>Fault</i> or <i>Alarm</i> is active
				 For parameter setting VFD mode = Test applies: Relay contact (NO) closes provided that all self-check procedures of the VFD control system have been successfully completed and medium voltage is switched off
				 Relay contact (NO) opens if medium voltage is switched on by accident or any <i>Fault</i> or <i>Alarm</i> is active
				NOTE: Digital output (DO) <i>VFD ready</i> corresponds to the LED indicator <i>VFD ready</i> on the operating unit (HMI).
	3 4	Synchronization successful	16 A, 250 V AC	Synchronisation process for the fct. Synchronous <u>transfer</u> : Relay contact (NO) closes • provided that the VFD output voltage is synchronized
				with the <i>MV mains voltage</i> (measured phase angle difference $\Delta \phi$ is within the set value of parameter <i>Synchronization: Max. permitted</i> $\Delta \phi$, and same value of the corresponding phase voltages)
				 Relay contact (NO) opens once the synchronicity conditions are no longer fulfilled
		I/O interface unit ready	16 A, 250 V AC	Relay contact (NO) closesif the PLC of the I/O interface unit is ready for operation
	5 6			PENL DI-COM
		VFD control unit RESET	16 A, 250 V AC	Relay contact (NO) closesif the VFD control unit detects any internal fault
	7 6 8			n.a. DI-COM 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	Al or AO specification	Description of AI or AO function
-XS16		Power supply		Supply voltage for lower terminal blocks
	1		+24 V DC	
	2		0V na	
		Communication: Distributed control		Communication interface for DCS
-XS17	1	system (DCS)	RS485+	RS485A: RxD/TxD_bigh" level
-	2		RS485-	RS485B: RxD/TxD "low" level
	3		GND	Ground and shielding
	1 2	Al 1: f/n Setpoint	Analog input (Al): Current: 0/4 – 20 mA	You can set the measuring range of transfer characteristics for the <i>frequency setpoint</i> with the parameters:
				Al 1 (f/n Setpoint): Meas.range start und Al 1 (f/n Setpoint): Meas.range end
				Meas. scale start ≙ 0 Hz Meas. scale end ≙ Parameter: <i>Maximum</i> <i>frequency</i>
				Accuracy: 1.5%.
	3 4	Al 2: f/n Feedback	Analog input (Al): Current: 0/4 20 mA	You can set the measuring range of the transfer characteristics for the <i>frequency feedback</i> can be set with the parameters:
				AI 2 (f/n Feedback): Meas.range start and AI 2 (f/n Feedback): Meas.range end
				Meas. scale start ≙ 0 Hz Meas. scale end ≙ 100 %
				Accuracy:1.5 %.
	5 6	AO 3: Output frequency	Analog output (AI): Current: 4 20 mA	Transfer measured variable: VFD output frequency
				Meas. range start ≙ 4 mA Meas. range end ≙ 20 mA
VC10				Meas. scale start ≙ 0 Hz Meas. scale end ≙ parameter: <i>Maximum</i> <i>frequency</i>
-^310				Burden: max. 500 Ω, 10-bit A/D sampling, Resolution: 0.1 %, Accuracy: 1.0 %
	7 8	AO 4: Output current	Analog output (AI): Current: 4 20 mA	Transfer measured variable: <i>VFD output phase current</i>
				Meas. range start ≙ 4 mA Meas. range end ≙ 20 mA
				Meas. scale start ≙ 0 A Meas. scale end ≙ 150 % of parameter <i>Rated</i> <i>output current</i> [A]
				Burden: max. 500 Ω, 10-bit A/D sampling, Resolution: 0.1 %, Accuracy: 1.0 %
	9 10	AO 1: parameterizable	Analog output (AI): Current: 0/4 20 mA	The analog output can be configured for one of the following different measured variables:
				Output frequency
				Meas. range start ≙ 4 mA Meas. range end ≙ 20 mA
				Meas. scale start ≙ 0 Hz Meas. scale end ≙ parameter <i>Maximum</i> fraguency
				 Output current Meas. range start ≙ 4 mA



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





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

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.







Power cell Power cell gate drive board 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





POWER CELL COMPONENTS – REAR SIDE



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



Rear mounting handle

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
6	Optional power cell bypass: IGBTs

- *Power cell input*: The input terminals R, S, T are connected to a three-phase secondary winding of the multi-*R*, *S*, *T* 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:A correspondingly high clocking of the control signals produces a square-wave voltage at
the output of the power cell.

Power cell bypass: *type = Contactor bypass* or *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.

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

CONTROL BOARD AND 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



	Power supply	
	2 Overvoltage detection (limit value: 1150 V)	
	3 Overtemperature detection	
	4 Loss of phase detection	
	Error coding logic	
	Power supply failure	
	Fibre optic (FO) failure	
	8 Receive decoding	
	Bypass drive	
	S1 DC voltage input	
	S2 AC voltage output (max. 690 V AC)	
	S3 FO interface TX: signals to send (light grey)	
	S4 FO interface RX: signals to receive (blue-grey)	
	S8 NC contact	
CONTROL SIGNALS	The power cell control board receives the signal from the main controller through ibre optics (-XS4). After receiving and decoding, the data is used to control:	n the
	• the cell IGBTs,	
	• the bypass IGBT, or	
	the contactor bypass.	
Power cell fault detection	he power cell <i>control board</i> has a variety of <i>cell fault detection circuits</i> such as:	
	overtemperature detection	
	phase loss detection	
	DC bus overvoltage detection (limit value: 1150 V)	
	fibre optic (EQ) failure detection	
	drive failure detection	
	 integrated cell bypass failure detection. 	
	fter the fault signal is encoded by the controller, it is sent back to the main controlle ibre optic cable (XS3) to provide status feedback.	er via
Power supply	he power supply of the cell control board is taken from the DC bus (through XS1) in nain power cell circuit. The power supply is galvanically isolated and stepped down, he required local control power is obtained.	n the , and
VOLTAGE STATUS INDICATOR OF THE POWER CELL	fter disconnection from the mains, the voltage status display (green LED) on the po ell control module only goes out after approx. 10 minutes.	ower



3.6.4 Power Cell Gate Drive Board

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



Fig. 3-44 Power cell gate drive 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 B DRCM: Drive control module for IGBT Q3 Ā DRCM: Drive control module for IGBT Q4 6 Isolated power supply for DRCM Q1 6 Isolated power supply for DRCM Q2 0 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

Operating unit (HMI) with touchscreen

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- 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
 - EMERGENCY STOP switch for manual shutdown of the VFD in case of emergency
 - Key switch to enable crank access for the disconnector/earthing switch



Alarm: Transformer overtemperature

master computer of the distributed control system (DCS).

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 <i>alarm event</i> is active, the alarm message is				
		displayed in plain text in the right array of the lower status				
		bar, on a <i>yellow</i> background.				
		For instance, Alarm: Transformer overtemperature:				
	Magn. Flux control: 5,00; 2,00 s	DC bus voltage 0,00 Synchronisation: 0,0 BESET Other settings				

	Fig 1_2	Operating unit (HMI): Indication of an alarm event	
ł	119.7-2		

- Remote control (DCS): The VFD sends data points for the alarm message to the
- 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.

Л	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

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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*:

Magn. Flux control: 5,00; 2,0	2,00 s	DC Bus voltage	0,00	Δφ 0,0	 RESET	settings
Fault: Doo	or alarm	n cell cabine	t			

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):

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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



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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.

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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 <i>Operating</i> mode or <i>Test</i> mode <i>Manual START/STOP of</i> <i>the motor</i> 	 Parameter setting: <i>Operating mode = Local</i> <i>control (HMI)</i>
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) 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: <i>Operating mode = Remote</i> <i>control (DI)</i> 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 Parameter setting: <i>VFD mode = Test</i>
Operation	VFD operation with real application, connected to medium voltage	Parameter setting: <i>VFD mode = Operation</i>

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.



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 User LEVEL: Standard Start

- STEP 1: Inspect the VFD visually system for any external damage or abnormalities.
- Unlock the EMERGENCY STOP signal chain (unlock both the EMERGENCY STOP STEP 2: 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.
- Switch on the LV circuit breaker in the control/feeder panel to enable power STEP 4: 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	INSTRUCTION – Switching off the VFD to exit <i>ready to start</i> (standby) state				
READY TO START 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 <i>EMERGENCY STOP</i> signal chain (press the <i>EMERGENCY STOP</i> sw on the VFD control/feeder cabinet).			
	STEP 4:	Check the medium voltage disconnection as follows:			
		• The status indicators for the <i>Main contactor</i> must clearly show the <i>OFF position</i> for this switchgear unit:			
		• <i>Main Contactor Closed</i> = OFF (status indicator is <i>off</i>)			
		 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: <i>Disconnector Operating Handle Access Shutter Release</i>) 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 <i>Disconnector/Earthing switch</i> must clearly show the <i>OFF position</i> on this switchgear unit:			
		o <i>Disconnector Closed (Live)</i> = OFF (status indicator is <i>off</i>)			
		o 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

 \Rightarrow 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*.

UCor	MV ready		VFD read	dy	VFI operatio	D n	Alarm/ Fault		20:05:51 09 / 03 / 20
System status	MV not re	ady					 ст	20,4 °C	FU Monit
	ode: Test	Setpoint entry	20,0	00 Н					Trend recorder
STOP mo	ode: Free-wheel STOP	RUN frequency	0,00	Hz	RUN speed				Paramete
	ode.: Setpoint via HMI	Input voltage	0	V	Output voltage				setup
Operating mo	ode: Local control (HMI)	Input current		A	Output current				Ev ent
Master/Slave m	ode: Master	f/n Setpoint (Al 1)		%	f/n Feedback (Al 2)			START	recorder
	type: ASYNC Motor U/f	Input power		kW	Output power				Power ce
Speed cor	ntrol: 5,00; 3,00 s	Input power			Output power			STOP	status
					Synchronization :		1	RESET	Other setti



1 Manufacturer's logo

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- 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):
 - o the indicator turns red when a fault message is active
 - o 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

operating status, VFD start/stop control, etc.

VFD OPERATIONAL INFORMATION

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.

Main display area, including display of main parameter settings, measured values, VFD

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)



MV ready status indicator



- 3 VFD operation status indicator
- 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



Fig. 4-15 MV switched on

VFD READY



Fig. 4-16 VFD ready for operation

VFD OPERATION



Fig. 4-17 VFD in operation

ALARM/FAULT



Fig. 4-18 Active Alarm or Fault

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

> If the VFD is in operation, the LED is green.

Medium voltage (MV) supply status indication

VFD Ready-to-start (standby) status indicator

> If the VFD is ready for operation, the LED is green.

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

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

> If the VFD is not in operation, the LED is grey.

Indication of active disturbance event

- > At least one Alarm/Fault event is active:
 - o If an active *fault* event is present, LED is red.
 - o 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 2
		Motor parameters 1
		Motor parameters 2
		Function parameters 1
		Function parameters 2
		Function parameters 5
Event recorder	Sottingo	
Power cell status	Settings	
Other settings		
Other settings	Other systems	
	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. 4-2Menu structure of the operating unit (HMI)



MOTOR CONTROL SPECIALISTS		Operating and Display
4.5.4	Menu Navigation	
	You can operate and set the VFD using the touchscreen. You can	ר:
	 enter or exit a main menu or submenu (navigating betw menu level or different menu levels) 	veen menus on the same
	call up different menu pages within a menu (navigation or	n the same menu level)
	 The touchscreen uses virtual buttons, which can be used as: <i>Direct selection keys</i> or 	
	Navigation keys	
DIRECT SELECTION KEYS	To navigate between menus and menu levels:	
"Menu name"	Press the menu button of your choice to gain direct acces	s to this menu.
Fig. 4-19 Menu direct access		
"Menu name"	Once a menu button is pressed, it highlighted in blue and	white text.
Fig. 4-20 Opened menu	Returns to previous menu level	
Fig. 4-21 Menu level - Return Return to previous page	Returns to the previously accessed menu page	
Fig. 4-22 Previous menu page- Return		
Fig. 4-23 Close menu and return	Returns to the next higher menu level by closing a (sub) n	nenu
Navigation keys	To navigate between menu pages on the same menu level:	
Prev. page 1/7 Next page Fig. 4-24 Scrolling menu pages	• You can scroll through the menu pages. The numbers i current page number/total page number.	n the center indicate the



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							
\equiv	You can select Operator and Engineer user level via the touchscreen, then enter the password when prompted.							
	 If user level <i>Manufacturer</i> 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.

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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)

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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.

AuCom	MV ready	VFD ready	VFD operation	Alarm/ Fault	20:05:51 09 / 03 / 2023
Other Systems	Precharge System E	citation System	Operating hours SW version	ions User center	FU Monitor
User Ce	enter	_	Status User Le	evel: Standard	Trend recorder
	Configuration Area		Log-in Area		Parameter setup
	System Settings		User Login		Ev ent recorder
	Equipment Setting	s	Logout		Power cell status
					Other settings



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:



(Change user	level	
	Username	Operator ~	
11	Enter password	000000	
1	2	3	
4	5	6	
7	8	9	
	0	<-	Close



SELECT USERNAME

STEP 3: Tap to open the dropdown menu.

> Open dropdown menu shows the available usernames:

	Change user	level	
**	Username Enter password	Operator ~ Engineer Operator	
1	2	3	
4	5	6	
7	8	9	
	0	<-	Close

Fig. 4-28 Username – Open dropdown menu

STEP 4: Select Engineer.

Select username "Engineer"

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

	Change use	level	
	Username	Engineer <	
19	Enter password	000000	
1	2	3	
4	5	6	
7	8	9	
	0	<-	Close

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.

C	Change user	level	
	Username	Engineer 🗸	
1	Enter password	000000	
1	2	3	
4	5	6	
7	8	9	
	0	<-	Close

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.

User Center	Status User Level: Engineer
Configuration Area	Login Area
System Settings	Change Password User Login
Equipment Settings	Logout

Fig. 4-31 Status User level: Engineer

	NOTE
	You can also open the <i>Change user level</i> screen directly via the <i>Parameter setup</i> main menu.
	After entering the password and closing the screen, the <i>Inverter</i> parameters 1 menu opens automatically.





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

1	

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

Ð	
\square	
\equiv	

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:

		1					
AuCom	MV ready	VI-D rea	dy 🔘	VFD operation	Alar Fa	m/ ult	20:05:51 09 / 03 / 2023
Inver	ter parameters 1						VFD Monitor
VFD type	ASYNC Motor U/f	~	Star frequenc	t 0.20 Hz	Acceleration ramp	30.0 s	
VFD mode	Test	~	Maximur Frequenc	n y 50.00 Hz	Deceleration ramp	50.0 s	Trend recorder
START mode	Normal start	~	Minimur Frequenc	y 0.00 Hz	Max. permitted FRT duration	0 ms	Parameter
STOP mode	Deceleration ramp	~	Rated inpu voltag	ut 6000 V	Dead-time- compensation	1 H s	setup
Master/Slave- operation	Disable	~	Rated outpo voltag	ut 6000 V	Power cells: by pass fct	0	Ev ent recorder
Master/Slave- mode	Master	~	Rated outpo currer	ut 6000 A	Number of cells per phase	5	Power cell
Freq. search current 0.4	0 pu Master-Slave freq. difference	0.5 Hz	VFD input: Ra CT prim. curr	ent 200 :5	Torque boost gain	0 %	status
Parameter download	Parameter upload			Prev. page	1/7	Vext page	Other settings

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



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.

AuCom	MV ready	VFD read	y 🌔	VFE		Aları Fat	m/ ult		20:05:51 09 / 03 / 2023
Inver	ter parameters 1		-						VFD Monitor
VFD type	ASYNC Motor U/f	~	Start frequency	0.20	Hz	Acceleration ramp	30.0	s	
VFD mode	Test	~	Maximum Frequency	50.00	Hz	Deceleration ramp	50.0	s	Trend recorder
START mode	Normal start	~	Minimum Frequency	0.00	Hz	Max. permitted FRT duration	0	ms	Parameter
STOP mode	Normal start		Rated input voltage	6000	V	Dead-time- compensation	1	۳s	setup
Master/Slav e- operation	Parameter identification 1		Rated output voltage	6000	V	Power cells: bypassfct	0		Ev ent recorder
Master/Slav e- mode	Parameter identification 2		Rated output current	6000	А	Number of cells per phase	5		Power cell
Freq. search 0.4	freq. difference	<u></u>	VFD input: Rate CT prim. curre	ed 200	:5	Torque boost gain	0	%	status
Parameter download	Parameter upload			Prev.	page	1/7 N	lext page	•	Other settings

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:



OPERATING AND DISPLAY

	AUCOM MV ready VFD ready VFD operation Alarm/ Fault	20:05:51 09 / 03 / 2023
	Inverter parameters 1	VFD Monitor
	VFD type ASYNC Motor U/f Start frequency 0.20 Hz Acceleration 30.0 s	Trend
	VFD mode Test Maximum 50.00 Hz Deceleration 50.0 s	recorder
	START mode Speed start Minimum Prequency 0.00 Hz Max.permitted 0 ms	Parameter setup
	STOP mode Deceleration ramp V Rated input 6000 V Dead-time- compensation 1 µs	
	Master/Slave Disable V Power cells: 0 operation Voltage 6000 V Power cells: 0	Ev ent recorder
	Master/Slave- mode Master Rated output current 6000 A Number of cells per phase 5	Power cell
	Freq. search current 0.40 pu Master-Slave freq. difference Vz VFD input: Rated CT prim. current 200 :5 Torque boost gain %	status
	Parameter Parameter download upload Prev. page 1/7 Next page	Other settings
Save changes	 Fig. 4-34 Selected setting option: Speed start Button for saving the parameter settings STEP 5: Tap Parameter download button. If the storage is <i>successful</i>, the following message appears in the display for a 1.5 s: 	approx.
	Fig. 4-35 Parameter changes saved successfully	
LAN "LINGINEER USER LEVEL		
	► 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



USER LEVEL: Standard

System settings							X
Settings:	Year	Month	Day	Hour	Minute	Second	
System time	0	0	0	0	0	0	ОК

Fig. 4-36 System time parameter group

SELECT "YEAR" PARAMETER

n	numeric									
٨	Min: 2000 Max: 2050									
l	0									
	7	8	9	А	В	<-				
	4	5	6	С	D	CE				
	1	2	3	E	F	Del				
	-	0		ESC	0	к				

Fig. 4-37 Numeric keypad

SET THE YEAR

- STEP 2: Tap the corresponding digits for the desired year, one digit at a time, on the numeric keypad.
- The year entered appears in the white field above the keypad.

2023					
7	8	9	А	В	<-
4	5	6	С	D	CE
1	2	3	E	F	Del
-	0		ESC	0	К

Fig. 4-38 Numeric keypad: set the year

CONFIRM THE "YEAR" ENTERED

STEP 3: Tap OK on the numeric keypad.

> The updated year appears in the field Year.

System settings	
Settings:	Year
System time	2023

Fig. 4-39 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:

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

> 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.







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.





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

INSTRUCTION (example) - Enable/Disable Standby page

Start	User Level: Standard

ENTER "SYSTEM SETTINGS" MENU

Standby page – settings: Latency time
Latency
100 s

Fig. 4-42 Standby page – current settings

ENABLE "STANDBY PAGE"



Fig. 4-43 Standby page enabled

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*.

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.

CHAPTER REFERENCE

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



DISABLE "STANDBY PAGE"



Fig. 4-44 Standby page disabled

END

4.5.7 SELECTING THE MENU LANGUAGE

STEP 3: Tap the disable button

be activated by taping on it).

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.

> The grey *enable* button indicates that the *Standby page* is *deactivated* again (and can

				3			
AuCom	MV ready	VFD ready		VFI operatio		Alarm/ Fault	20:05:51 09 / 03 / 2023
Other systems	Precharge system	Excitation system	Operating h	ours	SW versions	User center	FU Monitor
System se	ttings						Trend recorder
System	time 0	onth Day H	Iour Minute 0 0) Sec	ond	ОК	Parameter setup
Standby pa settings:	ge-	Select menu language	German				Ev ent recorder
	enable		English Russian	^	FU Mo Measuranc	onitor: I selection	Power cell status
time			French	~			Other settings
			G				

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



System settings menu



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.



MAIN MENU (HMI) 4.6

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.

	0			2		
	AuCom	V ready	VFD ready	VFD operation	Alarm/ Fault	20:05:51 09 / 03 / 2023
	System status	MV not ready		Temperature monitoring	CT 20,4 °C	FU Monitor
	VFD mode: Test START mode: Normal start	Setpoint en	try 20,00 Hz			Trend recorder
	STOP mode: Free-wheel S Setpoint mode: Setpoint via H	HMI Input volta	ncy 0,00 Hz ge 0 V	RUN speed 0 U/min Output voltage 0 V		Parameter setup
	Operating mode: Local control Master/Slave mode: Master	(HMI) Input curre	ent 0,0 A	Output current 0,0 A	START	Ev ent recorder
	VFD type: ASYNC Mo Speed control: 5,00; 3,00	tor U/f (A s	ver 0 kW	(AI 2) (A	STOP	Power cell status
	Act.current control: 1,00; 10,0 Magn. flux control: 5,00; 2,00	0 ms fac I S DC Bus volta	ver 0,00 stor 0,00 pge 0,00	Output power factor Synchronization: Δφ	RESET	Other settings
	6 Fig. 4-46 Main me	enu – VFD Moni	itor	5	4	
	1 VFD system	n status mess	ages			
	2 Button for a2 Display of ta	calling up me	nus, e.g., <i>Tem</i>	perature monitoring	7	
	4 Manual ope	eration: STAR	T/STOP contro	bl; RESET of fault me	essages	
	5 Manual inpu values	ut of the star.	<i>t frequency</i> an	d display of the <i>oper</i>	rating measur	red
	6 VFD main p	arameter set	tings			
System status: messages	The information a VFD system.	rea System s	tatus shows t	he current message	about the sta	atus of the
OPTIONAL SHORTCUT BUTTONS	If set via paramet start page of the V	er or program (FD monitor.)	mmed, furthei A correspondii	r menus can be call ng button appears in	ed up directly the <i>VFD Mor</i>	y from the <i>nitor</i> .
ΒυττοΝ	The Temperature	<i>monitoring</i> bi	utton only app	ears with the param	eter setting F	U Monitor:

ΒυττοΝ "TEMPERATURE MONITORING" *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 OPERATIONFor 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.

To enter the *frequency* at which the motor is to be operated, tap the field next to Setpoint

SETPOINT ENTRY

Min: -80 Max: 80								
0.00								
7	8	9	А	В	<-			
4	5	6	С	D	CE			
1	2	3	E	F	Del			
•	0		ESC	0	К			

Fig. 4-47 Numeric keypad – frequency setpoint entry

MEASURED OPERATING VALUES

entry, then enter the value via the numeric keypad.

- > 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 OHz, the motor will not start!

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) (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 Al 1
f/n Feedback (AI 2) [%]	f/n feedback via the Analog input Al2
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: Ubc[pu] = [(Ubc,A1 + Ubc,B1 + Ubc,C1) / 3] / Ubc,rated Measured value display in the per-unit system
Synchronisation: $\Delta \phi$	Phase angle difference between the phase voltages at the VFD input and VFD output. 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
 - Information window representing the recorded measured values
 - Trend curve: motor frequency
- 2345678 Trend curve: VFD output voltage
 - STOP button to stop the time progression
 - *Refresh* button to continue the time history
 - Access to parameter menu to set the trend curve display
 - Sliders for zoom along X-axis

ğ

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- Parameterisation mask to define the dynamic, real-time display range (x-axis)
- Buttons for fast-forwarding and rewinding the data recording (x-axis)
- Sliders for zoom along Y-axis



AuCon	MV ready		VFD ready	VFD operation	Alarm/ Fault	20:05:51 09 / 03 / 202
Curv e			(Meas.) variable	ST Value range	TOP Refresh	FU Monitor
						Trend recorder
				Image: Constraint of the second sec	Image: Constraint of the sector of	Parameter setup
						Event recorder
						Power cell status
	03-09 20:06	03-09 20	Export curve histe	Delete curve hi	20:06 03-09 2 story Settings	0:0 } Other setting

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



Start time of the displayed time frame End time of the displayed time frame

Time frame for displaying the trend curves

SLIDING MARKER AND

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*.

ΒυττοΝ					
STOP	Refresh				
OR					
STOP	Refresh				

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



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

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

Parameter name Setting value		Unit	Setting range				
	(Default setting)						
Curve history							
Start time	Start time 2016/01/01 12:00:00 yyyy/mm/dd hh/mm/ss						
End time	2112/01/01 12:00:00	yyyy/r	mm/dd hh/mm/ss				
	Displayed time frame (X-a	axis)					
Time frame	1	min	1 1e+10 min				
Dis	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	А	-1e+10 100				
Max.	100	А	-100 1e+10				
Output voltage							
Min.	-6000	V	-1e+10 6000				
Max.	6000	V	-6000 1e+10				

PARAMETER OVERVIEW

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

Tab. 4-7 Trend recorder - Parameter overview



"SETTINGS" MENU

Del

Parameter:

Start time

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

Setting via keypad



CHAPTER REFERENCE

For parameter setting, see chapter "4.5.6 Changing Parameter \triangleright Settings (General)".

Parameter:

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

Setting via keypad



CHAPTER REFERENCE

CHAPTER REFERENCE

Settings (General)".

 \triangleright For parameter setting, see chapter "4.5.6 Changing Parameter Settings (General)".

Fig. 4-52 Keypad - "End time"

qwertyuiop

Fig. 4-51 Keypad - "Start time"

DISPLAYED TIME FRAME
(X-axis)

ESC OK

Parameter:

Time frame

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

For parameter setting, see chapter "4.5.6 Changing Parameter

Setting via numeric keypad

 \triangleright



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

	NOTE
\equiv	1e+10
—	= 10 ¹⁰

(e-notation) (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, •

End time







- the output current, and ٠
- the output voltage •

Settings via numeric keypad

NOTE

-1e+10

= -10¹⁰



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

Ð
\cong
=

CHAPTER REFERENCE > For parameter setting, see chapter "4.5.6 Changing Parameter Settings (General)".

Т	_			٦.	1
Т	-				
L	-	_	_	•	
L	-	_	_	•	
н	-			•	

(e-notation) (potency notation) - 10 000 000 000 (decimal notation)

Switch type [DEC]						
Min: 50 Max: 1e+10						
50						
7	8	9	А	В	<-	
4	5	6	С	D	CE	
1	2	3	E	F	Del	
-	0		ESC	0	К	

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.

For parameter setting, see chapter "4.5.6 Changing Parameter

Settings via numeric keypad

 \triangleright

CHAPTER REFERENCE

Settings (General)".

Switch type [DEC]						
Min: -1e+10 Max: 77						
-77						
7	8	9	А	В	<-	
4	5	6	С	D	CE	
1	2	3	E	F	Del	
•	0		ESC	0	к	

Fig. 4-56 Numeric keypad -Output current "Min."

Switch type [DEC]						
Min: 77 Max: 1e+10						
77						
7	8	9	А	В	<-	
4	5	6	С	D	CE	
1	2	3	E	F	Del	
•	0		ESC	0	к	

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



Fig. 4-58 Numeric keypad -Output voltage "Min."

	Switch type [DEC]							
P	Min: -6000 Max: 1e+10							
	6000							
	7	8	9	А	В	<-		
	4	5	6	С	D	CE		
	1	2	3	E	F	Del		
	-	0		ESC	ОК			

Fig. 4-59 Numeric keypad -Output voltage "Min."

ΒυττοΝ М

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.

Set time range		×
Recent time	Hour	OK Cancel
Fixed time	Today	
Given time		
2023 Year 5	Month 11 Day	
12 Hour 38	Minute 7 Second	

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



CHAPTER REFERENCE

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



•: enabled

O: disabled

PARAMETER OVERVIEW

Parameter name	Setting value (Default setting)	Setting range or setting options
Recent time	0	○/●
(Numerical value)	10	0 596523 [Unit]
(Unit-dropdown menu)	Hour	Second / Minute / Hour / Day / Month / Year
Fixed time	0	\bigcirc / \bigcirc
(Dropdown menu)	Today	Today / This month / Yesterday / Last month
Time division point	0	0 23 (Hour)
Given time	۲	○/●
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



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



Minimum value of a trend curve (zero line) 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 2 of the total time frame 1 to the left, and
- Moving the right slider shift by 1/5 **3** of the total time frame **1** to the right

The *value range* shows the *width* of the respective current time window:



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



Button to export (save) curve history Button to delete curve history

ΒυττοΝ

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.

ΒυττοΝ

Taping this button *deletes all curves* from the trend recording.

Delete curve history

\square	NOTE
=	The bu
	user l

The button "Delete curve progression" only applies when the *Engineer* user level is activated.



User Level: (Standard)

INSTRUCTION – Export curve history

STADT	
JIANI	

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

Settings	
Start time	2016/01/01 12:00:00
End time	2112/01/01 12:00:00

Fig. 4-65 Start time and End time parameters

DEFINE PERIOD FOR DATA RECORDING

- **STEP 2:** Tap the *Settings* button.
- The Settings menu opens, and the parameters Start time and End time are displayed.
- **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:



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:
			1	

- 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

	0			2		3					
14.1	Nn(cow	MV	ready	VFDrea	dy 🔘	VF operatio	D n	Alar Fa	rm/ ult		20:05:51 09 / 03 / 2023
\sim	Inve	rter par	ameters 1 -								VFD Monitor
	VFD ty	ASYNC	: motor U/f		Sta frequenc	rt 0.20	Hz	Acceleration ramp	30.0	s	
	VFD mod	le Test		~	Maximur Frequenc	n 50.00	Hz	Deceleration ramp	50.0	s	Trend recorder
	START mod	e Normal	start	~	Minimur Frequenc	n y 0.00	Hz	Max. permitted FRT duration	0	ms	Parameter
	STOP mod	e Deceler	ation ramp	~	Rate input voltag	d 6000	V	Dead-time compensation	1	۴s	setup
	Master/Slav operatio	e- Disable		~	Rate output voltaç	d je 6000	v	Power cells: bypass fct	0		Event recorder
	Master/Slav mod	e- Master		~	Rate output curre	d 6000	A	Number of cells per phase	5	-	Power cell
	Freq. search 0.	40 pu	Master-Slave freq. difference	0.5 Hz	VFD input: Ra CT prim. cur	ated 200	:5	Torque boost gain	0	%	status
	Parameter download		Parameter upload			Prev.	page	1/7	Next page	•	Other settings
		6	6					4			

Fig. 4-67 Main menu page 1/7: Parameter setup – Inverter parameters 1



1 Parameter name

- Drop down menu with a list of options
- **2** 3 Entry field to set a value
- Ă Current menu page / total number of pages in the menu
- 5 Button Parameter upload
 - Button Parameter download

AuCom	MV ready	VFD read	dy 🔵 of	VFD	AI	arm/ Fault	C	20:05:51)9 / 03 / 2023
Func	tion parameters 3	}						VFD Monitor
Tranfer release: VFD<->Grid	Disable	~	Active moto parameter se	or Motor paramet	ter set 1	~] _	
Cooling method	Air-cooled	~	DCS communic Protocol ty p	e Modbus		~]	Trend reccorder
Manual fan control	STOP	~	Baud rate	9600		~		Parameter
MV connection at active Alarm	Disable	~	VFD addres	s 1		~		setup
Open cab door : Disturbance selection	Alarm	~						Ev ent recorder
Message: Clean air filter	Ignore	~						Power cell status
Synchronous motor transfer	Transfer to grid	~						
Restore to	default settings			Prev. page	7/7	Next page)ther settings
	1							

Fig. 4-68 Main menu page 7/7: Parameter setup – Function parameters 3



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).

ΒυττοΝ: RESTORE TO DEFAULT SETTINGS All parameters of the Parameter setup menu are restored to the factory settings.



The button Restore to default settings is only available if parameter setting Restore to default settings = Enable.



INVERTER PARAMETERS 1

4	AuCom	MV ready	VFD rea	dy 🔵	VFD operation		Alar Fa	m/ ult			20:05:51 09 / 03 / 2023
	Invert	er parameters 1									VFD Monitor
	VFD type	ASYNC Motor U/f	~	Start frequency	0.20	Hz	Acceleration ramp	30.0	s		
	VFD mode	Test	~	Maximum Frequency	50.00	Hz	Deceleration ramp	50.0	s		Trend recorder
	START mode	Normal start	~	Minimum Frequency	0.00	Hz	Max. permitted FRT duration	0	ms	ĺ	Parameter
	STOP mode	Deceleration ramp	~	Rated input voltage	6000	v	Dead-time compensation	1	۳s	ļ	setup
	Master/Slave- operation	Disable	~	Rated output voltage	6000	V	Power cells: by pass fct	0			Ev ent recorder
	Master/Slav e- mode	Master	~	Rated output current	6000	A	Number of cells per phase	5		ľ	Power cell
	Freq. search 0.4	0 pu Master-Slave freq. difference	0.5 Hz	VFD input: Rate CT prim. currer	d 200	:5	Torque boost gain	0	%	-	status
	Parameter download	Parameter upload			Prev.p	age	1/7	vext page	•		Other settings

Fig. 4-69 Main menu: Parameter setup – Inverter parameters 1

PARAMETER OVERVIEW

E.

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 mod	es								
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 of	peration								
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 sta	art								
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	А	30.0 300 0.0 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 s	etting		
Dead-time compensation	1	μs	0 20µs	
	Power ce	lls		
Power cells: Bypass fct.	0	-	0 2	
Number of cells per phase	5	-	2 9	
	Motor sta	art		
Torque boost gain	0	%	1 15%	

Tab. 4-10Inverter 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:

Asynchronous motor with extended U/f characteristic

Asynchronous motor, vector control with speed sensor (speed feedback)

Synchronous motor with extended U/f characteristic

ASYNC Motor U/f
ASYNC VC with sensor
SYNC Motor U/f



SYNC VC with sensor

ASYNC VC without sensor

SYNC VC without sensor



CHAPTER REFERENCE

Asynchronous motor, vector control without speed sensor

Synchronous motor, vector control with rotor position sensor

 For further information on excitation settings, see chapter "4.6.6 Main Menu: Other Settings".

Synchronous motor, vector control with rotor position sensor (pole wheel angle feedback)

VFD MODES

Parameter:

medium voltage.

This parameter defines the VFD mode.

Test

Operation

Use this setting for operation *with* medium voltage applied.

MOTOR START/STOP

Parameter:

This parameter defines the motor start mode.

Setting options:

Normal start Th

Speed start

The VFD accelerates from the *start frequency* to the *set motor frequency* according to the *acceleration ramp*.

Use this setting for *commissioning* and *service* as well as factory tests *without* applied

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).

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.

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.

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.

MVH 2.0

START mode

VFD mode



OPERATING AND DISPLAY

AUTOMATIC MOTOR-PARAMETER IDENTIFICATION The *relative stator resistance Rs[%]* is a referred value determined by the VFD according to the following formula:

 $R_{s}[\%] = 100 \% * \sqrt{3} * R_{s}[\Omega] * \frac{\text{Motor rated current [A]}}{\text{Motor rated voltage [V]}}$

- <u>where:</u> Rs[Ω]: *Absolute* value of the stator resistance per phase (quotient of measured phase voltage and measured phase current)
 - Rs[%] *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 subprogrammes 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 Enable Master/Slave operation is disabled.

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:

The VFD is *Master*. The VFD is *Slave*.

Master	
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.

- 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*.

Setting range: 0.0 ... 1.0 Hz



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:

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

Maximum 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

_	
	 <u> </u>
L	

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:

Setting range: 380 ... 15000 V This parameter defines the *rated output voltage* of the VFD.

Parameter:

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
\equiv	The <i>se</i> 5 A an
	5 A ar

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*.

Rated output voltage

Rated output current







- VFD output frequency Motor rated frequency (motor rated speed)
- T₁: Motor ramp-up time
- T₂: 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 T₂*, the VFD will take to decelerate from the value set in parameter *Rated motor frequency* to 0Hz (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*.

MVLOSS

Parameter:

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

Max. permitted FRT duration

Setting range: 0 ... 20 µs

This parameter is used to	o compensate for the	e 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.



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:

Die power cell bypass function of the VFD is disabled.

NOTE

0

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

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



VFD output frequency Motor rated voltage Voltage increase 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:

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 = 61A*,

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 = 61A*,

Then, the *absolute starting current* is <u>36,6 A</u>

To determine the *torque boost gain [%]* at a given starting current, the following results:

Torque boo	st gain [%]:
	Starting current [A]
	⁼ Motor rated current [A] * Motor overload limit [%] * 0.001
or:	
	Starting current [pu]
	⁼ Motor overload limit [%] * 0.001

INVERTER PARAMETERS 2

AuCom	V ready	VFD ready		VFD operation	AI	arm/ Fault	20:05:51 09 / 03 / 2023
Inverter pa	rameters 2						VFD Monitor
High torque sta							Trond
Torque mode	Disable		~				recorder
VFD outpu voltage imbaland compensatio	t: ce Disable n		~				Parameter setup
Power cell by pass: ty	e Without cell bypass		~				Ev ent recorder
							Power cell status
Parameter download	Parameter upload			Prev. page	2/7	Next page	Other settings

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. 4-11Inverter 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.

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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

AuCom	MV rea	dy 🌔	VFD ready		ope	VFD eration	A	larm⁄ Fault	D		20:05:51 09 / 03 / 2023
Motor	parame	ters 1									VFD Monitor
Mot rated frequer	or 50.00	Hz	Motor rotational inertia	30.0	kg m²	PI-contr.	(magn.flux P-gain) 5.00			
Mot rated volta	or 6000 ge	V	Stator resistance	0.100	%	PI-contr.	(magn.flux I-time	2.00	s		Trend recorder
Mot rated spe	or 980	rpm	Stator leakage inductance	16.000	%	PI-co	ntr. (speed P-gain	5.00		ĺ	Parameter
Mot rated pow	or 1000 er	kW	Synchronization: Max. permitted ∆q	5.0	0	PI-co	ntr. (speed I-time	3.00	•		setup
Mot rated curre	or 77	A	Motor overexcitation gain	0	%	PI-contr. (a	active curr. P-gain): 1.00			Ev ent recorder
Mot ov erload lin	or 100 nit	%	Motor overexcitation as of frequenc	20	Hz	PI-contr. (a	active curr. -time): 10.00	ne.		Power cell
Mot idle curre	or 25.000) %	Magn. flux: Setpoint	0.96	pu						status
Parameter download	Para	meter load				Prev. page	3/7	Next pa	ge		Other settings

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	А	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 m ²	1.0 3000.0 kg m ²
Stator resistance	0.1	%	0.000 25.000 %
Stator leakage inductance	16.000	%	0.000 50.000 %
	Synchronous transfer		
Synchronization: Max. permitted $\Delta\phi$	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):	5.00	-	0.50 20.00
P-gain			
PI-contr. (magn.flux):	2.00	S	0. 10 20 .00 s



Motor rated frequency

Motor rated voltage

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. 4-12Motor parameters 1 - Parameter overview

Parameter description:

MOTOR RATED VALUES

Setting range	:
5. 00 80 .00 H	Z

This parameter defines the *rated frequency of the motor*. Set the motor rated frequency according to the motor nameplate data.

Parameter:

Parameter:

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:

e: U: VFD output voltage



f: VFD output frequencyMotor rated voltage

Motor rated frequency [Hz]

2 Motor rated frequency [Hz]3 Maximum motor frequency



Motor rated speed

Motor rated power

Motor rated current

- 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:

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:

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:

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: Er 100 ... 200% Ex

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.

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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:

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

Motor rotational inertia

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:

D [0/] - 100 0/ * √2 * D [0] *	Motor rated current [A]
$N_{\rm S}[70] = 100.70$ V3 $N_{\rm S}[\Omega]$	Motor rated voltage [V]

- - Rs[%] *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 $\Delta\phi$

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

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*.

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Parameter:

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

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

This parameter defines the magnetic flux setpoint for the motor.

• 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



This parameter defines the *integral time* of the *magnetic flux controller*.

Setting range: 0.10 ... 20.00 s

PI-CONTROL OF

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).

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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.

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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

PI-contr. (active curr.): I-time

Setting r	ange:
0.10	15.00

This parameter defines the *proportional gain* of the *active current controller*.

Parameter:

Setting range: 0.10 ... 50.00 ms This parameter defines the *integral time* of the *active current controller* (fine-tuning).



MOTOR PARAMETERS 2

AuCom	MV ready	VFD r	eady 🔘	VFD operation	Alarn Fau	n/	20:05:51 09 / 03 / 2023
Motor	r parameters 2		Speed cont	rollor:			VFD Monitor
mode	Residual voltage test	~	autom. calo	ulation			
Phase sequence: VFD output	Clockwise rotating field	~	Active curr autom. calo	ent controller. sulation			Trend recorder
Speed sensor: Number of pulses	1024	~	Magn. flux autom. calo	controller. ulation			Parameter
Load type	Fan	~	U/f slip con	npensation			ootap
LI]		Ev ent recorder
							Power cell status
						J	
Parameter download	Parameter upload			Prev. page	4/7 N	ext page	Other settings

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
V	FD 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 Clockwise rotating field The VFD output voltages have a *counterclockwise* rotating field: phase sequence $U \rightarrow W \rightarrow V$

The VFD output voltages have a *clockwise* rotating field: phase sequence $U \rightarrow V \rightarrow W$

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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
Pump

This setting offers a *long* excitation waiting time. It is suitable for most medium/heavy loads (not just *fan* loads).

This setting offers a *short* excitation waiting time. It is suitable for most *light* loads (not just *pump* loads).

PI-CONTROLLER

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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:

V

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*.



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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.

AuCon	n	MV ready	0	VFD read	у 🔘	VFD Operation		Alarm/ Fault			20:05:51 09 / 03 / 2023
Fi	unction	parameter	rs 1 —								VFD Monitor
Restore to default settings	Disable			~	Analog output AO 1	Output frequency			~	ŀ	
AI 1: f/n Setpoint - failure	Disable			~	Analog output AO 2	Output current			~		Trend recorder
AI 2: f/n Feedback - failure	Disable			~	Release: VFD reverse	Disable			~	ľ	Parameter setup
Instantan. VFD Trip at MV loss	Disable			~	Setpoint via D	Speed section 3			~		
Automatic star after MV loss	t Disable			~	Operating mode	Local mode (HMI)			~		Ev ent recorder
Release: Switch-over (DI) operating mode	Disable			~	Setpoint mode	Setpoint via HMI			~		Power cell status
Remote START/ STOP: DI mode	Lev el sig	gnal		~	n/f control loop	Open loop			~	-	
					[Prev. page	5/7	Next pag	e		Other settings

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	
Al 1: f/n Setpoint - failure	Enable	Minimum frequency / Last setpoint
Al 2: f/n Feedback - failure	Enable	Zero / Last act. value
	MV loss	
Instantan. Trip at MV Ioss	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	e: VFD reverse Disable Disable / Enable				
	Preset fixed setpoint frequ	iency			
Setpoint via DI	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.

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\equiv	۶	The <i>Restore to default settings</i> button is located on menu page 7/7 of the <i>Parameter setup</i> main menu.
	۶	Pressing the <i>Restore to default settings</i> button resets all parameter settings of the <i>Parameter setup</i> 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 Enable The button *Restore to default settings* is *disabled*.

The button *Restore to default settings* is *enabled*.

ANALOG INPUTS

Parameter:

Al 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.

The setpoint frequency is set to the value set in parameter *Minimum frequency*.

Setting options:

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:

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

Zero

Instantan. Trip at MV loss

This parameter defines the VFD trip behaviour in case of a mains failure (MV loss).

Setting options:

Parameter:

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.

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:

After an MV loss, the VFD does not restart automatically, but returns to standby mode.

After an MV loss, the VFD performs an automatic restart.

NOTE

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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
Enable

Switching the VFD operating mode via DI is not released.

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 c
 NOTE

NOTE

NOTE

VFD operation mode Remote control (DI) Is active.



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).

The digital inputs (DI) are activated/deactivated by pulses. The pulse length is at least

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This parameter only applies for parameter setting *Operation mode = Remote control (DI)*.

Setting options:

Pulse signal

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		-		
		=		

500 ms.

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



-) 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 AO1* is connected to terminals 11 (I4) and 10 (M4) of terminal block -XS18T of the I/O interface unit.

Setting options:

Momentary VFD output frequency value

Momentary VFD output phase current value

Temperature in power cell cabinet value

Excitation current setpoint (synchronous motors only)

Momentary VFD output power value

NOTE

NOTE

Momentary motor active power factor (*cos phi* of the motor)

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 AO2.

The signal lines of the *Analog output AO2* are connected to terminals 11 (I4) and 12 (M4) of terminal block -XS18T of the I/O interface unit.



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.

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- 1	_	_	
- 1			

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.

Output frequency Output current Power cell temperature Excitation current Output power Output power factor Output voltage Enable

Release for a motor reverse operation is *enabled*. Reverse running of the motor is possible.

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.



- 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

- ▶ f1, or
- ▶ f2, or
- ≽ f3

Speed section 7

- ▶ f1, or
- ▶ (2 * f1+ f2) / 3, or

VFD set frequency is determined to:

VFD set frequency is determined to:

- ▶ 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.

	Sta			
Selection of Speed section	DI: <i>Set frequency 3</i> (-XS1:1,5)	DI: <i>Set frequency 2</i> (-XS1:1,4)	DI: <i>Set frequency 1</i> (-XS1:1,3)	Fixed set frequency
	0	0	0	invalid
	0	0	1	f1
	0	1	0	f2
Speed section 3	1	0	0	f3
	0	1	1	invalid
	1	0	1	invalid
	1	1	0	invalid
	1	1	1	invalid
	0	0	0	invalid
	0	0	1	f1
	0	1	0	(2 * f1+ f2) / 3
Speed section	1	0	0	f2
7	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

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Ξ		This parameter only applies to the parameter setting <i>Release: Switch-over (DI) operating mode= Disable.</i>
	•	If parameter <i>Release: Switch-over (DI) operating mode</i> is set to <i>Enable</i> and parameter <i>Operating mode</i> is set to <i>Remote control (DI)</i> or <i>Remote control</i> <i>(DCS)</i> , then, parameter <i>Operating mode</i> is automatically set to <i>Local control (HMI)</i> .
	>	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 <i>Operating mode = Remote control (DCS)</i> and communica- tion fails between the VFD control unit and DCS, the VFD continues running with the current settings. You can change <i>required</i>

operating mode to *Remote operation (DI)* or *Local operation (HMI)*

Setting options:

Local control (HMI)

Remote control (DCS)

Remote control (DI)

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.

via the operating unit (HMI).

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*.

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
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This parameter can be modified during VFD operation.

Setting options:

Setpoint via HMI

Setpoint via Al

You can enter the setpoint for the VFD output frequency directly via the *operating unit (HMI)* (local operation).

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 ٠ 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.

AuCom	/V read	у	VFD ready		ope	VFD	AI	arm/ Fault		20:05:51 09 / 03 / 2023
Function p	arame	ters	2							VFD Monitor
Resolution of set frequency	0.10	Hz	DI: Set frequency f1	10.00	Hz	PI (control I	D-controller oop): P-gain	10.00		
Skip frequency 1 L	51.00	Hz	DI: Set frequency f2	30.00	Hz	PI (control	D-controller loop): I-time	10.00	min	Trend recorder
Skip frequency 1 U	51.00	Hz	DI: Set frequency f3	50.00	Hz	PI (control l	D-controller oop): D-time	0.00	min	Parameter
Skip frequency 2 L	51.00	Hz	AI 1 (f/n Setpoint): Meas.range end	20.00	mA	Filter clea	ining interval	30	d 499	setup
Skip frequency 2 U	51.00	Hz	AI 1 (f/n Setpoint): Meas.range start	4.00	mA	Fans: Fo	ollow-up time	30	min	Ev ent recorder
VFD input voltage: Correction faktor	100	%	AI 2 (f/n Feedback): Meas.range end	20.00	mA					Power cell
Max. permitted MV loss duration	1	s	AI 2 (f/n Feedback) Meas.range start	4.00	mA					status
						Prev.page	6/7	Next pag	je	Other settings

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 8 0.00 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	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 8 0.00 Hz					
DI Set frequency f3	50.00	Hz	0. 00 8 0.00 Hz					
	Analog inputs							
Al 1 (f/n Setpoint): Meas.range end	20.00	mA	10.00 25.00 mA					
Al 1 (f/n Setpoint): Meas.range start	4.00	mA	0.00 8.00 mA					
Al 2 (f/n Feedback): Meas.range end	20.00	mA	10.00 25.00 mA					
Al 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. 4-16Function 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.





The following four parameters define two skip ranges for unwanted operating frequencies:

Paramete	er:						Skip	freq	uency	1L

Setting range:
0.00 80.00 Hz

This parameter defines the *lower* limit of the *first* frequency range to be skipped.

Parameter:

Setting range: 0.00 ... 80.00 Hz This parameter defines the *upper* limit of the *first* frequency range to be skipped.

Parameter:

Setting range	€:
0.00 8 0.00 H	Ζ

This parameter defines the *lower* limit of the *second* frequency range to be skipped.

Skip frequency 1 U

Skip frequency 2 L



Parameter:

Skip frequency 1 L

Setting range: 0.00 ... 80.00 Hz

MEASURED VALUE ADJUSTMENT VFD INPUT VOLTAGE



VFD input voltage: correction factor

Max. permitted MV loss duration

This parameter defines the *correction factor* for the measured value of the *VFD input voltage*.

This parameter defines the upper limit of the second frequency range to be skipped.

1		
	=	

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!

- 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

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.

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	_		
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		_	

Parameter:

ucti

NOTE

- This parameter only applies to the parameter setting Automatic start after MV loss = Enable.
- Parameter setting Max. permitted MV loss duration = 100s 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.

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This parameter only applies to the parameter setting Setpoint mode = Setpoint via DI.



DI: Set frequency f1

DI: Set frequency f2

DI: Set frequency f3

- For further information, refer to the description of parameter \triangleright Setpoint via DI.
- This parameter cannot be modified during VFD operation. \triangleright

Parameter:

Setting range: 0.00 ... 80.00 Hz

This parameter defines the *fixed setpoint f1* for DI Set frequency 1 (terminal -XS1:1,7).

Parameter:

Setting range: 0.00 ... 80.00 Hz

This parameter defines the *fixed setpoint f2* for DI Set frequency 2 (terminal -XS1:1,6).

Parameter:

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 Al 1 and Al 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





Analog input Al 1 – Transfer characteristics: f/n setpoint Fig. 4-80

Setting range:



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

Setting range:

0.00 ... 8.00 mA

This parameter defines the *maximum input signal current* (measured range end) for *Analog input Al 1*, that can flow for the *maximum frequency setpoint* set in parameter *Maximum frequency* (measurement scale end).

Parameter:

Al 1 (f/n Setpoint): Meas.range start

This parameter defines the *minimum input signal current* (measured range start) for *Analog input Al 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 AI2*, 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 AI2*, that can flow for the *minimum frequency feedback of OHz* (measurement scale start).

PID-CONTROLLER: f/n CONTROL LOOP

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Ľ	_	_	_	
L	_	_	_	
Ŀ	-	-	-	
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For parameter setting *f/n control loop* = *Closed loop*, the *speed setpoint* is calculated by the internal PID-controller.

≻	The following three PID parameters only apply to the parameter
	setting <i>f/n control loop</i> = <i>Closed loop.</i>

- > You cannot modify this parameter during VFD operation.
- > For further information, contact the manufacturer.

NOTE



You can set the *f/n PID-controller* via the following three parameters:

Parameter:

Setting range: 0.00 ... 50.00

This parameter defines the *proportionality coefficient* of the P-control.

Parameter:

Setting range: 0.01 ... 20.00 min This parameter defines the *integral time* of the I-control.

This parameter defines the *differential time* of the D-control.

Parameter:

PID-controller (control loop): D-time

Filter cleaning interval

Fans: Follow-up time

PID-controller (control loop): P-gain

PID-controller (control loop): I-time

Setting range: 0.01 ... 20.00 min

VFD MAINTENANCE

Setting range	Thi
	Cle
15 30000 days	

This parameter defines the *time interval* between each display of the message *Alarm: Clean air filter*.

ſ		
- 1	=	
- 1		
- 1		
_ L		

Parameter:

NOTE This reminder only applies to the parameter setting *Message: Clean air filter = Remind.*

VFD COOLING

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.

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L	_		-	
L	=	_	-	
L				

Parameter:

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.

AuCom	MV ready	VFD read	iy 🔵 ope	VFD eration	Alarm/ Fault	D	20:05:51 09 / 03 / 2023
Fund	ction parameters 3						VFD Monitor
Tranfer release: VFD<->Grid	Disable	~	Active motor parameter set	Motor paramet	er set 1	\sim	
Cooling method	Air-cooled	~	DCS communic.: Protocol type	Modbus		~	Trend reccorder
Manual fan control	STOP	~	Baud rate	9600		\sim	Parameter
MV connection at active Alarm	Disable	~	VFD address	1		~	setup
Open cabinet door : Alarm/Fault selection	Alarm	~					Ev ent recorder
Message: Clean air filter	Ignore	~					Power cell status
Synchronous motor transfer	Transfer to grid	~					
Restore to	default settings			Prev. page	7/7 Next pa	ge	Other settings

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		
			START		
	Alarm/Fault mess	ages			
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 syst	em (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



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).

DI: Synchronous transfer start

Parameter: Transfer release: VFD<->Grid



Fig. 4-83 Block diagram – Release for synchronous changeover VFD<->Grid via DI

Setting options:

Disable
Enable

Synchronous transfer VFD<->Grid via DI is not released.

NOTE

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.



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 Water-cooled VFD cooling by ventilation

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

Tap this button to turn off the cooling fans. Tap this button to turn on the cooling fans.

- 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	
START	

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 Enable The VFD will trip or connection to the medium voltage is blocked when an alarm occurs.

The VFD continues to run or connection to the medium voltage is allowed when an alarm occurs.

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:

Parameter:

Alarm

When opening a door of the cell cabinet or transformer cabinet, the following message is displayed:

- Alarm: Door alarm cell cabinet, or
- Alarm: Door alarm transformer cabinet

The VFD remains in operation.



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.



When opening a door of the cell cabinet or transformer cabinet, the following message is displayed:

- Fault: Door alarm cell cabinet, or
- Fault: Door alarm transformer cabinet

Der VFD is switched off.

VFD COOLING

Fault

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:

The motor is switched from the VFD to the MV mains (grid).

Transfer to 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 Motor parameter set 2 Motor parameter set 3 Motor parameter set 4 The VFD uses the *motor parameter settings* saved in *Motor parameter set 1*.

The VFD uses the motor parameter settings saved in Motor parameter set 2.

The VFD uses the motor parameter settings saved in Motor parameter set 3.

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.



- > 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
Profibus
PROFINET

The VFD supports Profibus DP (on request).

The VFD supports Modbus RTU (using an RS485 interface).

The VFD supports Profinet (on request).

NOTE

Parameter:		Baud rate
This parameter defines s	<i>symbol rate</i> for data transmission.	
Definition Symbol rate:	Number of symbols transmitted per second, unit: [Baud], abbreviation: [Bd]	

	-	
I —	-	

You must set the same baud rate on both the transmitter and receiver sides.

Setting options:

Baud Baud Baud Baud Baud

1200
4800
9600
19200
38400

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.

AUC	Com	MV ready		VFD ready	VFE operation		Alarm/ Fault		20:05:51 09 / 03 / 2023	
No.	Time		Event		VFD output: f[Hz]VFD	VFD output: U[V]	VFD output: I[A]	^	ELL Monitor	
1	2023-03-29	10:56:56	L	ocal STOP command	0.00	0.00	0.00		FUNIONITOR	
2	2023-03-29	10:04:34	Lo	cal START command	0.00	0.00	0.00		Trend	
3	2023-03-29	10:03:45		VFD Reset	0.00	0.00	0.00			
4	2023-03-29	10:01:22	Test mo	de: MV-ON forbidden	0.00	0.00	0.00			
5	2023-03-29	10:00:19	Resto	ore to default settings	0.00 0.00		0.00	Parameter		
6	2023-03-29	09:53:23		VFD Reset	0.00	0.00	0.00		setup	
7	2023-03-29	09:21:56		Alarm: Fan failure	0.00	0.00	0.00			
8	2023-03-29	09:06:56	Fau	Fault: Excitation system 0.00 0.00		0.00	0.00	Ev ent recorder		
9	2023-03-29	2023-03-29 08:56:50 F		ote START command	0.00	0.00	0.00			
10	2023-03-29	07:47:33	Alarm: Do	or alarm trafo cabinet	0.00	0.00	0.00		Power cell status	
11	2023-03-29	07:47:33	Alarm: Do	oor alarm cell cabinet	0.00	0.00	0.00	\sim		
<							>			
Export	event log	Delete	event log				Settings		Other settings	
							_			

- No.: consecutive number of the event 1
- 2 Time: time stamp of the event
- 3 Event: clear text describing the event
- VFD output .: f[Hz]: Measured value of the VFD output frequency (RUN frequency) 4 at the time of event recording
- VFD output.: U[V]: Measured value of the VFD output voltage at the time of event 6 recording
- 6 VFD output .: I[A]: Measured value of the VFD output current at the time of event recording
- 0 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.
 - Each event entry is assigned a *time stamp* with the *date* and *time* at which the event TIME STAMP message was generated by the VFD control unit.
OPERATING AND DISPLAY



EVENTS -For each event entry, the *plain text* of the message is given in the *Event* column. The PLAIN TEXT MESSAGES 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 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 VALUES- SNAPSHOT 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: Tap the Delete event log button to delete all entries in the event log. DELETE EVENT LOG NOTE The function key Clear Event Log is only available for user level Engineer or higher. BUTTON: Tap the Export event log button to save the current event log. EXPORT 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 Set time range

Recent time		Cancel
10	Minutes	Vear Year
Fixed time	Today	Month
ime division point	0	🗹 Day
Given time		🗹 Hour
2023 Year 5	Month 8 Day	Minute
11 Hour 32	Minute 9 Second	Second

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	۲	○/●					
Recent time	0	○/●					
(Numerical value)	10	0 3.57914e+07 Minute					
Fixed time	0	○/●					
(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	0	○/●					
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	Ø						
Month	Ø						
Day	Ø						
Hour	Ø						
Minute	Ŋ						
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.

		0				
AuCo	MV ready	VFI	D ready ope	VFD eration	Alarm/ Fault	20:05:51 09 / 03 / 2023
Phase A	Phase A Power cell status	Phase B	Phase B Power cell status	Phase C	Phase C Power cell status	FU Monitor
A1	Normal	B1	Normal	C1	Normal	
A2	Normal	B2	Normal	C2	Normal	Trend recorder
A3	Normal	B3	Normal	C3	Normal	Parameter
A4	Normal	B4	Normal	C4	Normal	setup
A5	Normal	B5	Normal	C5	Normal	Ev ent recorder
A6	Normal	B6	Normal	C6	Normal	
A7	Normal	B7	Normal	C7	Normal	Power cell status
A8	Normal	B8	Normal	C8	Normal	
A9	Normal	B9	Normal	C9	Normal	Other settings
			2			

Fig. 4-86 Main menu – Power cell status



Power cells of the corresponding phases A, B and C for the three-phase voltage system formed at the VFD output.

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	tus Description	
Normal	Power cell is ready for operation	
Unknown state	Power cell is <i>not</i> ready for operation	

Tab. 4-20 Power cells – Availability

POWER CELLS SELF-TEST

sr 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	I	
	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. 4-21Structure 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

- Menu: Monitoring water cooling cell cabinet
- Menu: Monitoring power cell bypass units
- Menu: Temperature monitoring

2

3

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.



Fig. 4-88 Menu: Monitoring power cell bypass units



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.



OPERATING AND DISPLAY

 POWER CELL BYPASS UNITS
 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 supert of a failed celf test or failure of the hyperse unit of a power cell during.

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.

Temperature mor	nitoring						×
Measured values	s Settings						
Mo							
No.	Name	Value	Unit	No.	Name	Value	Unit
1	TEMP. 1	0,00	°C	2	TEMP. 2	0,00	°C
3	TEMP. 3	0,00	°C	4	TEMP. 4	0,00	°C
5	TEMP. 5	0,00	°C	6	TEMP. 6	0,00	°C
7	TEMP. 7	0,00	°C	8	TEMP. 8	0,00	°C
9	TEMP. 9	0,00	°C	10	TEMP. 10	0,00	°C
11	TEMP. 11	0,00	°C	12	TEMP. 12	0,00	°C
Transf	ormer						
1	TEMP. 1	0,00	°C	2	TEMP. 2	0,00	°C
3	TEMP. 3	0,00	°C				

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*.



Tempera	ture monitoring								X
Measure	d values Settings								Unit: [°C]
									1
No.	Name	Alarm	Fault	ACTV	No.	Name	Alarm	Fault	ACTV
1	TEMP. 1	0.00	0.00	ACTV	2	TEMP. 2	0.00	0.00	ACTV
3	TEMP. 3	0.00	0.00	ACTV	4	TEMP. 4	0.00	0.00	ACTV
5	TEMP. 5	0.00	0.00	ACTV	6	TEMP. 6	0.00	0.00	ACTV
7	TEMP. 7	0.00	0.00	ACTV	8	TEMP. 8	0.00	0.00	ACTV
9	TEMP. 9	0.00	0.00	ACTV	10	TEMP. 10	0.00	0.00	ACTV
11	TEMP. 11	0.00	0.00	ACTV	12	TEMP. 12	0.00	0.00	ACTV
	Transformer				[Display settings			
1	TEMP. 1	0.00	0.00	ACTV		Meas. value display: No. of Motor temp. data	12		
2	TEMP. 2	0.00	0.00	ACTV		Meas. value display: Trafo temp. data	Yes	~	
3	TEMP. 3	0.00	0.00	ACTV		FU Monitor:	Yes	~	

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





CHAPTER REFERENCE

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

Fig. 4-91 Editing via keypad

ALARM AND FAULT MESSAGES

	Alarm	Fault	ACTV
TEMP. 1	0.00	0.00	ACTV
TEMP. 3	0.00	0.00	ACTV

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: <i>Alarm</i> [°C]	Limit temperature: <i>Fault</i> [°C]
В	130	110	120
F	155	130	140
Н	180	155	165

Tab. 4-23Insulation 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)".

For parameter setting see chapter "4.5.6 Changing Parameter Settings

Parameter:

Fault

This parameter defines the *overtemperature limit* for the output of a *fault* message.

CHAPTER REFERENCE

Setting via numeric keypad

≻

(General)".



Fig. 4-94 Parameter setting via numeric keypad

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 Yes Transformer temperatures 1 to 3 are *not displayed* on the measured values menu page.

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:



OPERATING AND DISPLAY

No Yes The shortcut button is disabled.

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:

0		2
Excitation system	Parameter settings -	
Excitation 0.0 START	AO 1(2) (Setpoint excit. current) 20.00 mA Meas.range end	Motor: Rated 0.00 A
Excitation system output [A]	AO 1(2) (Setpoint excit. current) Meas.range start	Excitation system: 0.00 A
ON Excitation system Excit. current- feedback [A] Excitation	AI 3 (Feedback excit. current): 20.00 mA Meas.range end	ASYNC Start: 3.00 Hz
Excitation options	Al 3 (Feedback excit. current): 4.00 mA Meas.range start	Setpoint refresh 35.00 Hz
Excitation control Disable Operating Manual	PID-controller (Excitation): P-gain	Power factor setpoint 0.95
Excitation SYNC Excit. current No feedback No	PID-controller (Excitation): 10.00 min I-time	Excit. current 0.00 A
	PID-controller (Excitation): 0.00 min D-time	
		Return
8		

Fig. 4-95 Menu: Excitation system



Excitation monitor

Parameter settings – Excitation system



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: DI (-XS2:1,7) <i>Excitation system ready</i> is inactive.	
	green	\bigcirc	Signal from external excitation field to PLC: DI (-XS2:1,7) <i>Excitation system ready</i> is active:	
Excitation system fault	grey 🔘		Signal from external excitation field to PLC: DI (-XS2:1,5) <i>Excitation system fault</i> is inactive.	
	red		Signal from external excitation field to PLC: DI (-XS2:1,5) <i>Excitation system fault</i> is active:	
Excitation system ON	grey 🔘		Signal from external excitation field to PLC: DI (-XS2:1,6) <i>Excitation system ON</i> is inactive.	
	green		Signal from external excitation field to PLC: DI (-XS2:1,6) <i>Excitation system ON</i> is active.	

Tab. 4-24Excitation monitor – Status LEDs

Measurement readings				
Meas. quantity	Meas. range	Description		
Excit. current setpoint [A]	0.1 160 0.0 A	Excitation current <i>setpoint</i> depending on excitation control		
Excit. current feedback [A]	0.0 16 00.0 A	Excitation current <i>feedback</i> 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) <i>Sync.Motor: Excitation ON/OFF</i> (-XS13:9,10)	
STOP	Tap this button to deactivate the digital output (DO) <i>Sync.Motor: Excitation ON/OFF</i> (-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 / Constant power factor
Excitation feedback	No	No / Yes

Tab. 4-27 Excitation options – Parameters

Parameter:

This parameter enables/disables the excitation system function.

Disable Enable

Excitation system is enabled.

Excitation system is disabled.

Parameter:

Excitation control

Excitation start mode

Operating mode

Excit. current feedback

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

Manual

Yes

The synchronous motor is started immediately with excitation switched on.

Parameter:

This parameter defines the operating mode for the excitation system function.

The motor is operated with the value set in parameter Excit. current setpoint.

The motor is operated with the value set in parameter *Power factor setpoint*.

Parameter:

This parameter defines the presence of an excitation current feedback (actual excitation current).

No

Constant power factor

There is no feedback of the excitation current. Excitation current control with a closed control loop is not possible.

The actual excitation current is fed back via the Analog input AI3. 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 curr	ent		
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 2 0.00 min	
PID-controller (Excitation): D-time	0.10	min	0.00 30.00 min	
Excitation system: Rated values				
Motor: Rated excitation current	0.0	А	0.1 160 0.0 A	
Excitation system: Rated current	0.0	А	0.0 1600.0 A	
ASYNC Start: Excitation frequency	0.00	Hz	0. 00 8 0.00 Hz	
Setpoint refresh rate	0.00	Hz	0. 00 8 0.00 Hz	
Operating mode: Constant power factor				
Power factor setpoint	0.00	I	0.00 1.00	
Operatin	g mode: Manual excitat	ion		
Excit. current setpoint	0.0	А	0.0 1 600.0 A	

Tab. 4-28 Excitation system – basic and control parameters

Parameter description

NOTE

SETPOINT SETTING: EXCITATION CURRENT The *excitation current setpoint* can be transmitted either via *Analog output AO1* or *Analog output AO2*.

L	

To configure parameter *Analog output AO1* or *Analog output AO2*, 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 AO1* and *Analog inputs AO2*. 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 AO1 or Analog output AO2*, 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

This parameter defines the maximum output signal current as (measured range start) of

Analog output AO1 or Analog output AO2, that can flow for the minimum excitation

Setting range: 0.00 ... 8.00 mA

FEEDBACK: EXCITATION CURRENT

The excitation current is *fed back* via the Analog input AI 3.

current setpoint of 0 A (measurement scale start).

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:

	Al 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

This parameter defines the maximum input signal current as (measured range end) of Analog input AI3 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

This parameter defines the maximum input signal current as (measured range start) of Analog input AI3, that can flow for the minimum excitation current feedback of OA (measurement scale start).

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.

PID-controller (Excitation): P-gain

This parameter defines the *proportionality coefficient* of the P-control. Setting range: 0.00 ... 20.00

Parameter:

	Parameter:	PID-controller (Excitation): I-time
Setting range: 0.00 20.00 min.	This parameter defines	the <i>integral time</i> of the I-control.
	Parameter:	PID-controller (Excitation): D-time
Setting range: 0.00 30.00 min	This parameter defines	the <i>differential time</i> of the D-control.

Setting range: 0.00 ... 25.00 mA

Setting range:
0.00 8.00 mA

PID-CONTROLLER: EXCITATION CONTROL

0.00



Excitation system: Rated values		
	Parameter:	Motor: Rated excitation current
Setting range: 0.1 1600.0 A	This parameter defines the <i>rated ex</i>	<i>citation current</i> of the synchronous motor to be driven
	Parameter:	Excitation system: Rated current
Setting range: 0.0 1600.0 A	This parameter defines the <i>excitatio</i>	on system rated current.
	Parameter:	ASYNC Start: Excit. frequency
Setting range: 0.00 80.00 Hz	This parameter sets the <i>frequency</i> a	at which the <i>excitation is switched on</i> .
	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 <i>power mode = Constant power factor</i> .	factor setpoint for the parameter setting Operating
OPERATING MODE:		

OPERATING MODE: MANUAL EXCITATION

Parameter:

Setting range: 0.1 ... 1600.0 A

This parameter defines the *excitation current setpoint* for the parameter setting *Operating mode = Manual.*

Excit. current setpoint



MENU: OPERATING HOURS

NOTE

The operating hours menu provides information about the *motor running times* when the motor is operated via the VFD.

_	
_ 1	
_ 1	
_ 1	

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:







Actual motor run time (operated via VFD) 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



VFD control unit – version

I/O interface unit- version

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

_	
<u> </u>	

NOTE

Software version of the touchscreen (HMI)

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 are	<i>ea:</i> pass	word and	user level s	ettings		
	0	2		3		
AuCom	NV ready	VFD ready	oper	VFD ation	Alarm/ Fault	20:05:51 09 / 03 / 2023
Other systems	Precharge system Ex	c tation system	Operating hours	SW versions	User center	FU Monitor
User cente			_	Status Us ≱r level: \$	Standard	Trend recorder
	Configuration area	-16	Login a	rea		Parameter setup
	System settings		Change pa	ogin		Ev ent recorder
	Equipment settings	<u> </u>	Logou	ıt .		Power cell status
						Other settings
			6	5	4	

Fig. 4-99 Menu: User center

- 1 Menu: *System settings*
 - Menu: *Equipment settings* (AuCom only)
 - Menu: Change password
 - Display: Status of current user level
 - Menu: User Login

23456

Button: *Logout*



Configuration area: System settings

		2 (
AuCom	MV ready	0	VFD ready VFD Operation Fault	20:05:51 09 / 03 / 2023
Other systems	Precharge s	stem I	xcitation system Operating hours SW versions User center	FU Monitor
Systemset	ngs		X	Trend recorder
Settings:	Year	Month	Day Hour Minute Second	
System ti	me O	0	0 0 0 0 ОК	Parameter setup
Standby pag settings:	e-		Select menu German 🗸	Ev ent recorder
••••	enable		FU Monitor: Measurand selection	Power cell status
Latency time	100	s		
				Other settings

Fig. 4-100 Menu: System settings



4

Settings: System date and time

Standby page settings (activation and time delay)



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

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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).



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

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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.

Measurand selection		X
Input power factor Input power	Output power factor Output power	

Fig. 4-102 Measured variable selection for display in the VFD Monitor

Setting options:



 \checkmark

The measured value of the selected measurand is not displayed.

	(AI 1)	0,0	%	I/IT Feeuback (AI 2)	0,0	%	
	Input power			Output power		,	F
	Input power factor			Output power factor			0
DC	Bus voltage	0,00		Synchronization: Δφ	0,0	0	Ģ

Fig. 4-103 VFD Monitor – Example: no readings displayed

The measured value of the selected measurand is *displayed*.

	(AI 1)	0,0	%	(AI 2)	0,0	%	
	Input power	0	kW	Output power	0	kW	F
	Input power factor	0,00		Output power factor	0,00		
DC	CBus voltage	0,00		Synchronization: $\Delta \phi$	0,0	0	è

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

Username Operator
Enter current password
1 2 3
4 5 6
7 8 9

- **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.

Fig. 4-105 Enter current 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

NEW PASSWORD ENTRY

Change password		X
Username	Operator	~
En	ter new passv	vord
0 0	• •	•
1	2	3
4	5	6
7	8	9
Delete	0	ОК

Fig. 4-108 Entered password digits

After entering the last password digit, the screen is displayed with the request to enter the new password.

- **STEP 3:** Enter the *new* password for the *Operator* user level via the displayed numeric keypad.
- 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:

User center		Status User level: Standard
	Configuration area	Login area
	System settings	Change password User Login
	Equipment settings	Logout

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



- Park's transformation (dq transformation) of measured values into vectors
- to depict the motor model
- PI magnetic flux controller
- PI reactive motor current controller (magnetising current)
- 3 4 PI speed controller
- 6 PI active motor current controller (torque)
 - inverse Park's transformation (inverse dq transformation)
- 7 Dead-time compensation and PWM modulation
- 8 IGBT ignition pulses

The VFD applies:

1

- the motor model,
- the measuring values of stator voltages U_{a_1} U_{b_1} U_{c_1} and
- the measuring values of the stator currents ia, ib, ic

to calculate

- the magnetic flux Ψ •
- the synchronous speed ω_{s_i}
- the synchronous electrical angle θ_s and
- the slip ω_{slip} •

According to the synchronous electrical angle θ_s the transformation of the stator currents into the *dq coordinate system* results in:

- the magnetising current ids and
- the active motor current iqs.

The PI-controller for magnetic flux performs a proportional and integral control PI-CONTROLLER: depending on the difference between the $\mathit{setpoint} \ \Psi^\star$ and the calculated $\mathit{actual} \ \mathit{value} \ \Psi$ of MAGNETIC FLUX the magnetic flux, thus generating a magnetising current setpoint $\frac{*}{ds}$

PI-CONTROLLER: The PI controller for speed performs proportional and integral control depending on the Speed difference between the speed setpoint ω^* and the speed actual value ω_r , thus generating an active current setpoint i

- PI-CONTROLLER: The PI-controller for magnetising current performs a proportional and integral control MAGNETISING CURRENT depending on the difference between the magnetising current setpoint i the magnetising current actual value ids (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: The PI controller for active current (torque) performs proportional and integral control depending on the difference between the active current setpoint i as and the active current 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 <u>dq</u>-axes are subjected to an inverse transformation of the dg-coordinates depending on the synchronous angle θ_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: The VFD starts the motor then transfers the motor to the incoming line (MV grid). VFD to GRID:
- 2. TRANSFER: The VFD synchronizes to the motor then transfers it off the incoming line and on-to the GRID TO VFD: 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 PARAMETERTo enable the master/slave application, you must set the parameter Master/SlaveSETTINGSoperation to Enable for all VFDs involved. For each VFD you must set parameterMaster/Slave mode as either Master or Slave.





Fig. 5-4 VFD type = ASYNC Motor U/f: Current balancing control in slave

- 1 Distributed control system (DCS)
- Im Motor set current (Master)
- fm Motor frequency
- fs Set frequency (Slave)
- Is Motor current (Slave)
- PI Current balancing controller







- Distributed control system (DCS)
- Motor set current (Master)
- f^{*}m Motor frequency
- fm 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).

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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 **1** to **9** used to control motor reverse operation via the VFD:

		1	2	3	4	6	6	7	8	9
				ST	ART/S	TOP co	ontrol	via:		
	Parameter settings	нмі	нмі	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	Remote START/STOP: DI mode = Level signal	0	0	0	0	1	1	0	0	0
für <i>Remote</i> control (DI)	Remote START/STOP: DI mode = Pulse signal	0	0	0	0	0	0	1	1	1
	Setpoint mode = Setpoint via HMI	1	0	0	1	0	0	0	0	1
Setpoint setting	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 Al	0	0	0	0	0	1	0	0	0
	Start motor reverse operation	HMI	HMI	DCS	DCS	DI	DI	DI	DI	DI
START-	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
conditions	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
	HMI: <i>STOP</i> button	1	1	0	0	0	0	0	0	0
STOP-	DCS-Stop command	0	0	1	1	0	0	0	0	0
conditions	DI (-XS1:1,10) Remote-Start/Stop signal	0	0	0	0	х	х	х	х	х
	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



- 2 START/STOP control via touchscreen (HMI) and setpoint setting via DCS
 - START/STOP control and setpoint setting via DCS
 - START/STOP control via DCS and setpoint setting via touchscreen (HMI)
 - START/STOP control and setpoint setting via digital inputs (DI: level signal)
 - START/STOP control via digital inputs (DI: level signal) and setpoint setting via analog input (AI)
 - START/STOP control and setpoint setting via digital inputs (DI: pulse signal)
 - START/STOP control via digital inputs (DI: pulse signal) and setpoint setting via DCS

START/STOP control via digital inputs (DI: pulse signal) and setpoint setting via touchscreen (HMI)



7 8

9



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

2 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 1 and 2 of a motor reverse operation:



3 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

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 3 and 4 of a motor reverse operation:







5 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

Parameter settings:

- Release: VFD reverse = Enable
- Operating mode = Remote control (DI)
- Remote START/STOP: DI mode = Level signal
- Setpoint mode = Setpoint via Al

Set frequency example:

- Motor forward run: Al 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 **5** and **6** of a motor reverse operation:



6 START/STOP CONTROL VIA DIGITAL INPUTS (DI: LEVEL SIGNAL) AND SETPOINT SETTING VIA ANALOG INPUT (AI)

VFD OPERATION

START/STOP CONTROL AND SETPOINT SETTING VIA DIGITAL INPUTS (DI: PULSE SIGNAL)

8 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 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

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*

9 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 **7**, **8** and **9** of a motor reverse operation:













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.



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	ration T1 < T2 Instantan. VFD Trip at MV loss = Disable; Automatic start after MV loss = Enable		VFD operation
VFD operation	T1 > T2	T2 Instantan. VFD Trip at MV loss = Disable; Automatic start after MV loss = Disable	

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*:





I: Motor current IN: 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/IN [%]	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


If the VFI

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*.





NOTE
The <i>n</i> fixed i

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.



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 \triangleright 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.



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

	NO	TE
\equiv	۶	0

- 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 <u>UNB</u> and <u>UNC</u> 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



N N

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
	Temperature	• Thermometer	 -5 +40 °C Derate VFD for use between 40 50 °C, reduce rated output current by 1 °C.
	Humidity	Hygrometer	• 5 95 Hz non-condensing
Operating environment	DustGreaseWater and drips	 Visual inspection 	No dustNo greaseNo water leaks
	Vibration	Dedicated tester	 0.15 mm, 9 58 Hz, max. 3 m/s²
	Gas	Dedicated tester,Sniff,Visual inspection	 No odor, no abnormal chemical smell or smoke
	Heat	Dedicated tester,Thermometer	 Outlet temperature is normal
VFD	Sound	Dedicated sound meter,Hearing	 No abnormal sounds, vibration, or squeaks
	Gas	Sniff,Visual inspection	No odor,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
	Heat	Dedicated tester,Thermometer	 No abnormal high temperature No overheating No burning odor
Motor	Sound	Dedicated sound meter,Hearing	 No abnormal sound or vibrations
	Vibration	 Dedicated tester 	No abnormal vibration

Tab. 6-1Routine Inspection schedule

6.2 REGULAR MAINTENANCE

You must perform the following maintenance work regularly, depending on the conditions of use of the VFD.

1	

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
•	• Main circuit terminals	ScrewdriverWrenchesTorque wrenchVisual inspection	Bolts and screws properly tightened,No damage to the cable or lugs
	• PE/Ground terminals	ScrewdriverWrenchesTorque wrenchVisual inspection	Screws tightened,No damage to the cable
VFD	 Control circuit terminals 	ScrewdriverTorque screwdriver	 Wires inserted, Screws properly torqued, No damage to the wires or cables
	Internal connection cablesConnections	ScrewdriverTorque screwdriver	No damage to the wires or cablesScrews properly torqued
	Mounting screws	ScrewdriverSleeve	Sleeve fastening
	• Dust/dirt	Vacuum cleanerCompressed 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

NOTE

VFD switch-on test and
RUN RECORDIf 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 VAC auxiliary winding of the transformer. Slowly increase the voltage to the rated voltage of the power cells via a voltage regulator.



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*.



Tab. 6-3VFD 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 Al 2
Alarm: No setpoint signal at Analog input Al 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 Al 2	No analogue signal for the speed setpoint	 Measure whether an analogue signal is present. 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 Al 1	No analogue signal for the speed setpoint	 Measure whether an analogue signal is present. 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. Check the correct alignment of the door contact switch and adjust if necessary. 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 <i>Filter cleaning interval</i>	 Increase parameter setting value.
	Faulty communication line between main processor board AP4 and I/O interface unit	 Ensure that the network cable is plugged in correctly. Check network cable and replace if necessary.
	I/O interface unit failure	 Check the polarity of the connected power supply and correct as necessary. I/O interface unit is defective ⇒ Contact AuCom.
Alarm: Communication error control unit	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. 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.
	Excitation current diffe	rence limit value = 10 %
	Incorrect parameter settings of the excitation system	Correct parameter settings.
Alarm: Excitation current difference > 10%	 Incorrect parameter setting of <i>Analog input AI 3</i> (feedback of the exciter current actual value) Defective <i>Analog input AI 3</i> Wire break of <i>Analog input AI 3</i> 	 Check whether the difference between the supplied excitation current and the feedback excitation current value is above 10 %, correct as necessary. Correct parameter setting. Check wiring of <i>Analog</i> <i>input AI 3</i> and correct as necessary.
	Medium voltage is not being applied to the VFD and parameter <i>Manual fan control</i> is set to <i>Stop</i> .	• When medium voltage is applied to the VFD, the fans will activate and <i>Alarm: Fan failure</i> will automatically clear.
Alarm: Fan failure	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 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. Check the fan filter for dirt and replace if necessary.
	Fan power circuit breaker or thermal relay has tripped	 Check the circuit breaker and the thermal relay are operational and replace if necessary. Ensure that there is no fan overload condition.
Alarm: Fan power supply	Fan contactor does not switch	 Check the wiring of the fan contactor for errors and correct as necessary. Check the correct operation of the fan contactor and replace if necessary.
	Faulty fan auxiliary contacts	Correct or replace fan.
	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.
Alarm: Motor overload	Incorrect parameter settings for motor rated current and/or motor idle current	Correct the settings of parameters <i>Motor rated</i> <i>current</i> and <i>Motor idle</i> <i>current</i> .
	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.
	Fuse has tripped	Replace power cell.
	Cell bypass IGBT fault	Replace power cell.
	Fibre optic fault	Replace power cell.
Alarm: Cell bypass	Cell bypass contactor fault	Replace power cell.
	Power cell overheated	Replace power cell.
	Too much dust in the power cell	Replace power cell.
	Temperature lin	mit value = 55 °C
Alarm: Cell cabinet overtemperature	Failure of one or more fans	 Check whether the fan circuit breaker has tripped. Check the correct operation of the fan contactor and the thermal relays and replace if percent to the second second



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.
	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. Check the correct
Alarm: Door alarm cell cabinet		alignment of the door contact switch and adjust if necessary.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.
	Missing / insufficient power supply 24VDC for the operating unit (HMI)	Check for 24 V DC supply to rear connector of touchscreen.
Alarm: Communication error HMI	Faulty network line for communication with the operating unit (HMI)	 Ensure that the network cable is plugged in correctly. 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. Check the correct alignment of the door contact switch and adjust if necessary. 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 beat	Heat exchanger leaks	Contact AuCom.
exchanger leakage	Other cause of water ingress detected by visual inspection	• Eliminate the identified cause of water ingress.
	Temperature li	imit value = 95 °C
	Incorrect parameter setting for temperature limit value	Correct parameter setting.
Alarm: Transformer overtemperature	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
- And the mossing of		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. 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. 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. Refill cooling water.
	Faulty wiring of the feedback signals	Check the wiring of the feedback signal lines and correct as necessary.

Tab. 7-2Alarm 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
	Switch cabinet (Synchronous transfer)	 Check that the primary power wiring L1, L2, L3 in the switch cabinet is properly terminated. Is the circuit-breaker switched on?
	Primary cable inlet	 Check that the wiring from the synchronous transfer cabinet to the VFD is correct.
VFD & accessory	Interlock wiring & control power	Check if cabinet control loop power supply is operating normally.Check if MV interlock switch wiring is correct.
equipment	VFD	 Check if the primary wiring from the transformer cabinet to the cell cabinet is correct. Check if VFD parameters are set correctly. Is the VFD status <i>MV not ready</i>? Check whether fault indicator is on. Resolve fault condition before attempting to energize.
	Primary winding	Check if wiring from VFD to motor is correct.
Load equipment	Motor	 Check load. Check if the motor rotation is mechanically blocked. Check if it runs normally at rated frequency. 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 repor	ts a <i>fault</i> message.

Fault message	Possible cause	Remedy	
Fault: No motor run at start signal	DI <i>External VFD release</i> (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. 	
	Temperature	limit value = 60 °C	
Fault: VFD cabinet overtemperature	Fan power circuit breaker or thermal relay has tripped	 Check the circuit breaker and the thermal relay are operational and replace if necessary. 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: Dowor coll	Bypass contactor is damaged	Contact AuCom.	
bypass unit	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 <i>MV not ready</i> (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! 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 <i>Excitation</i> <i>system fault</i> at terminals - XS2T:1,5 of the I/O interface unit	 Check wiring and correct as necessary. Check external contact for DI Excitation system fault and correct as necessary. 	



Fault message	Possible cause	Remedy	
	VFD trip by optional motor protection device or - if included - by upstream protection system	 DI <i>External fault 1</i> is active (terminals: -XS2:1,10) ⇒ Determine cause of external trip and correct as necessary. DI <i>External fault 2</i> is active (terminals: -XS2:1,9) ⇒ Determine cause of external trip and correct as necessary. 	
Fault: External fault	VFD trip by EMERGENCY OFF	 DI EMERGENCY-OFF is active (terminals: -XS3:1,5) ⇒ Check whether one of the EMERGENCY STOP switches is actuated. ⇒ Determine and eliminate the cause and restore the EMERGENCY STOP signal chain. ⇒ Reset safety relay. 	
	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. 	
Fault: Fibre optics (FO)	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. 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. 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. Measure the earthing resistance of the VFD cabinet (⇒ it must be less than or equal to 0.1 Ω). 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. 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. Visually inspect the entire length of the fibre optic cable for cable breakage or severe kinks and replace if necessary. 	
Fault: MV mains failure	Mains-side power failure during VFD operation	Check for any abnormal situation on the site power grid.	
(MV loss)	Incorrect setting of parameter Max. permitted FRT duration	Check parameter setting and correct as necessary.	
	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.	
Fault: IGBT power cell	The motor load has stalled	Clear the mechanical fault	
	The VFD cabinet is not properly grounded	 Check the earthing connection of the VFD cabinet. Measure the earth resistance of the VFD intra cabinet (⇒ it must be less than or equal to 0.1 Ω). 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. 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.	
	Incorrect input power wiring or grounding of the transformer	 Check the VFD's main circuit wiring and correct as necessary. Perform a dielectric test on the main transformer line to ground, then compare the result with values from the transformer supplier. 	
Fault: VFD input ground fault	The input cable insulation is damaged	 Measure the insulation resistance of the input cable. Verify that it is within the allowed range. 	
	The lightning arrestors (if installed) are damaged	 Replace lightning arrestors. 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. 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. Supply voltage to terminal strip 	
		-XS16 of the lower terminal board.	
Fault: Low frequency	The torque at the VFD output is insufficient at low frequency.	 Adjust the setting of the <i>Torque</i> boost gain parameter. 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.	
up	VFD is in current-limiting operation	Adjust the setting of parameter <i>Motor overload limit.</i>	
	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
T duit message	Parameters are not vet	Unload parameters: the fault
Fault: VFD control unit version error	uploaded	message is then automatically cleared.
	Software programme versions are not compatible	Contact AuCom.
	Protective function setting range. 110 – 150 % of VFD rated output c	current
Fault: Motor	Incorrect settings of the motor parameters	Check settings of <i>Motor parameter 1</i> or <i>Motor parameter 2</i> and correct as necessary.
overcurrent	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.
	Deceleration time is too short for a high inertia load	• Check settings of parameter <i>Deceleration ramp</i> and correct as necessary.
Fault: VFD overvoltage	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 <i>magnetic flux</i> and <i>speed</i> .
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.
	<i>Precondition:</i> This fault message is only activate <i>Open cabinet door: Fault selectio</i> .	ed for the parameter setting n = Fault.
Fault: Door alarm cell	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.
Cabinet	At least one door contact switch is faulty	Check door contact switch and replace if necessary.
	Temperature i	limit value = 85 °C
	Cooling fans do not work properly	Check by holding a piece of paper in front of the filters. If
Fault: Power cell overtemperature	Filters are dirty and/or clogged	the paper is not held by the suction air flow, the filters are dirty or clogged and should be cleaned.
	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	
	Deceleration time is too short	 Increase setting value of parameter <i>Deceleration ramp</i>. Adjust value of parameter <i>Motor overexcitation gain</i> 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. 	
Fault: Power cell overvoltage	Current in VFD output oscillating	Adjust the speed ratio system parameters: <i>PI-contr. (speed): P-gain</i> and <i>PI-contr. (speed): I-time</i>).	
	Faulty <i>Hall sensors</i> for current measurement	 Check wiring of the hall sensor and correct as necessary. 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.	
	The output voltage of a power cell is too low	 Determine the defective power cell via <i>Power cell status</i> menu. Replace power cell. Contact AuCom. 	
Fault: VFD output phase unbalance	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.	
	Temperature lii	mit value = 150 °C	
	Incorrect temperature limit setting	Check parameter setting and correct as necessary.	
Fault: Transformer overtemperature	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. Check the correct operation of the fan contactor and thermal relays and replace if necessary. 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.
	Precondition: This fault message is only activate cabinet door: Fault selection = Fault At least one of the doors of the transformer cabinet has been	ed for the parameter setting <i>Open</i> <i>pult.</i> • Check that all doors of the cell cabinet are properly closed and
Fault: Door alarm transformer cabinet	unlocked when the VFD is switched on. At least one door contact switch	Ocked.Check door contact switch and
	The safety earthing of the main circuit was not removed before commissioning.	replace if necessary. Remove safety grounding before energizing the VFD.
Fault: VFD instantaneous trip at	Incorrect connection of the VFD ground	• Ensure the main circuit ground wire is connected properly and a low impedance earth ground is present.
power on	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.
	Pickup limit value = 150 % c	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.
Fault: VFD overcurrent	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 <i>parameter identification.</i>
	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 <i>PI-controller: Speed P-gain.</i>



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. Measure the voltage at each Hall sensor and check that the voltage is within the permissible range in each case. Contact AuCom.
	Deceleration time is too short	 Increase the value of parameter <i>Deceleration ramp</i>.
	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 <i>Start Frequency</i> parameter.
	Torque boost gain is set too Iarge	Decrease setting value of <i>Torque boost gain</i> 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. 7-5Fault 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.

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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.



- 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

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.



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. 8-3 Cooling air flow paths in the various cabinet types – Example: 11 kV VFD: a) Control/feeder cabinet and cell cabinet b) Transformer cabinet



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.





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

Top fan
 VFD cabinet
 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.

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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.

Always follow the safety instructions in chapter *Safety* when carrying out any work.

SAFETY INSTRUCTIONS

ELECTRICAL AND ELECTRONIC COMPONENTS

	DISPOSAL NOTE		
X	>	Assemblies of the VFD containing electrical or electronic components must be disposed of in accordance with <i>Directive 2012/19/EU</i> .	
	۶	<i>Non-EU countries:</i> Waste electrical equipment must be disposed of in accordance with the locally applicable legal regulations.	
	۶	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 Assemblies of the VFD that do not contain electrical components, such as control cabinet COMPONENTS 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)
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RIGHT FROM THE START

