MVH2.0

Variable frequency drive
2.3 kV~11 kV

User Manual

Document number: 890057-00-02

About this user manual

This manual is for the MVH2.0 series Medium Voltage Variable Frequency Drive of Benshaw, Inc.

Technical support

If you encounter any problem about the MVH2.0 series Medium Voltage Variable Frequency Drive, please contact Benshaw, Inc. technical service.

Please refer to back cover for contact information.

For more detailed information on products, please visit our website: www.benshaw.com.

This manual has been checked with due care and attention. However, should the user find any errors, these should be reported to Benshaw, Inc.

Entries in this manual may differ from the actual product, please refer to the user manual that was provided with the product.

Benshaw reserves the rights to improve products and this manual.

About this user manual

This manual is for Benshaw's MVH2 Medium Voltage Variable Frequency Drive. It covers both the UL/NEMA designs and the IEC designs.

Technical support

For technical support on this product, please contact Benshaw's technical service team.

E-mail: support@benshaw.com

Technical Support Hotline: +1 800-203-2416 or +1-412-968-0100
Technical Support Canada: +1 877-291-5112 or +1-519-291-5112

Technical support is available by contacting Benshaw Customer Service at any of the above telephone numbers. A service technician is available Monday through Friday from 8:00 a.m. to 5:00 p.m. EST.

NOTE
An on-call technician is available after normal business hours and on weekends. Call Benshaw and follow the recorded instructions.

To help assure prompt and accurate service, please have the following information available when contacting Benshaw:

- Name of company
- Telephone number where the caller can be contacted
- Benshaw product name
- Benshaw model number
- Benshaw serial number
- Name of product distributor
- Approximate date of purchase
- A brief description of the application

For more detailed information on products, please visit our website: www.benshaw.com

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Important notice

Congratulations on the purchase of your new Benshaw MVH2 Medium Voltage Variable Frequency Drive. This User Guide may not cover all of the applications for the MVH2, nor can it provide information on every possible contingency concerning installation, programming, operation, or maintenance specific to MVH2 VFD systems. Older versions of software may not contain all the user parameters and functionality as described in this manual.

The content of this manual will not modify any prior agreement, commitment or relationship between the customer and Benshaw. The sales contract contains the entire obligation of Benshaw. The warranty enclosed within the contract between the parties is the only warranty that Benshaw will recognize, and any statements contained herein do not create new warranties or modify the existing warranty in any way.

Any electrical or mechanical modifications to Benshaw products without prior written consent of Benshaw will void all warranties and may also void any safety certifications; unauthorized modifications may also result in product damage, operation malfunctions, or personal injury.

Incorrect handling of the drive may result in an unexpected fault or equipment damage. For best results when operating the MVH2 drive, carefully read this manual and all warning labels attached to the system before installation and operation. Keep this manual on hand for reference.

Do not attempt to install, operate, maintain or inspect the drive until you have thoroughly read this manual and related documents carefully, and can use the equipment correctly.

Do not use the drive until you have a full knowledge of the equipment, safety procedures and instructions.

Contents

1. Safety information and precautions

1.1 Overview

Personal safety has been taken into consideration in the design of this drive. However, like any other medium voltage equipment, dangerous voltages exist in the cabinet. Improper use may cause personal injury or damage to the equipment.

To prevent personal injury or damage to equipment and property, read this manual carefully before use.

1.2 Warning and caution symbols

This User Guide classifies safety, protection, and general information levels as Warning, Caution, and Note.

WARNING
Warns of a physical safety condition or electrical hazard which can cause personal injury or death.

CAUTION
Warns of situations in which equipment damage may occur.

NOTE
Indicates a specific piece of information applicable to the use or operation of the equipment.

Read this chapter carefully when installing, commissioning, and servicing this equipment, and follow the required safety precautions.

1.3 Safety precautions

Technical training is available for site personnel involved in operating and maintaining the equipment. Contact Benshaw or your local supplier for details.

1.4 Safe operation

Initial inspection

WARNING

- Do not install the equipment if moisture is found in the cabinet, parts are missing, or parts are found to be damaged during unpacking.
- If the packing list does not match the model number indicated on the unit label, do not install the VFD.
- When moving or lifting the VFD, ensure that the material handling equipment is rated to handle the VFD weight and dimensions. If not, the VFD may become damaged in the handling process.
- Do not use the VFD if parts are missing or damaged.

Installation

CAUTION

- Install only on proper surfaces (metal or concrete) and away from any combustible materials to prevent risk of fire.
- During installation, do not directly touch the components inside the VFD cabinet as electrostatic damage may occur to the VFD.
- Do not over-torque bolts and other hardware.
- Do not allow metal filings, wire scraps or hardware to fall into the drive cabinet to avoid equipment damage during operation.
- When installing or removing circuit boards, wear anti-static protection.

Wiring

WARNING

- Follow the instructions in this manual. Installation must be performed by qualified personnel.
- Never connect the input power to the output terminals T1, T2, T3 (U, V, W) of the VFD. Pay close attention to the labels on the terminals.
- The input and output cables must meet the voltage and current requirements for less than 3% drop, in addition to insulation and capacity requirements in accordance with national, local and industry standards.
- The motor speed encoder (if used) must use shielded wires, and the shield must be single-ended grounded.
- Wiring should only be performed by only qualified personnel and in accordance with relevant electrical safety work standards.
- Make sure that all power sources are disconnected before performing any wiring, to avoid electrical shock or fire.
- Properly ground the cabinet to eliminate the potential for the VFD cabinet to become electrically charged.

Operation

WARNING

- Before applying power, confirm that the power supply voltage level is the same as the rated voltage of the VFD. Also confirm that the main circuit wiring terminals are tight and properly terminated.
- The VFD should be energized only after the drive wiring is completed and the cabinet door is closed. DO NOT open the cabinet door when power is applied to avoid the risk of electric shock.
- When automatic start is enabled, safety isolation measures must be taken to prevent personal injury due to related mechanical equipment.
- Once power is applied to the VFD, the terminals of the VFD are energized, even in the stop mode. Do not touch the terminals as this may cause electric shock.
- Do not disconnect the fan power while the VFD is running because overheating and damage to the system may result. This will also result in a control system shutdown.
- For water-cooled VFDs, shut down the cooling water system immediately after stopping to prevent condensation from damaging the VFD. Only add cooling water when the drive is not powered.
- The fault indications should only be reset after confirming that the run command has been removed. If not, this could result in personal injury.

Synchronous transfer operation

WARNING

- Ensure that the output of the VFD is isolated and grounded before engaging in any power circuit work.
- If the load may remain operating while the VFD is being serviced, the VFD must be isolated from the motor to avoid electric shock.

Maintenance and inspection

WARNING

- Do not perform troubleshooting and maintenance on the VFD with power on. Ensure you power off VFD before opening the cabinet door and follow all lock-out/ tag-out safety procedures.
- To prevent personal injury caused by the residual voltage of the main circuit capacitors, wait at least 10 minutes after power shutdown or failure and confirm that power indication is off before performing maintenance and inspection.
- Only qualified electrical maintenance personnel should perform maintenance, inspection, or replacement of parts.

Others

WARNING

DO NOT modify the VFD. Only the manufacturer should modify the VFD.

CAUTION

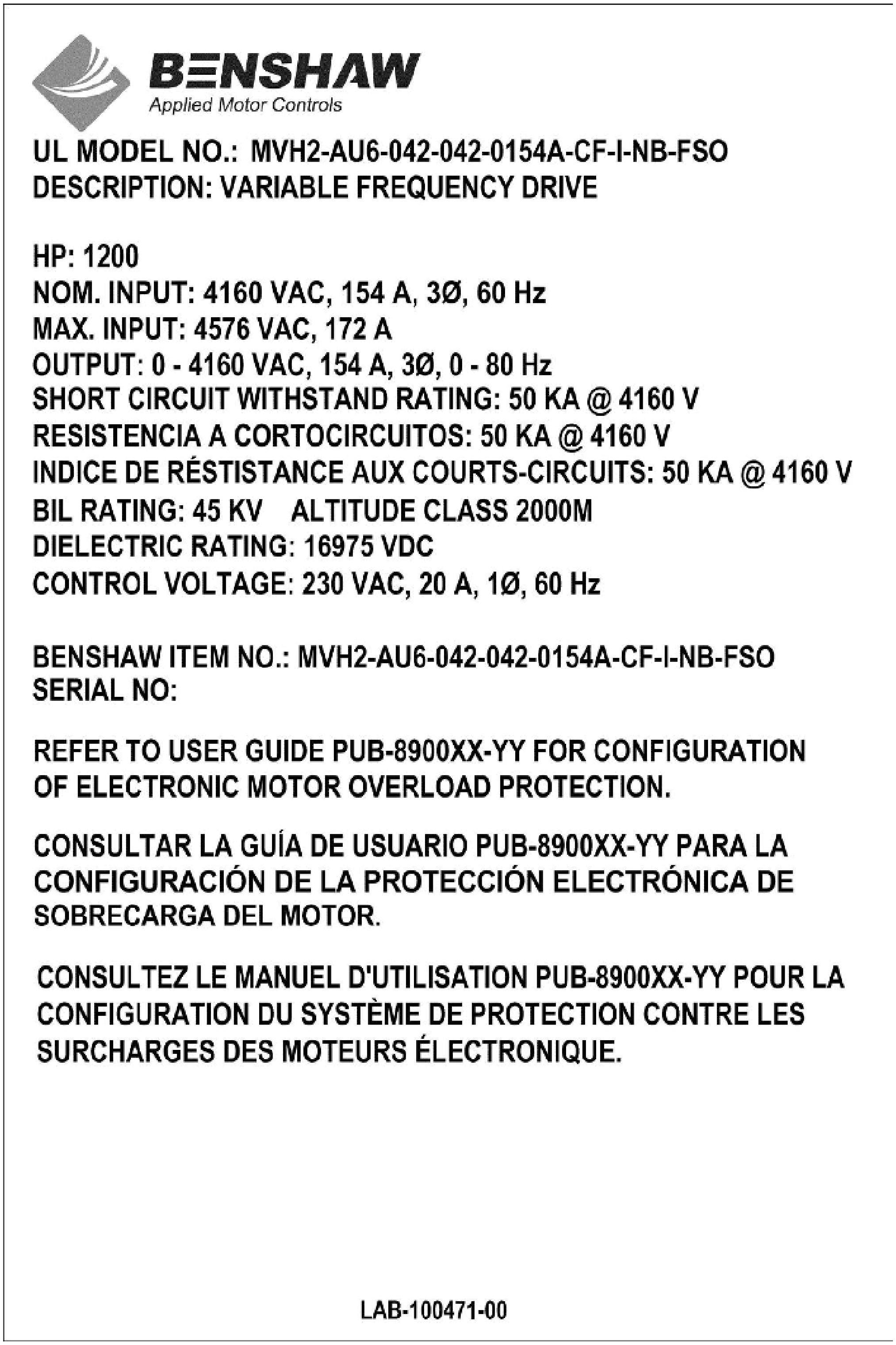
Properly dispose of any used components or parts.

2. Product introduction

2.1 Product information

NEMA / UL Product nameplate

Figure 2-1: NEMA / UL Product nameplate



Type code

MV VFD - A I 5 - 060 - 060 - 048 A - CF - I - NB - FSO

Cabinet type:
FSO = Front side access only
DSO = Double side access, e.g. front and rear access
CC = Compact cabinet
ACC4 = Compact cabinet 4.16kV
ACC7 = Compact cabinet 7.2kV
ACC13 = Compact cabinet 13.8kV

NB = No cell bypass
CB = Cell bypass
RB = Redundant cell bypass

I = In-line contactor
N = No in-line contactor

CF = Fusible disconnect
ND = No disconnect

Cooling method:
A = Air-cooled
W = Water-cooled

Rated power cell current (A rms)*

Output rated voltage (V rms)**

Input rated voltage (V rms)**

Input frequency:
5 = 50 Hz
6 = 60 Hz

I = IEC
U = UL

A = Asynchronous (induction) motor
S = Synchronous motor

MV drive product type

* Power cell rated current

Part #	A rms	Part #	A rms	Part #	A rms	Part #	A rms
0031	31	0165	165	0360	360	0800	800
0040	40	0173	173	0364	364	0960	960
0048	48	0195	195	0400	400	1000	1000
0061	61	0205	205	0425	425	1200	1200
0077	77	0220	220	0462	462	1250	1250
0086	86						
0096	96	0243	243	0500	500	1445	1445
0104	104	0275	275	0550	550	1540	1540
0115	115	0304	304	0600	600		
0130	130	0325	325	0660	660		
0154	154	0340	340	0750	750		

** Rated voltage

Part #	V rms	Part #	V rms
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

2.2 Features

The MV VFD is suitable for speed regulation and control of medium voltage three-phase AC motors. The VFD has the following functions and features:

- Motor control methods

Standard induction motor, vector control, sensorless vector control, and synchronous motor control.

- Power cell bypass technology

Optional bypass modes, including mechanical bypass and electronic bypass.

- Neutral point shift technology.

When a power cell fails, only the failed cell is bypassed, and the neutral point of the output voltage is adjusted to improve the voltage output capability.

- Output voltage self-adjustment

As the input voltage fluctuates (-10% ~ + 5%), the VFD will adjust and supply rated voltage to the motor.

- Torque boost function

Increases the load capacity of the motor during startup and low frequency operation.

- Rotating speed start (flying-start) function

When the motor is still rotating, the drive can catch and control the motor smoothly.

- Momentary power loss function

When a momentary power failure occurs, the drive can operate continuously and stably.

- Auto restart after power loss

After input power is reapplied or after short-term power failures, the VFD can be programmed to automatically restart.

- Synchronous transfer switch function (with optional synchronous switch cabinet)

Provides smooth and non-disruptive switching of the motor between power line operation and variable frequency operation.

- Leader – Follower control function (see *Master-Slave settings*)

VFD dual- or multi-machine linkage operation of process PID control function.

The VFD also displays the following standard fault and alarm messages when applicable:

Fault

- VFD overcurrent
- Over voltage fault
- High voltage power loss fault
- Power cell over-heat fault
- Cabinet over-heat fault
- Transformer cabinet temperature fault
- Unit cabinet temperature
- Power supply fault
- Three-phase output unbalance
- Output short circuit to ground
- Input imbalance
- Analog line drop
- System overspeed
- Overtemperature
- Excitation fault

Alarm

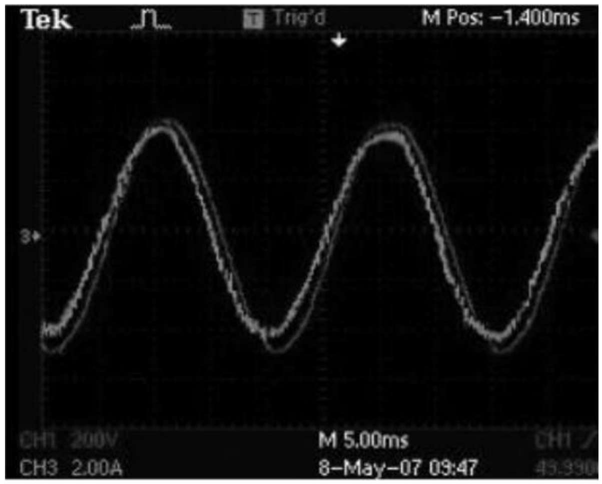
- Motor overload
- Parameter setting error
- Transformer door alarm
- Power cell door alarm
- Power cell cabinet overheat alarm
- Transformer over-heat alarm
- Fan alarm
- Power cell bypass
- Controller communication
- Fan loss of power

NOTE

For IEC designs, door status switches are required and must be configured to trigger a fault if a door is opened.

The VFD three-phase input power complies with IEEE STD 519-2014 and GB/T 14549-1993 standards. There should be no need to install input filters. After the input is converted by a phase-shifting transformer, multi-pulse diode rectification is used to provide isolated power for each power cell. Multi-pulse operation eliminates most of the harmonic current caused by individual power cells (see *30 pulses input waveform (CH1 voltage, CH3 current)* on page 12).

Figure 2-2: 30 pulses input waveform (CH1 voltage, CH3 current)



The MV VFD uses power cells in a series connection using H-bridge multilevel overlapping PWM technology. This provides for an output waveform with low harmonic content and a nearly perfect sine wave (see *Output line voltage waveform* on page 12 and *Output current waveforms* on page 13). Compared with other forms of medium voltage large-capacity VFDs, our MV VFD has the following advantages:

- No need for an extra output filter
- Can directly drive the medium voltage AC motor
- No need to derate the motor for PWM operation
- Lower dv/dt to prevent damage to insulation of motor and cables
- No torque ripple induced by harmonics, so the service life of motors and mechanical devices can be extended
- No cable length requirement when the cable voltage drop is less than 3%

Figure 2-3: Output line voltage waveform

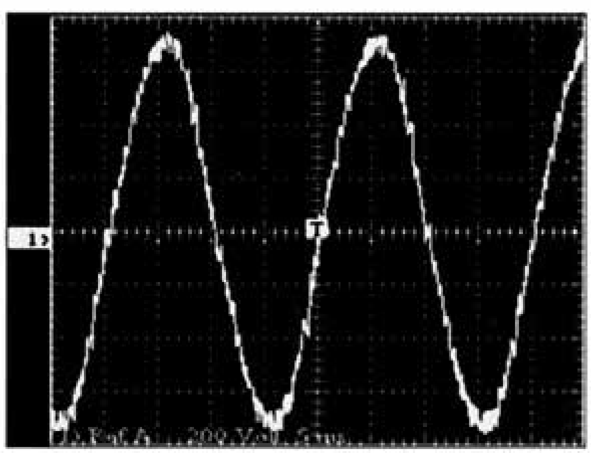


Figure 2-4: Output current waveforms

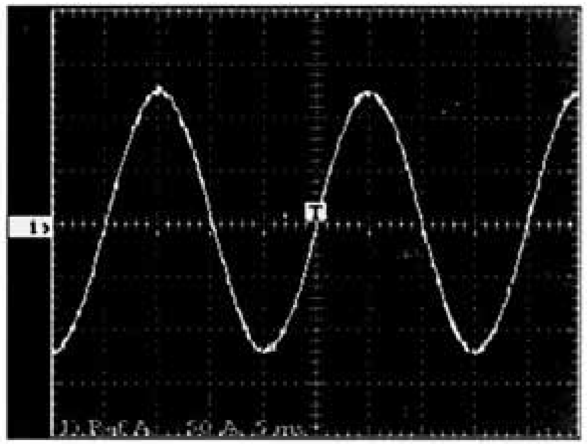


Table 2-1: Technical parameters

Item	Parameter
VFD rated power	210~28000 KVA
Rated voltage	2.3~13.8 kV (-10%~+5%)
Rated input frequency	50/60 Hz (-10%~+10%)
Control power	NEMA UL: 240 VAC, single phase, 10 kVA IEC: 380 VAC three-phase, 10 kVA
Rated input power factor	≥0.96
Efficiency	>96-98% depending on specified options
Output frequency range	0~80 Hz
Speed accuracy	±0.5% (open loop vector) ±0.1% (closed loop vector)
Instantaneous overcurrent protection	150% (can be adjusted according to user requirements)
Over capacity	120% load for 120 s
Torque limitation	10%~150%
Analog input	3: 4~20 mA / Excitation feedback 4~20 mA (customized)
Analog output	4: 4~20 mA
Host communication	Isolated RS485 interface, Modbus RTU, Profibus DP (optional), Industry Ethernet protocol (optional)
Acceleration and deceleration time	5~6000 s
Digital inputs/outputs	14 inputs, 22 outputs
Operating temperature	-5~+45°C
Storage temperature/Transportation temperature	-25~+55°C
Cooling method	Air-forced cooling (AF)
Humidity	<95%, non-condensing

Item	Parameter
Altitude	≤328 ft (1000 m). When altitude is higher than 328 ft (1000 m), for each 32.8 ft (100 meters), derate current of VFD by 1%.
Dust	Non-conductive, non-caustic, <6.5 mg/dm3
Protection level	IP30/Type 1
Cabinet colors	ANSI 61 Grey RAL7035

Contact your local supplier for information beyond this table.

2.3 Model selection notation

The MV VFD model selection depends on the motor type, load characteristics, and motor ratings. In the case of special or non-typical loads, motors, or environments, users should abide by the following advice:

- If the load torque ripple such as that caused by a reciprocating compressor, vibrating machine, or mixer load is high, select the MV VFD based on the maximum current required for proper operation.
- For submersible pump or oil pump applications, the rated current of the MV VFD should be greater than the *Motor rated current*.
- When used in extreme environments, such as in high temperature or high altitude (> 1500 m) environments, the MV VFD output must be derated. This can result in a higher rated VFD being required for the application.

NOTE

- The above advice does not cover all of the cases of special loads and motors. Contact Benshaw or your local supplier to confirm the correct model selection.
- The MV VFD must be installed in a proper location as it is not an explosion-proof design.

2.4 Application industries and fields

The MV VFD series is a globally accepted product. The VFD provides a solution for soft start, speed regulation, energy savings, and intelligent control of medium voltage AC synchronous and induction motors.

Typical industries are:

- Petrochemical
- Cement
- Mining & minerals
- Municipal projects (water/wastewater & others)
- Power generation
- Metallurgy
- Light industry
- Others

Typical applications are:

Petrochemical

- Aeration fan
- Induced draft fan
- Force draft fan
- Water pump
- Sewage pump
- Hot water circulating pump
- Lift station
- Cleaning water pump
- Water supply pump

Power generation

- Booster fan
- Force draft fan
- Induced draft fan
- Pipeline transportation pump
- Water injection pump
- Feed water pump
- Submerged pump
- Oil transfer pump
- Brine pump
- Circulating water pump

Municipal projects

- Booster fan
- Condensation pump
- Slurry pump
- Water storage pump
- Circulating water pump
- Boiler feed pump
- Compressor

Cement

- Kiln draft fan
- Kiln gas blower
- Separator fan
- Cement mill fan
- Dust removal fan
- Circulating fan
- Grate cooler
- Raw mill fan
- Raw material mill
- Coal mill
- Clinker cooler fan
- Kiln drive
- Force draft fan

Mining & minerals

- Main fan
- Axial flow fan
- De-scaling pump
- Mud pump
- Slurry pump
- Cleaning water pump
- Feeding pump
- Stirring pump
- Agitating pump
- Drainage pump
- Conveyor drive

Metallurgy

- Induced draft fan
- Force draft fan
- Blast furnace blower
- Blast fan
- Converter fan
- Electric furnace fan
- Slag-flushing pump
- Feeding pump
- Water-delivery pump
- Mud pump
- De-scaling pump
- Oxygen compressor

Light industry

- Gas blower
- Hydraulic pump
- Cleaning pump
- Axial flow pump
- Compressor
- Shredding machine

Others

- Pump test stand
- VFD power supply test stand
- Motor test stand
- Wind tunnel test
- Kneading machine

2.5 Standards and norms

Table 2-2: UL/NEMA design standards

Standard	Definition
UL347A (pending)	Safety of Medium Voltage Power Conversion Equipment
UL50/50E	Safety of Enclosures for Electrical Equipment, Non-Environmental Considerations and Environmental Considerations
UL508A	Safety of Industrial Control Panels
UL61800-5-1	Safety for Adjustable Speed Electrical Power Drive Systems, Part 5-1
CSA C22.2 NO. 274	Safety for Adjustable Speed Drives
ANSI/IEEE C57.12.01	Standard General Requirements for Dry-Type Distribution and Power Transformers
ANSI/IEEE C57.12.91	Standard for Testing of Dry-Type Distribution and Power Transformers
ANSI/IEEE C57.12.51	Standard for Ventilated Dry-Type Power Transformers – General Requirements
ANSI/IEEE C57.18.10	Standard Practices and Requirements for Semiconductor Power Rectifier Transformers
UL 1562	Safety of Transformers, Distribution, Dry-Type – Over 600 Volts
NEMA - ICS1	Industrial Control and Systems: General Requirements
NEMA - ICS3	Standards for Medium Voltage Controllers
NEMA - ICS6	Standard for Industrial Control and System Enclosures
NFPA - 70	U.S. National Electric Code
IEEE Std 519 - 2014	IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems

Table 2-3: IEC design standards

Standard	Definition
IEC 60073-2002 / GB/T 4025-2010	Basic and safety rules for human machine interface signs and indicators and coding rules for operating devices
IEC 60204-11: 2000 / GB/T 5226.3-2005	Safety of machinery. Mechanical and electrical equipment. Part 11: Technical conditions for high voltage equipment with voltages above 1000 VAC or 1500 VDC, but not exceeding 36 kV.
IEC 60529: 2013 / GB/T 4208-2017	Enclosure protection class (IP)
IEC 60664-1: 2007 / GB/T 16935.1-2008	Insulation coordination for equipment in low voltage systems. Part 1: Principles, requirements, and tests.
IEC 61800-3: 1996 / GB 12668.3-2012	Adjustable speed electric power drive systems. Part 3: Electromagnetic compatibility requirements and their specific test methods
IEC 61800-4: 2002 / GB/T 12668.4-2006	Adjustable speed electric power drive systems. Part 4: Standard requirements. Rating specifications for AC power drive systems above 1000 VAC and not exceeding 35 kV
IEC 61800-5-1: 2007 / GB 12668.501-2013	Adjustable speed electric power drive systems. Part 5-1: Safety requirements, electrical, thermal, and energy
IEC 61800-5-2: 2007 / GB 12668.502-2013	Adjustable speed electric power drive systems. Part 5-2: Safety requirements function

Standard	Definition
GB 156-2007	Standard voltages
GB/T 1980-2005	Standard frequencies
GB/T 3797-2016	Electrical control equipment
GB4588.1-1996	Specification for single- and double-sided printed boards with plain holes
GB4588.2-1996	Sectional specification: single- and double-sided printed boards with plated-through holes
GB/T 12668.2-2002	Adjustable speed electric power drive systems. Part 2: General requirements for the rating of low voltage AC variable speed electric drive systems
GB/T 14549-1993	Quality of electric energy supply, harmonics in public supply network
GB/T 10228-2015	Technical parameters and requirements for dry-type power transformers
DL/T 994-2006	High pressure VFD for fan and water pump in thermal power plant
GB/T 1094.3-2017	Power transformers. Part 3: Insulation levels, insulation tests, and external insulation air gaps
GB/T 30843.1-2014	General-purpose variable frequency speed regulating equipment above 1 kV and not exceeding 35 kV. Part 1: Technical conditions
GB/T 30843.2-2014	General-purpose variable frequency speed regulating equipment above 1 kV and not exceeding 35 kV. Part 2: Test method
GB/T 12668.701-2012	Speed governing electric drive systems. Part 701: Common interfaces and usage specifications for electric drive systems
GB/T 12668.8-2017	Adjustable speed electric drive systems. Part 8: Voltage specifications for power interfaces

3. Hardware configuration

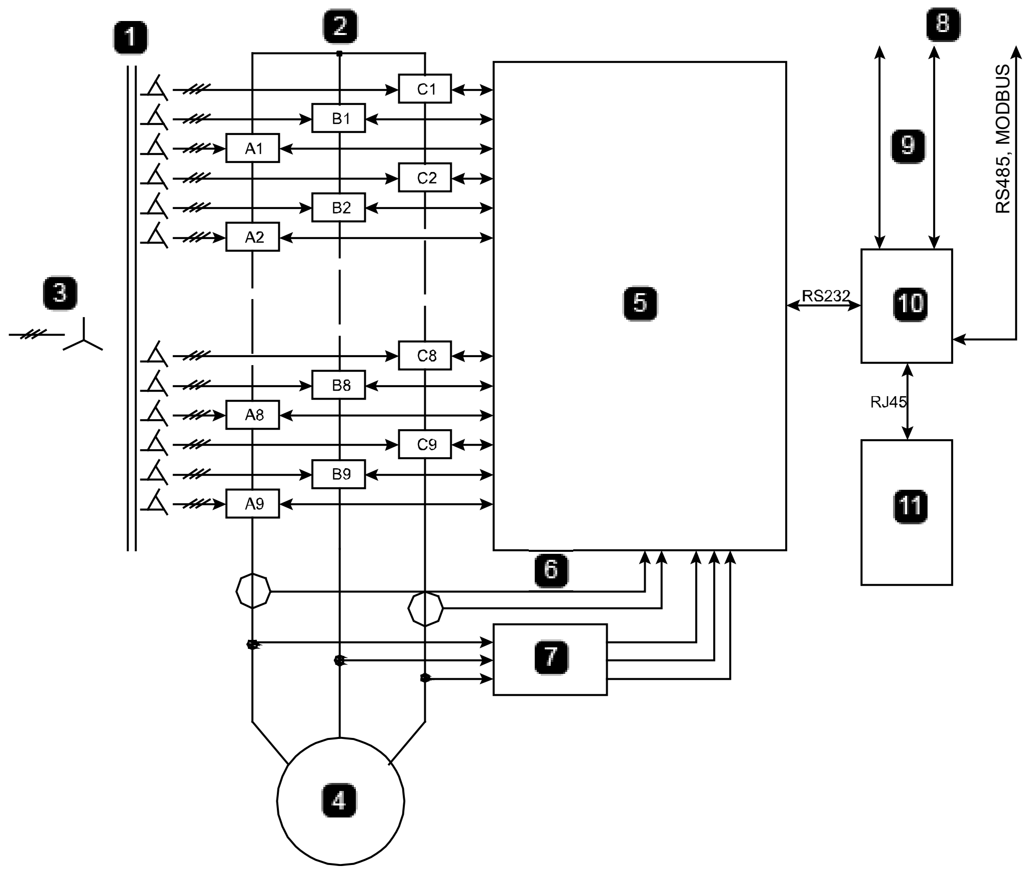
3.1 Theory

The MV VFD is composed of a transformer, power cells, and a control system.

Topology

The topology of the VFD is shown in *Standard MV VFD system diagram (11 kV example)* on page 18.

Figure 3-1: Standard MV VFD system diagram (11 kV example)



1	Insulation transformer
2	Power cell
3	Input power supply
4	11 kV motor

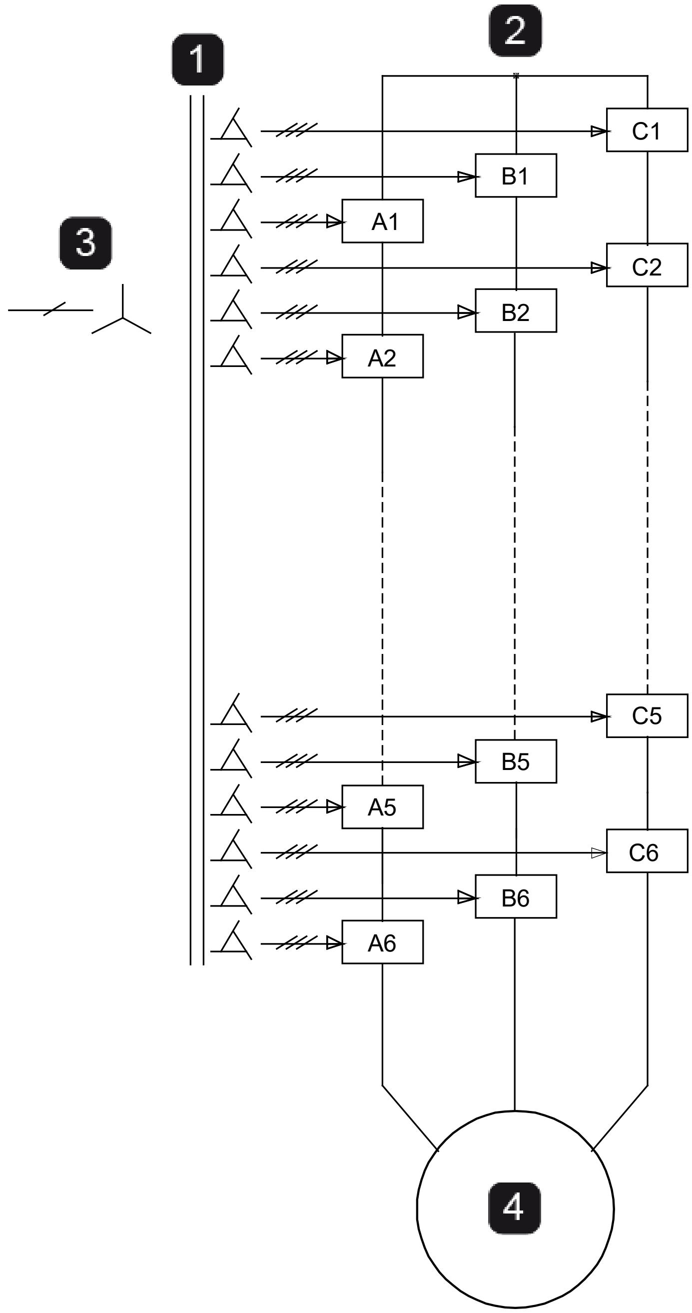
5	Controller
6	Output current detection
7	Output voltage detection

8	Fieldbus site system
9	I/O signal
10	I/O board
11	Touchscreen

Main circuit

The main circuit is shown in *VFD main circuit diagram (6 kV example)* on page 19.

Figure 3-2: VFD main circuit diagram (6 kV example)



1	Insulation transformer
2	Power cell
3	Input power supply
4	6 kV motor

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 minimize 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 by the following formula:

Phase shift angle=(60°)/n , n = number of cells in each phase

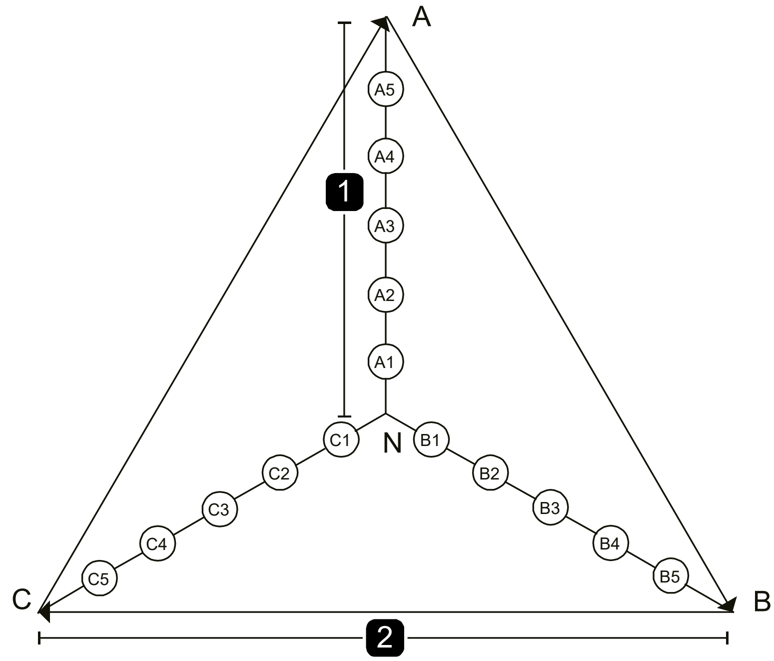
The VFD output is obtained by stacking multiple low voltage power cells with multiple three-phase inputs and single-phase outputs in series. For example, five power units with a rated voltage of 690 V are connected in series to obtain a 3450 V line to neutral phase voltage (see *Power cell configuration* on page 20).

Table 3-1: Power cell configuration

Rated voltage (kV)	Cells per phase	Input voltage per cell (V)	Phase voltage (V line-neutral)	Line voltage (kV)	Levels of voltage
2.3	3	450	1330	2.3	7
3.3	3	640	1900	3.3	7
4.16	4	600	2400	4.16	9
6	5	690	3460	6	11
6	6	640	3460	6	13
6.6	6	640	3810	6.6	13
10	9	640	5770	10	19
11	9	700	6350	11	19

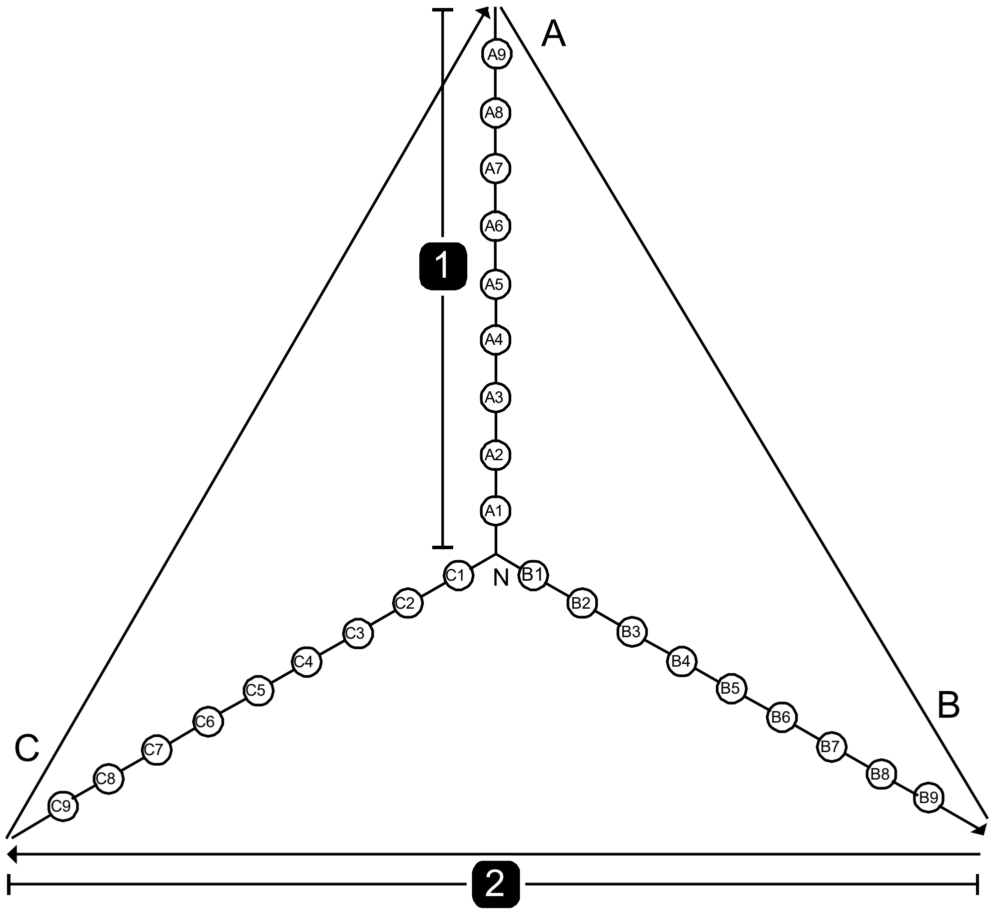
The three-phase output is Y-connected to obtain the medium voltage power supply required for driving the motor. The number of 4160 V power cells is 12. The number of 6 kV power cells is 15 or 18 (see *Voltage stacking diagram (6 kV VFD)* on page 20). The number of 11 kV power cells is 24 or 27 (see *Voltage stacking diagram (11 kV VFD)* on page 21).

Figure 3-3: Voltage stacking diagram (6 kV VFD)



1	Phase voltage (3450 V)
2	Line to line voltage (6000 V)

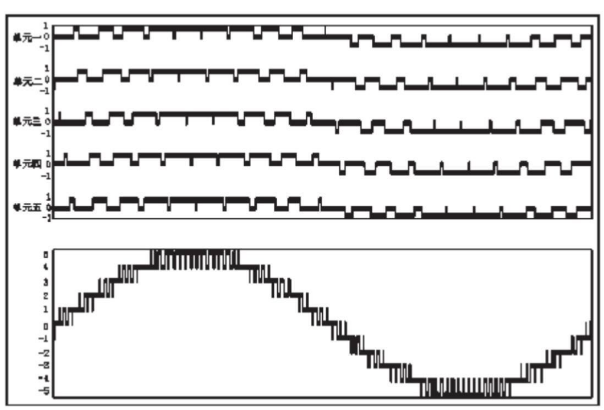
Figure 3-4: Voltage stacking diagram (11 kV VFD)



1	Phase voltage (5760 V)
2	Line to line voltage (11000 V)

In a 6 kV VFD with five power cells connected in series, there are 11 output levels (-5 to 0 to +5). When increasing the number of levels, the voltage value of each level is reduced, thereby reducing the level of dv/dt. The voltage waveform output by each power unit and the phase voltage waveform output after the units are connected in series are shown in *Voltage waveforms of five cells and phase voltage waveform* on page 21.

Figure 3-5: Output voltage waveforms of five series cells and phase voltage waveform



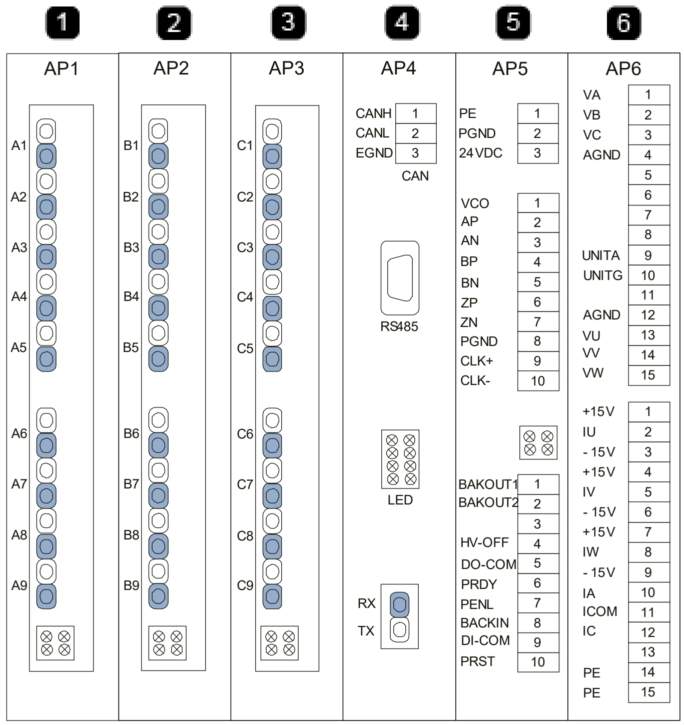
3.2 Control system

The control system of the MV VFD is composed of a microprocessor-based controller, I/O interface board, and touchscreen.

Controller components

The controller comprises the main control board, optical fiber board, power supply board, and signal board (see *Control panel schematic diagram* on page 22).

Figure 3-6: Control panel schematic diagram



1	Fiber board A
2	Fiber board B
3	Fiber board C
4	Main control board
5	Power supply board
6	Signal board

- ### Main control board

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

- **DSP subsystem:** Processes the motor control algorithms, power cell fault diagnosis, various real-time protections, and communication with interface boards.
- **FPGA subsystem:** Coordinates the real-time communication with the DSP, communication with the power cells, carrier phase-shifted PWM output, and other logic functions.

- ### Fiber optic board

The fiber optic board is a communication bridge between the controller and the power cells. Each controller is equipped with three fiber optic boards. Each fiber optic board controls all the power cells of one phase in each of the three phases of the VFD. The optical fiber board sends pulse-width modulation (PWM) signals and controls messages to the power cells. The power cell receives its trigger instructions and status signals through the fiber, then sends back a fault code signal to the fiber optic board when a cell has a fault.

- **Power board**

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, fiber optic boards, and signal board
- Digital signal transmission in VFD system
- For closed loop vector control models, it collects motor speed information fed back by the encoder.

- **Signal board**

The signal board 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.

3.3 Controller interface description

Fiber optic board interface description

Name	Description
A1/B1/C1	Optical communication interface for the 1st stage power cell
A2/B2/C2	Optical communication interface for the 2nd stage power cell
A3/B3/C3	Optical communication interface for the 3rd stage power cell
A4/B4/C4	Optical communication interface for the 4th stage power cell
A5/B5/C5	Optical communication interface for the 5th stage power cell
A6/B6/C6	Optical communication interface for the 6th stage power cell
A7/B7/C7	Optical communication interface for the 7th stage power cell
A8/B8/C8	Optical communication interface for the 8th stage power cell
A9/B9/C9	Optical communication interface for the 9th stage power cell
LED	Status indication

Main control board interface description

Name	Description
CANH	CAN communication interface
CANL	
EGND	
485A	485 communication interface
485B	
LED	Status indication
RX	Fiber optic communication interface
TX	

Power board interface

S/N	Name	Description
1 2 3	PE PGND 24VDC	Shield ground 24 V power supply ground/common 24 V power supply positive
1	VCO	Encoder power supply: +5 V or +24 V output, 200 mA
2 3	AP AN	Encoder signal A+ (RS422 differential signal level) Encoder signal A-
4 5	BP BN	Encoder signal B+ (RS422 differential signal level) Encoder signal B-
6 7	ZP ZN	Encoder signal Z+ (RS422 differential signal level) Encoder signal Z-
8	PGND	Encoder power supply ground
9 10	CLK+ CLK-	Clock signal + output (RS422 differential signal level) Clock signal - output
	LED	**Status indication**
1 2	BACKOUT1 BACKOUT2	Spare output 1, normally open contact Spare output 2
4 5 6	HV-OFF DO-COM PRDY	High voltage ready output, normally open contact, ready for HV when contact closed Output common point Controller ready output, normally open contact, ready when contact closed
7 8 9 10	PENL BACKIN DI-COM PRST	Interface board ready input, if PLC is ready this input is closed (+24V) Spare input Common input Controller reset input, open effective

Signal board interface description

S/N	Name	Description
1 2 3 4	VA VB VC AGND	Phase A input voltage signal Phase B input voltage signal Phase C input voltage signal Input voltage detection signal common terminal
9 10	UNITA UNITG	Power cell bus voltage sampling + Power cell bus voltage sampling -
12 13 14 15	AGND VU VV VW	Common terminal of output voltage detection signals Phase U output voltage signal Phase V output voltage signal Phase W output voltage signal
1 2 3	+15 V IU -15 V	Hall sensor positive power Phase U output current signal Hall sensor negative power

S/N	Name	Description
4	+15 V	Hall sensor positive power
5	IV	Phase V output current signal
6	-15 V	Hall sensor negative power
7	+15 V	Hall sensor positive power
8	IW	Phase W output current signal
9	-15 V	Hall sensor negative power
10	IA	Phase A input current signal
11	ICOM	Input current common ground
12	IC	Phase C input current signal
14	PE	Shield ground
15	PE	Shield ground

3.4 Interface board

Introduction

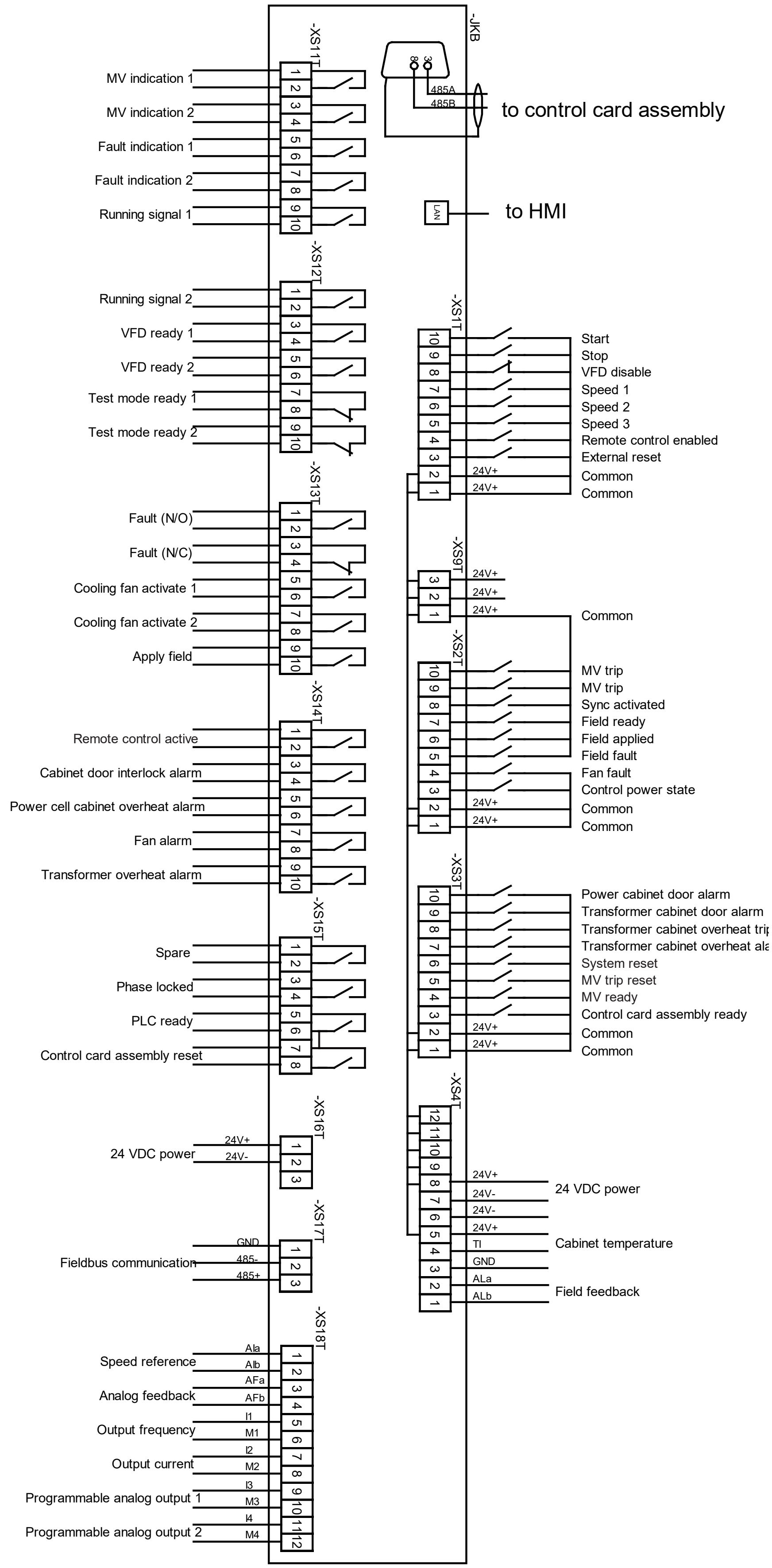
The interface board logic control device uses a Siemens S7-200 SMART PLC. The PLC is equipped with a Siemens high-speed processor chip. The basic instruction execution time can reach as fast as 0.15 μs. With the control requirements of the VFDs, 24DI, 16DO, 4AI, 4AO fast announcement and indication is ensured.

The S7-200 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. In addition, the CPU module integrates an RS485 interface, which can communicate with third-party equipment, and is also equipped with CM01 signal board to realize RS232/RS485 free communication.

The PLC integrates a micro-SD card slot. The program update and PLC firmware upgrade can be performed by using a universal micro-SD card, which eliminates the need to return the PLC to the factory or for a factory service technician to be present for firmware upgrades.

The interface board is used for the logical processing of internal signals, customer I/O and feedback signals, and status signals. It can also process four analog inputs and four analog outputs (see *I/O interface board schematic diagram* on page 26).

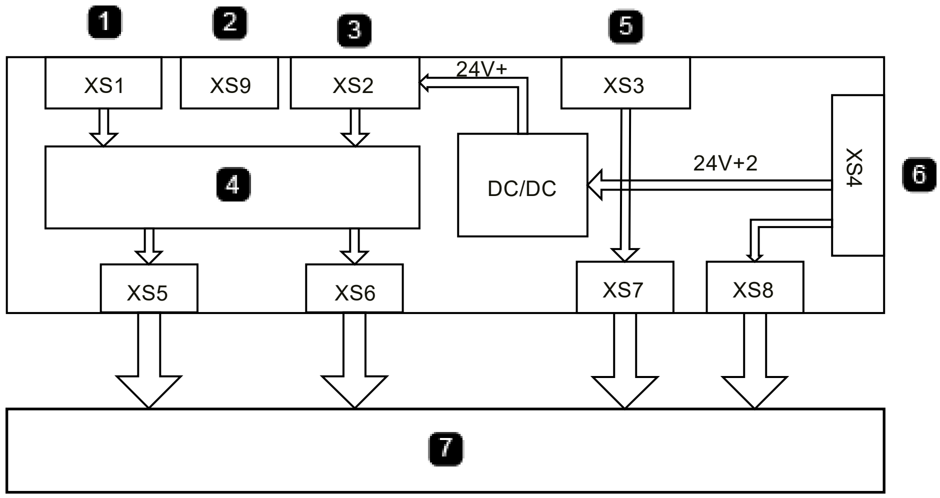
Figure 3-7: I/O interface board schematic diagram



The upper interface terminal block

The upper terminal strip interface signals are composed of external remote input signal groups, signals in the VFD cabinet, and excitation feedback signals. The +24 V input power (2) is powered by an external switching power supply module and then +24 V is generated by the DC/DC module to supply power to the remote signal part of the circuit. The remote signals are isolated from the PLC through relays. A schematic diagram is shown in *Interface block diagram* on page 27.

Figure 3-8: Interface block diagram



1	Remote control
2	Common terminal 2
3	Remote signal
4	Relay isolation
5	Cabinet inside signal
6	Common terminal 1 power supply temperature test and excitation
7	PLC

The upper terminal block is connected to remote operation and field switching input signals. Among them, there are a total of one analog input, 4~20 mA current input. The load impedance must be less than 500 Ω. Remote operation supports two types of signals, *level* and *pulse*, which can be set through the touchscreen function icon 'Remote start and stop mode'. The switch activate signal terminal is only used in the synchronous transfer function. For details, see the *MV VFD Synchronous Transfer Manual*.

NOTE

Digital inputs must be a passive or dry contact. When multiple digital inputs are used, the +24 V can be shared by them.

The interface board remote reset signal has the same function as the cabinet door **RESET** button (if supplied). If the VFD is not faulted, resetting will have no impact on the system operation. Resetting when running will not cause shutdown. After a fault occurs and the fault is eliminated, reset the control system to restore the VFD to a normal operating state.

The upper terminal block on the interface board is defined as follows:

Terminal number	**Position**	**Name**	**Status**	**Type**	**Note**
XS1T	1 10	Start	Closed/ Open	DI/level or pulse signal	Valid when parameter *Control mode* is set to ‘Remote control’. The *Remote start/stop mode* setting corresponds to two types of input mode: • Level mode: forward start when close, stop when open • Pulse mode: close then open (pulse width more than 500 ms), start (*Remote start/stop mode* set to ‘Pulse mode’)
	1 9	Stop	Closed/ Open	DI/level or pulse signal	Valid when parameter *Control mode* is set to ‘Remote control’. The *Remote start/stop mode* setting corresponds to two types of input modes: • Level mode: reverse start when closed, stop when open, VFD reverses set to ‘Permit pulse stop’, close then open (pulse width more than 500 ms) • Pulse stop: *Remote start/stop mode* set to ‘Pulse mode’
	1 8	VFD disabled (VFD MV Output Off)	Effective when open	DI/NC level signal	When open, the VFD output is inhibited, and the motor freely spins to a stop. Needs to be closed for VFD to run.
	1 7	Speed 1	Effective when closed	DI/NO level signal	Sets the VFD’s reference frequency, as selected in parameter ‘Switch given selection. These inputs are only read if parameter *Run mode* is set to ‘Open loop’ and the parameter *Set mode* is set to ‘DI set’.
	1 6	Speed 2	Effective when closed		
	1 5	Speed 3	Effective when closed		
	1 4	Remote control enable	Effective when closed	DI/NO level signal	If the parameter *Control mode set by remote* on the touchscreen is selected, the VFD control mode will be remote control.
	1 3	External reset	Effective when closed	DI/NO pulse signal	Remote equivalent to the function of the **RESET** button on the cabinet door.

Terminal number	Position	Name	Status	Type	Note
XS2T	1 10	MV TRIP	Effective when closed	DI/NO pulse signal	MV input power will be removed when closing contact (equivalent to the function of the **MV TRIP** pushbutton on the cabinet door).
	1 9	MV TRIP	Effective when closed	DI/NO pulse signal	MV input power will be removed when closing contact (equivalent to the function of the **MV TRIP** pushbutton on the cabinet door).
	1 8	Sync activated	Effective when closed	DI/NO pulse signal	Valid when the parameter *VFD-grid switch permit* on the touchscreen is set to 'Enable'. After closing, VFD output frequency will be increased to network frequency, and phases will be locked.
	1 7	Field ready	Effective when closed	DI/NO pulse signal	After the excitation system is ready, the contact will close (used on synchronous motor).
	1 6	Field applied	Effective when closed	DI/NO pulse signal	When the excitor is running, the contact is closed (used on synchronous motor).
	1 5	Field fault	Effective when closed	DI/NO pulse signal	When there is an excitation fault, this contact will close (used on synchronous motor).
	1 4	Fan fault	Effective when open	DI/NC level signal	When the fan trips, the contact opens triggering the fault.
	1 3	Control power state	Effective when open	DI/NC level signal	Used with the UPS option to indicate loss of input power to UPS. Must be closed (+24V) when control power is applied.
XS3T	1 10	Power cabinet door alarm	Effective when open	DI/NC level signal	When door switch opens, the contact opens triggering the fault. If no switch is used, this input must be set to closed (+24 V).
	1 9	Transformer cabinet door alarm	Effective when open	DI/NC level signal	When door switch opens, the contact opens triggering the alarm. If no switch is used, this input must be set to closed (+24 V).
	1 8	Transformer overheat trip	Effective when open	DI/NC level signal	When transformer RTD/temperature sensor detects an overtemperature the contact closes, triggering the fault. If no sensor is used, this input must be open (0 VDC).

Terminal number	Position	Name	Status	Type	Note
XS3T	1 7	Transformer overheat alarm	Effective when open	DI/NC level signal	When transformer RTD /temperature sensor detects an overtemperature alarm condition the contact closes, triggering the alarm. If no sensor is used, this input must be open (0 VDC).
	1 6	System reset	Effective when closed	DI/NC level signal	Resets system and faults when input is closed. Must be open to run.
	1 5	MV trip reset	Effective when closed	DI/NC level signal	Resets MV TRIP condition when closed. Must be open to run.
	1 4	MV ready	Effective when closed	DI/NC level signal	Signal received from the control card assembly. Will be closed (+24 V) if control cards are ready for MV to be applied.
	1 3	Control card assembly ready	Effective when closed	DI/NC level signal	Signal received from the control card assembly. Will be closed (+24 V) if control cards are ready to run.
XS4T	1 2	Field feedback	4~20 mA	AI/ current	Excitation current feedback to I/O board, VFD will perform relevant adjustment
	4 5 6	Cabinet temperature	4~20 mA	AI/ current	Cabinet temperature signal feedback to the interface board
	7 8	PLC power input	+24 V	+24 V, Com	+24 V supply for internal drive PLC Pin 8 = +24 VDC Pin 7 = 24 V Common

The lower interface terminal block

The lower terminal block is used to connect the status output signals, VFD cable inlet switch interlock signal, analog input/output, and communication signals. Terminals XS11T and XS13T are rated for up to 250 VAC/VDC. If a higher current or voltage rating is necessary, add intermediate pilot relays to extend the digital output capacity (see *Parameter setting window* on page 55). The analog value input must use shielded wiring, input impedance ≥250 Ω, max. input current 30 mA (max. input voltage 15 V). The phase lock success signal terminal only used with synchronous transfer switch function.

NOTE

Close permit and open signals described below are interlocked with a VFD upstream switch (e.g., breakers in the power cabinet, or VFD input contactors/breakers in the auto-bypass cabinet).

- Close permit is NO, connected in series to the circuit of the upstream switch, but not participating in the upper level switch operation. When it is closed, this enables the upper level switch to close to energize the VFD, otherwise it is not allowed.
- Open signal is NC, connected in parallel to the open circuit of the upper level switch. When a fault occurs while the VFD is running, the contact closes, automatically opening the upper level switch to protect the VFD.

Lower interface terminal block digital value definition:

Terminal number	Position	Name	Status	Type	Capacity	Note
XS11T	1 2	MV indication 1	True when closed	DO/NO	8 A/ 250 VAC	MV applied, contact, closed
	3 4	MV indication 2	True when closed	DO/NO	8 A/ 250 VAC	
	5 6	Fault indication 1	True when closed	DO/NO	8 A/ 250 VAC	Alarm = contact cycles open and closed (1 s, 1 cycle, 0.5 s on / 0.5 s off) Fault = contact always closed
	7 8	Fault indication 2	True when closed	DO/NO	8 A/ 250 VAC	
	9 10	Running signal 1	True when closed	DO/NO	8 A/ 250 VAC	VFD running, contact closed
XS12T	1 2	Running signal 2	True when closed	DO/NO	8 A/ 250 VAC	
	3 4	VFD ready 1	True when closed	DO/NO	8 A/ 250 VAC	When parameter *Control status* on the touchscreen is set to 'Normal' and the VFD has no severe faults, this contact closes.
	5 6	VFD ready 2	True when closed	DO/NO	8 A/ 250 VAC	
	7 8	Test mode ready 1	True when closed	DO/NC	8 A/ 250 VAC	When parameter *Control status* on the touchscreen is set to 'Debug' and the VFD has no severe faults output, this contact closes.
	9 10	Test mode ready 2	True when closed	DO/NC	8 A/ 250 VAC	
XS13T	1 2	Fault (N/O)	True when closed	DO/NO	8 A/ 250 VAC	Fault not failsafe. Closes on fault.
	3 4	Fault (N/C)	True when closed	DO/NC	8 A/ 250 VAC	Fault failsafe. Opens on fault.
	5 6	Cooling fan activate 1	True when closed	DO/NO	8 A/ 250 VAC	Fan run command based upon temperature command.

Terminal number	Position	Name	Status	Type	Capacity	Note
XS13T	7 8	Cooling fan activate 2	True when closed	DO/NO	8 A/ 250 VAC	
	9 10	Apply field	True when closed	DO/NO	16 A/ 250 VAC	Closes when field needs to be applied to a synchronous motor.
XS14T	1 2	Remote control active	True when closed	DO/NO	16 A/ 250 VAC	When the VFD control mode is remote control, this contact closes.
	3 4	Cabinet door interlock alarm	True when closed	DO/NO	16 A/ 250 VAC	When the cabinet door is opened, this contact closes.
	5 6	Power cell cabinet overheat alarm	True when closed	DO/NO	16 A/ 250 VAC	When the power cell cabinet overheats, this contact closes.
	7 8	Fan alarm	True when closed	DO/NO	16 A/ 250 VAC	When there is a fan fault, this contact closes.
	9 10	Transformer overheat alarm	True when closed	DO/NO	16 A/ 250 VAC	When the transformer reaches an overtemperature level, this contact closes.
XS15T	1 2	VFD ready	True when closed	DO/NO	16 A/ 250 VAC	The VFD has no internal fault and medium voltage is switched on. The VFD is ready for operation/start signal.
	3 4	Phase locked	True when closed	DO/NO	16 A/ 250 VAC	During synchronous transfer operation, when the VFD output is within phase tolerance with the incoming line this closes.
	5 6	PLC ready	True when closed	DO/NO	16 A/ 250 VAC	Contact closed when the internal PLC is ready to run. Signal goes to the control card assembly.
	7 8	Control card assembly reset	True when closed	DO/NO	16 A/ 250 VAC	Reset signal sent to control card assembly when contact closes.

Terminal row below the interface board power supply, communication and analog value definition:

Terminal number	Position	Name	Status	Type	Note
XS17T	1 2 3	Fieldbus communication		RS485	Communication interface between VFD controller and PLC. Pin 1 (right side looking at board, as mounted) = Com Pin 2 (center) = A - Pin 3 (left side looking at board, as mounted) = B +
XS18T	1 2	Speed reference	4~20 mA or 2~10 V	AI/ current or voltage	Adjust the mapped values by entering the minimum and maximum parameters. Precision is 1.5%. 4~20 mA corresponds to 0 Hz ~ max. frequency.
	3 4	Analog feedback	4~20 mA or 2~10 V	AI/ current or voltage	Adjust the mapped values by entering the minimum and maximum feedback parameters. Precision is 1.5%. 4~20 mA corresponds to 0~100%.
	5 6	Output frequency	4~20 mA	AO/ current	Max. load 500 Ω, 10-bit A/D sampling, resolution 0.1%~precision 1.0% 4~20 mA corresponds to 0 Hz ~ max. frequency.
	7 8	Output current	4~20 mA	AO/ current	Max. load 500 Ω, 10-bit A/D sampling, resolution 0.1%~precision 1.0% 4~20 mA corresponds to 0A~150% of *Rated output current*

Terminal number	Position	Name	Status	Type	Note
XS18T	9 10	Programmable analog output 1	4~20 mA	AO/ current	Max. load 500 Ω, 10-bit A/D sampling, resolution 0.1%, precision 1.0% according to *Analog output 1* on the touchscreen, corresponds to six types of output: • 4~20 mA corresponds to 0 Hz ~ max. frequency (if *Analog output 1* is set to ‘Output frequency’) • 4~20 mA corresponds to 0A~150% of *Rated output current* (if *Analog input 1* is set to ‘Output current’) • 4~20 mA corresponds to 0~100 ℃ (if *Analog output 1* is set to ‘Power cell temperature’) • 4~20 mA corresponds to 0~1 (if *Analog output 1* is set to ‘Output power factor’) • 4~20 mA corresponds to 0~150% of rated output power (if *Analog output 1* is set to ‘Output power’) • 4~20 mA corresponds to 0~excitation cabinet rated current (if *Analog output 1* is set to ‘Excitation current’)

Terminal number	Position	Name	Status	Type	Note
XS18T	11 12	Programmable analog output 2	4~20 mA	AO/ current	Max. load 500 Ω, 10-bit A/D sampling, resolution 0.1%, precision 1.0% according to *Analog output 2* on the touchscreen, correspond to six types of output: • 4~20 mA corresponds to 0 Hz ~ max. frequency (set to 'Output frequency') • 4~20 mA corresponds to 0A~150% of rated output current (set to 'Output current') • 4~20 mA corresponds to 0~100℃ (set to 'Power cell temperature') • 4~20 mA corresponds to 0~1 (set to 'Output power factor') • 4~20 mA corresponds to 0~150% of rated output power (set to 'Output power') • 4~20 mA corresponds to 0~excitation cabinet rated current (set to 'Excitation current')

3.5 Power cell

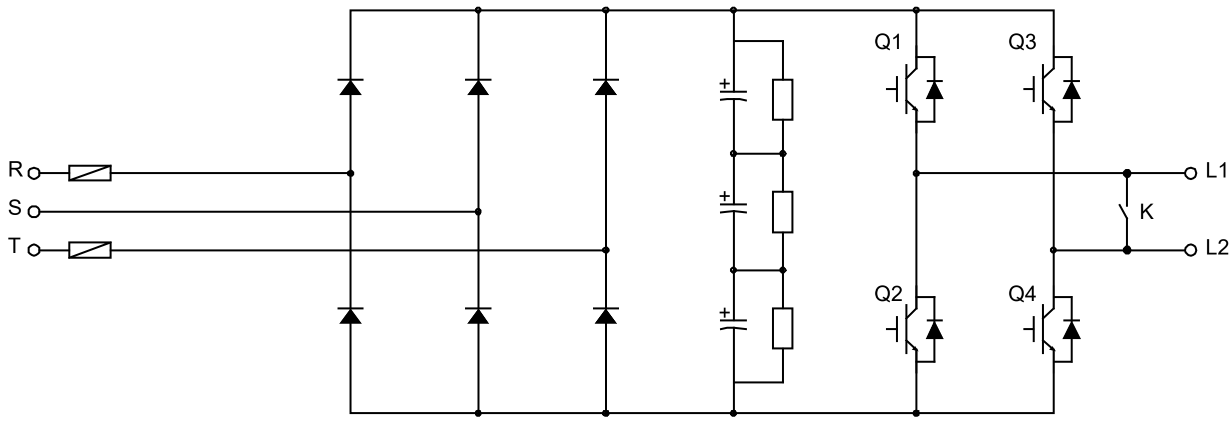
Electrical principle

The power cell electrical topology is shown in *Power cell topology* on page 36. The input terminals R, S, T are connected to a three-phase secondary winding of the transformer. 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 power cell receives the trigger signal through the fiber optic cable, which controls the ON and OFF of the IGBTs (Q1~Q4) and outputs a single-phase pulse width modulated waveform. Each unit has three output states:

- when Q1 and Q4 are on, the power cell output voltage is the DC bus voltage
- when Q2 and Q3 are on, the power cell output voltage is the negative DC bus voltage
- when Q1 and Q3 or when Q2 and Q4 are turned on, the power cell output voltage is zero.

When *Cell bypass model* is set to 'Mechanical cell bypass' or 'IGBT cell bypass', the 'power cell bypass function' is enabled. If a power cell has a problem, its status is displayed in the status bar (upper left corner of the touchscreen home page). If a power cell fails, it will inhibit the output of Q1~Q4, turn on the bypass IGBT or bypass contactor K, and then issue an alarm 'xx power cell bypass' (displayed in the yellow fault bar in the lower right corner of the touchscreen, where xx corresponds to the power cell number). This will ensure continuous operation of the VFD.

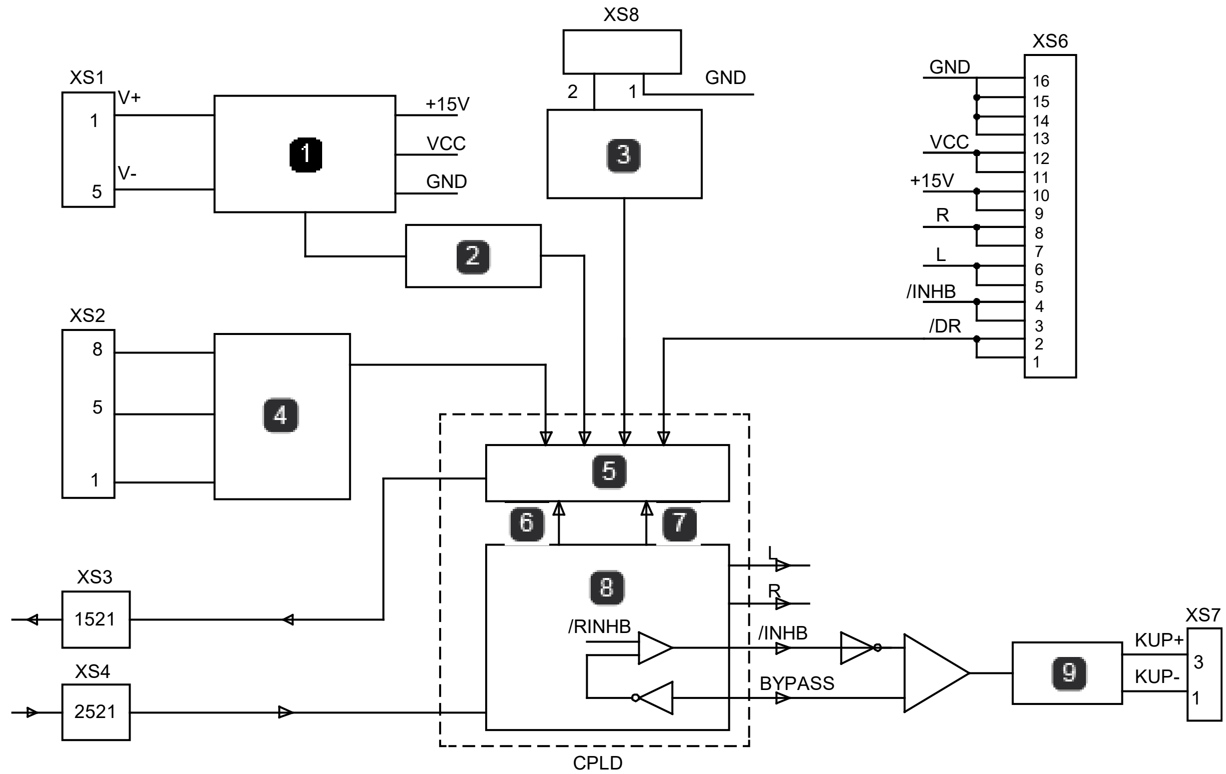
Figure 3-9: Power cell topology



Each power cell has an independent control board and a gate driver board: the control board is connected to the controller by fiber optics. See the power cell description in *Power cell control board principle diagram* on page 37. The cell driver boards are used to drive the IGBTs, see *Power cell driver board principle diagram* on page 38. Because the fibers are the only way the power cell and main controller are connected, it is electrically isolated from the power cells to the main controller.

The power cell control board receives the signal from the main controller through the fiber optics (XS4). After receiving and decoding, the data is used to control the cell IGBTs, bypass IGBT or bypass contactor. The power cell control board has a variety of cell fault detection circuits (such as overtemperature detection, phase loss detection, DC bus overvoltage detection, optical fiber failure detection, drive failure detection, contactor failure detection). After the fault signal is encoded by the controller, it is sent back to the main controller via fiber optic cable (XS3) to provide status feedback.

Figure 3-10: Power cell control board principle diagram



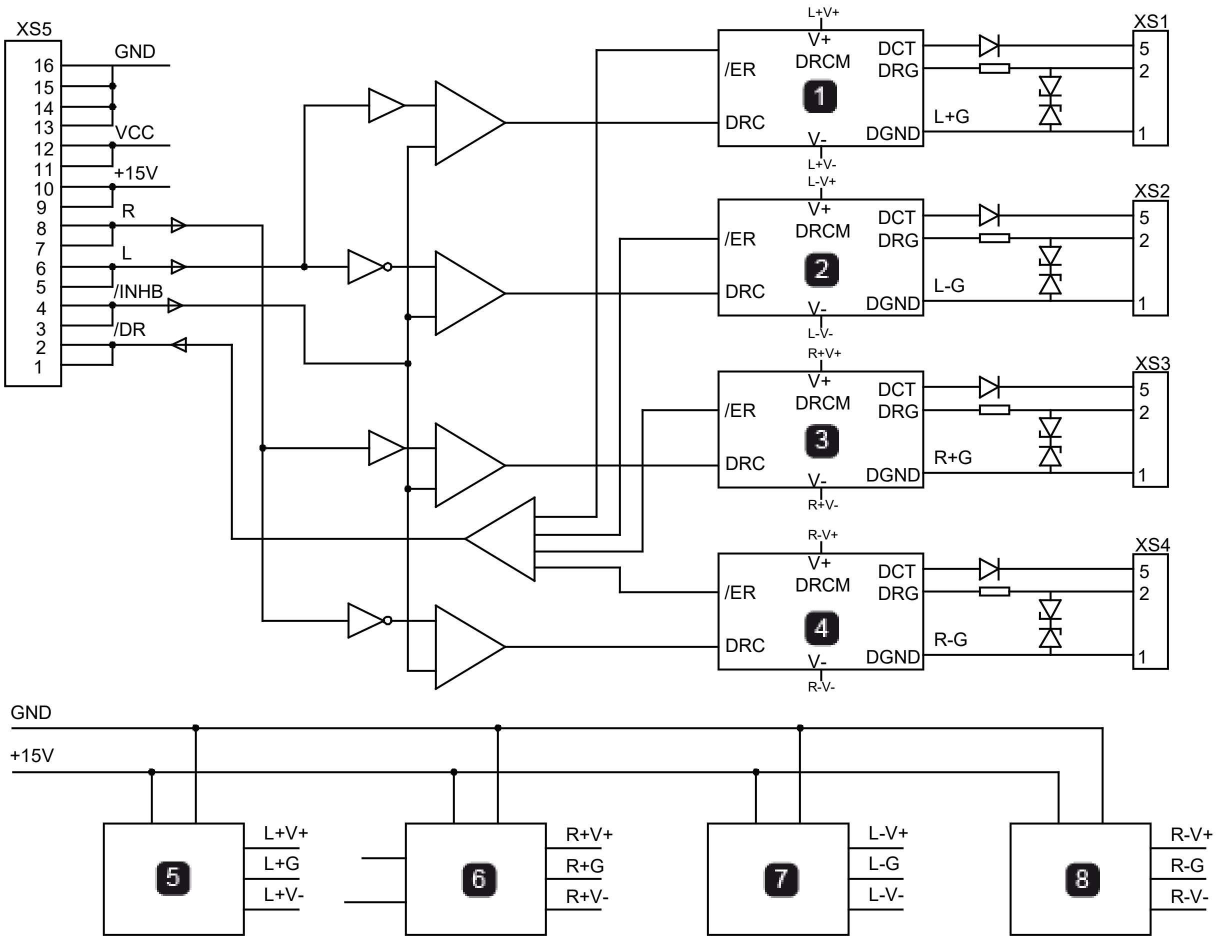
XS1	DC voltage input		**XS3**	Send
1	MV control power		**XS4**	Receive
2	Overvoltage detection (1150 V)		**CPLD**	
XS8	NC		**5**	Fault coding logic
GND	Ground		**6**	Power fault
3	Cell overtemperature detection		**7**	Fiber fault
XS2	AC voltage input ~690 VAC		**8**	Receive decoding
4	Phase loss detection		**9**	Bypass drive

The power supply of the cell control board is taken from the DC bus (through XS1) in the main power cell circuit. The power supply is isolated and stepped down, and the required local control power is obtained. After disconnecting the high voltage power supply, the cell control power does not dissipate immediately (the power indicator on the cell control board will go out after a few minutes).

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

- ‘L’ controls the two IGBTs (Q1, Q2) of the left bridge arm, ‘R’ controls the two IGBTs (Q3, Q4) of the right bridge arm, and the drive signals of ‘Q1, Q2’ and ‘Q3, Q4’ interlock.
- ‘/ INHB’ is the IGBT disable signal, and ‘/ DR’ is the IGBT fault signal, which is fed back to the cell control board for cell protection.
- The cell driver board is powered by the cell control board. The ‘+ 15 V’ power supply is isolated into four separate power supplies for driving each of the four IGBTs.

Figure 3-11: Power cell driver board principle diagram



1~4	Drive control module (#1 to #4)		**5~8**	Isolation power (#1 to #4)

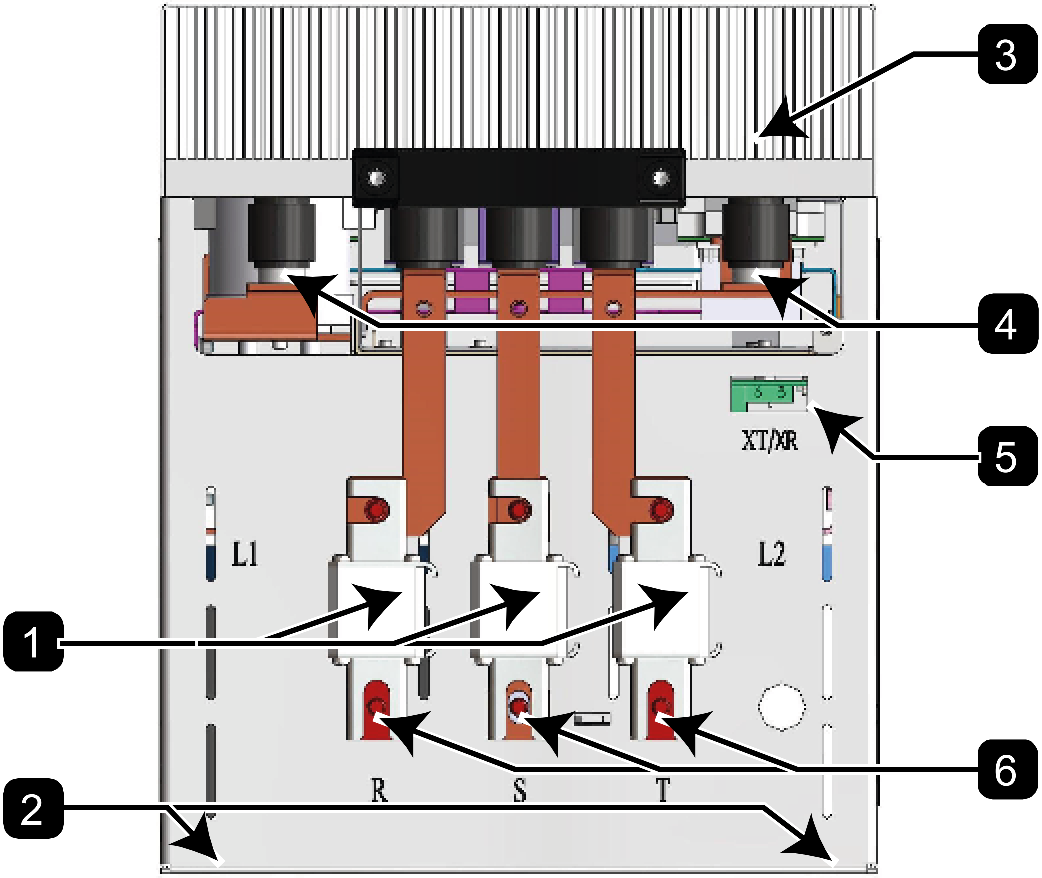
Power cell construction

The power cell (referred to as the cell, for short) is installed in the cell cabinet and mounted on the mounting rail by screws or bolts. The appearance of the power cell is shown in *Typical power cell appearance* on page 39. The cells in the cabinet have identical electrical and mechanical parameters and are interchangeable. The three-phase input of the cell is connected to the secondary winding of the phase-shifting main transformer.

After removing the mounting screws, input cables, output copper bars, and fiber optic connectors of the cell and the guide rail, the cell is completely separated from the cell cabinet and can be removed from the guide rail. The procedure for installing the cell is the reverse of disassembling.

Hazardous voltage still exists in the cell after the VFD is powered off. Therefore, you must wait for the power cell indicator to go out or at least 10 minutes before beginning work on the power cells.

Figure 3-12: Typical power cell appearance



1	Fuses	
2	Power cell mounting points	
3	Heatsink	

4	Power cell output
5	Fiber interface power indication
6	Power cell input

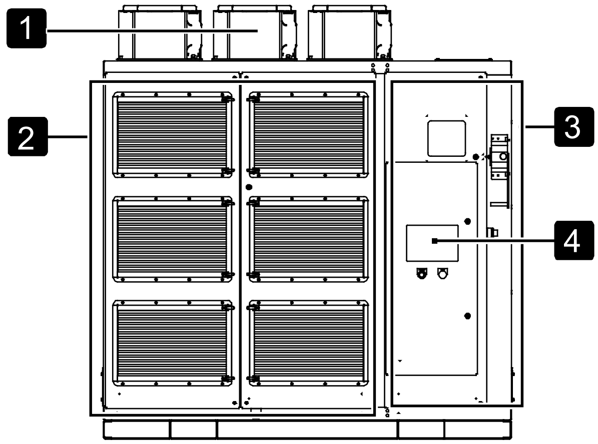
3.6 Cabinet configuration

The VFD is composed of the following parts:

- Transformer cabinet (for lower current VFDs, a transformer will be integrated with the VFD)
- Control/power cell VFD cabinet
- Pre-charge cabinet (required for high current models)
- Disconnect switch cabinet, MV fuses and other parts (for lower current VFDs, these components will be integrated with the VFD)

For smaller VFDs, the transformer, MV fuses and VFD unit are placed in a single compact cabinet.

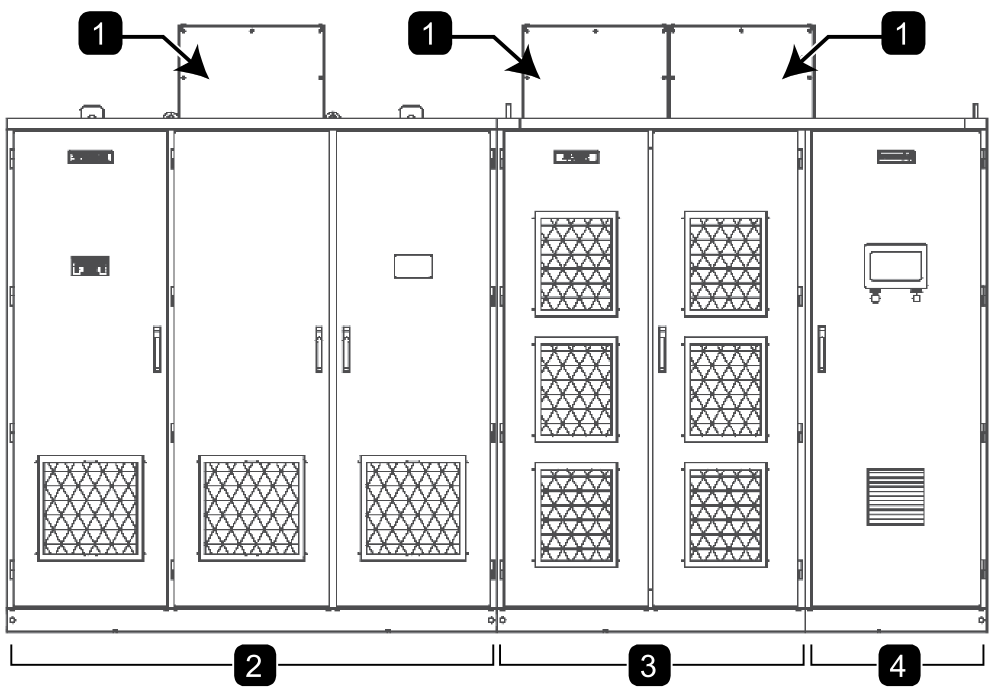
Figure 3-13: Typical integrated cabinet design



1	Cooling fans		**3**	Disconnector cabinet, including fuses
2	Power cell cabinet, including transformer		**4**	Touchscreen

For larger VFDs, the system may include multiple cabinets.

Figure 3-14: Typical non-integrated cabinet design



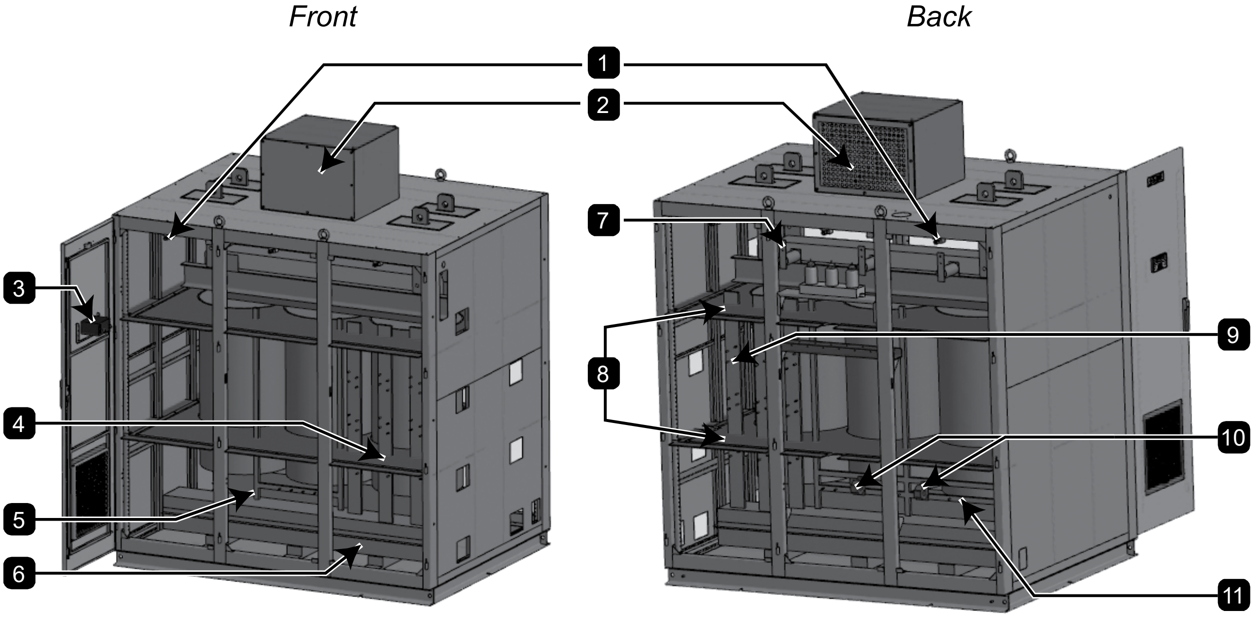
1	Cooling fans		**3**	Power cell cabinet
2	Transformer cabinet		**4**	Control cabinet

Transformer cabinet

The transformer cabinet (if supplied) contains a phase-shifting transformer and its auxiliary components. The typical arrangement in the cabinet is shown in *Typical transformer cabinet layout* on page 41, including:

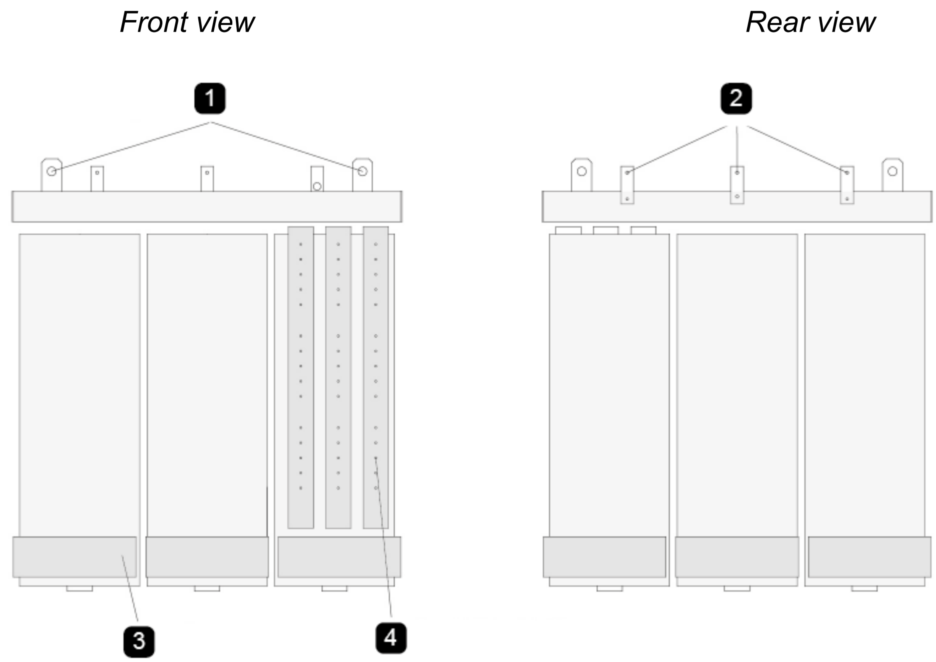
- Phase-shifting transformer
- Cooling fan on the top of the cabinet
- Bottom transformer fan (configured as required)
- Transformer temperature controller
- Current transformers
- Transformer cabinet fan control and protection circuit

Figure 3-15: Typical transformer cabinet layout



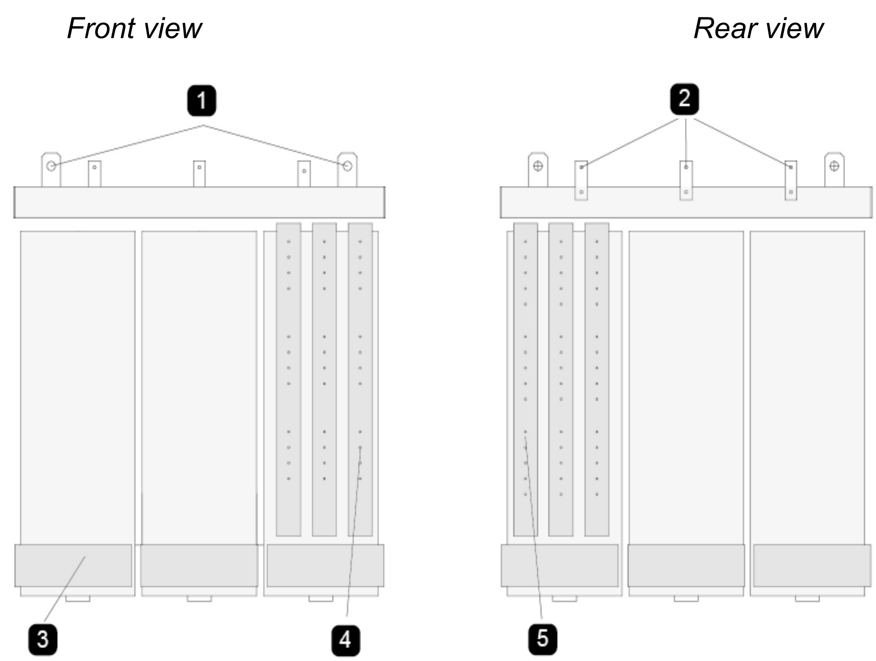
1	Switch		**7**	HV input terminals
2	Top fan		**8**	Air duct baffle
3	Transformer temperature controller		**9**	Secondary connection terminals
4	Secondary terminals		**10**	Current transformers
5	380 V or 480 V 3-phase auxiliary winding		**11**	Primary neutral junction
6	Bottom fan			

Figure 3-16: Transformer lifting brackets



1	Transformer lifting brackets		**3**	6 cooling fans (front and back)
2	Primary input terminals		**4**	Transformer secondary winding terminals

Figure 3-17: Alternate transformer



1	Transformer lifting brackets		**4**	Transformer secondary winding terminals (four phase groups in the front)
2	Primary input terminals		**5**	Transformer secondary winding terminals (five three-phase groups in the back)
3	6 cooling fans (front and back)			

The main component in the cabinet is a phase-shifting transformer, which provides isolated low voltage power for the power cells. Based on the transformer kVA centrifugal fans are installed on the top of the cabinet, and at the same time, six cooling fans can be equipped at the bottom of the transformer, one on both the front and back of each winding. The temperature controller is installed in the cabinet door and has the functions of temperature alarm and overheating protection. There is a door switch inside the cabinet door to monitor the status of the cabinet door.

The transformer is connected to the base with hardware for easy transportation and installation. For overall lifting, you must use the transformer lifting brackets (see *Transformer lifting bracket* on page 43 and *Transformer secondary construction* on page 43).

NOTE

The cabinet rings are only used for lifting the transformer cabinet and cannot be used for lifting the entire lineup.

The three-phase power input to the VFD enters through the bottom of the transformer cabinet or the side and is connected to the primary of the transformer.

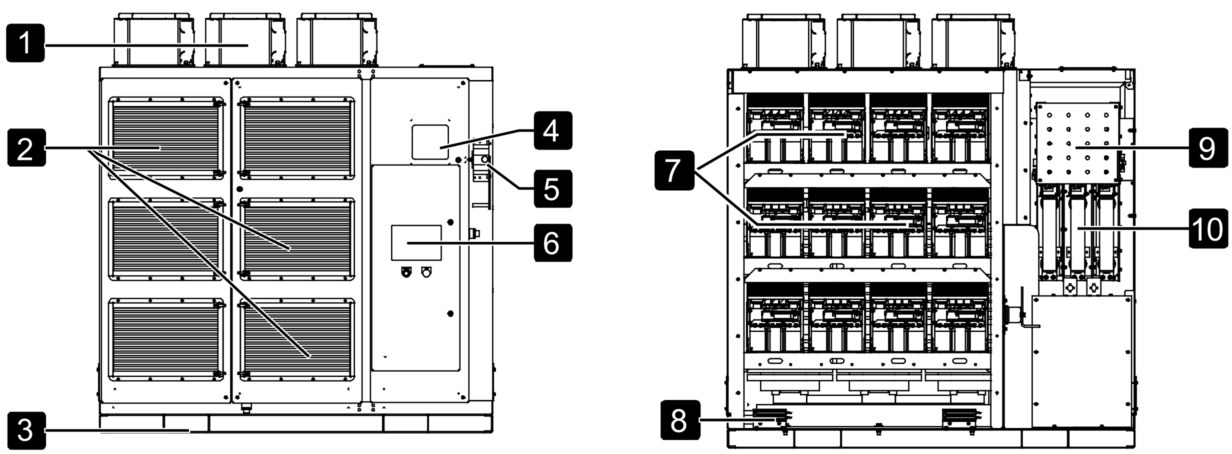
VFD cabinet

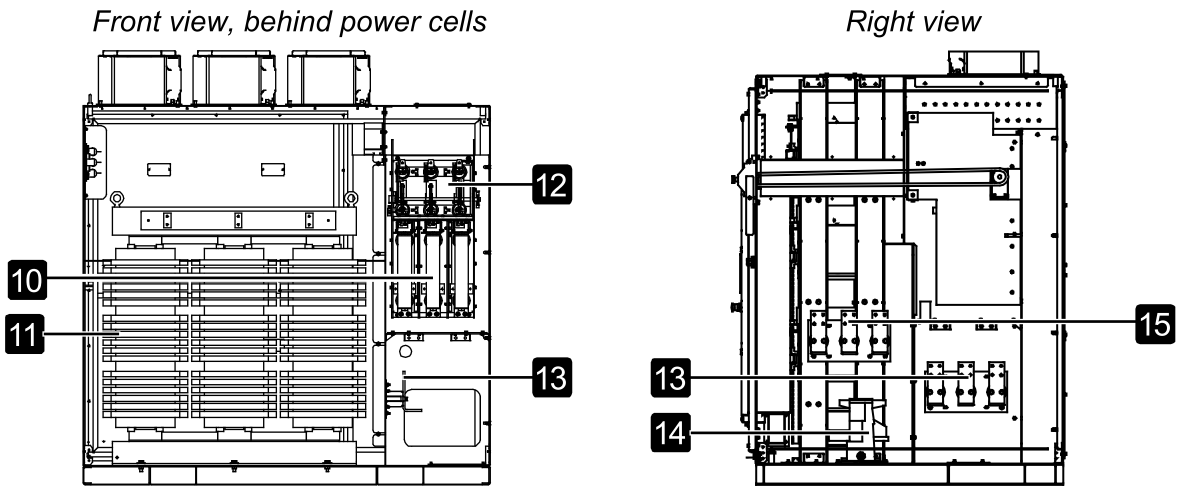
The VFD cabinet contains the control system, power cells, and its auxiliary components. The cabinet contains the following components:

- Main controller
- Interface board
- Touchscreen
- Power cells
- Cabinet heater (optional)
- Power cell voltage detection boards
- Control transformer assembly (optional)
- UPS (optional)
- Output current sensors
- Output voltage detection boards
- Input wiring terminals
- Output wiring terminals
- Cooling fans

Figure 3-18: Typical integrated cabinet layout

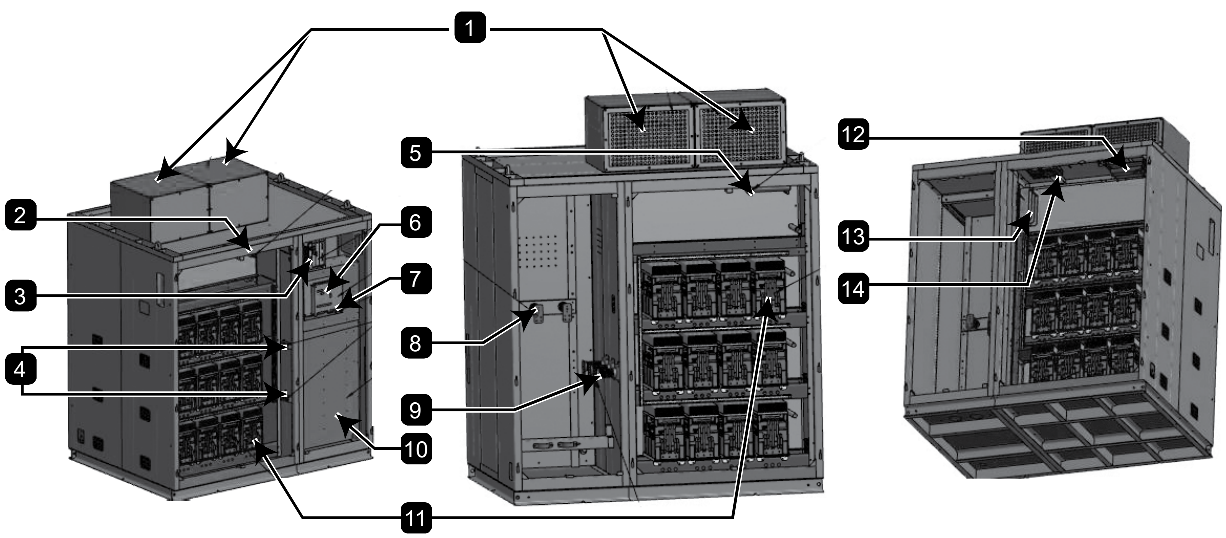
Front view, covers on — *Front view, covers removed*





1	Cooling fans		**9**	Disconnect protective shield
2	Air filters		**10**	Power fuses
3	Lifting holes for forklift or straps		**11**	Main transformer
4	Disconnect viewing window		**12**	Load break disconnect switch
5	Disconnect operating handle		**13**	MV input terminals
6	Touchscreen		**14**	Input vacuum contactor
7	Power cells (x12)		**15**	Motor output terminals
8	Cabinet heaters (optional)			

Figure 3-19: Typical separate VFD cabinet layout



1	Cooling top fan		**8**	Output terminals
2	Door position switch		**9**	Input terminals
3	Controller		**10**	Secondary cable connection board
4	Hall-effect current sensors		**11**	Power cell (x12)
5	Door position switch		**12**	Power cell resistance board
6	I/O board		**13**	Output voltage detection boards
7	Control transformer assembly		**14**	Power cell voltage detection board

- **2.3 and 3.3 kV series**

The power cells in the 2.3 kV and 3.3 kV VFD cabinet are divided into three groups, which are phase A (top), phase B, and phase C (bottom). Taking three series connection cells per phase as an example, each phase cell is arranged from right to left, such as A-phase cell from right to left are A1, A2, and A3. On the front of each cell is the connection to three-phase input power, which is connected to the secondary output of the transformer through semiconductor fuses. A single-phase output is located in the upper end of each cell. Each group of three cells is connected in series by a copper bar to form a phase. The left bridge arm of the three-phase first-stage cell is shorted to form a Y-connected neutral point, and the output of the last-stage cell is connected to the VFD output.

Each power cell is connected to the inner rail of the cabinet by two M8 screws. Cold air passes through the front cabinet door filter layer and flows through the cell heatsinks. The heat generated in each power cell is taken to the rear ventilation duct and directed to the cooling fans on the top of the cabinet. The main transformer is located behind the power cells in the rear of the cabinet.

Filters are installed outside the cabinet door to prevent dust from entering the unit. There is an optional door switch inside the cabinet door, which can be used to enable the cabinet door interlock alarm. The control system is installed inside the low voltage compartment located at the right side of the cabinet, behind the low voltage compartment door. The input and output power terminals are arranged inside the right side of the cabinet and are labeled. The load break disconnect switch, input vacuum contactor and MV power fuses are located at the rear, inside the right side of the cabinet.

- **4.16 KV series**

The 4.16 kV VFD series is functionally and mechanically identical to the 2.3 and 3.3 kV series with the exception that there is one additional cell per phase to accommodate the additional output voltage.

- **6 kV series**

The power cells in the 6 kV cell cabinet are divided into three groups from top to bottom, which are phase A, phase B, and phase C. Taking five series connection cells per phase as an example, each phase cell is arranged from right to left, such as A-phase cell from right to left are A1, A2, A3, A4, A5. On the lower end of each cell is the connection to three-phase input power, which is connected to the secondary output of the transformer through a semiconductor fuse. A single-phase output is located in the upper end of each cell. Each group of five cells is connected in series by a copper bar to form a phase. The left bridge arm of the three-phase first-stage cell is shorted to form a Y-connected neutral point, and the output of the last-stage cell is connected to the VFD output.

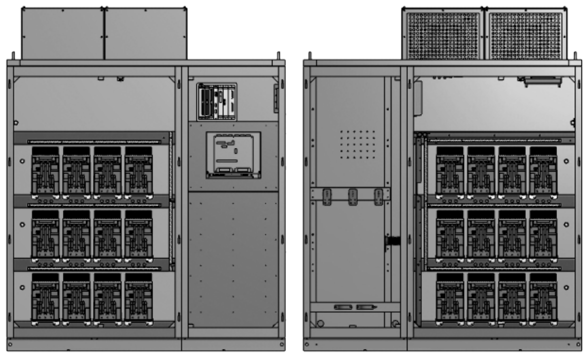
Each power cell is connected to the inner rail of the cabinet by two M8 screws. At the rear of the power cell cabinet is a ventilation duct. Cold air passes through the front cabinet door filter layer and flows through the cell heatsinks. The heat generated in each power cell is taken to the rear ventilation duct and directed to the cooling fans on the top of the cabinet.

Filters are installed outside the cabinet door to prevent dust from entering the unit. There is an optional door switch inside the cabinet door, which can be used to enable the cabinet door interlock alarm. The control system is installed on the right side of the back of the cabinet, with the controller above the interface board. The power switch and user wiring terminal are arranged on the right side of the back, and the VFD output terminals are arranged in the left side baffle on the back of the transformer cabinet.

- **11 kV series**

Figure 3-20: 11 kV power cell cabinet arrangement - Standard cabinet

Front view *Rear view*



Taking a single-phase of nine cells in series as an example, in order to reduce the width of the cabinet, the cells are arranged two deep, front to back (see *11 kV power cell cabinet arrangement - Standard cabinet* on page 46). The first four cells of each phase are located on the front of the cabinet. For example, phase A is arranged from right to left as A1, A2, A3, and A4. The control panel on the front right side is equipped with controllers, power supplies, switches, etc. At the back of the cabinet are the remaining five units of each phase, which are also arranged from right to left, such as phase A is A5, A6, A7, A8, and A9. The left bridge arm of the three-phase first-level unit is shorted to form a Y-connected neutral point, and the output of the ninth level unit is connected to the VFD output. The structural configuration is similar to that of the 6 kV series.

Pre-charge system

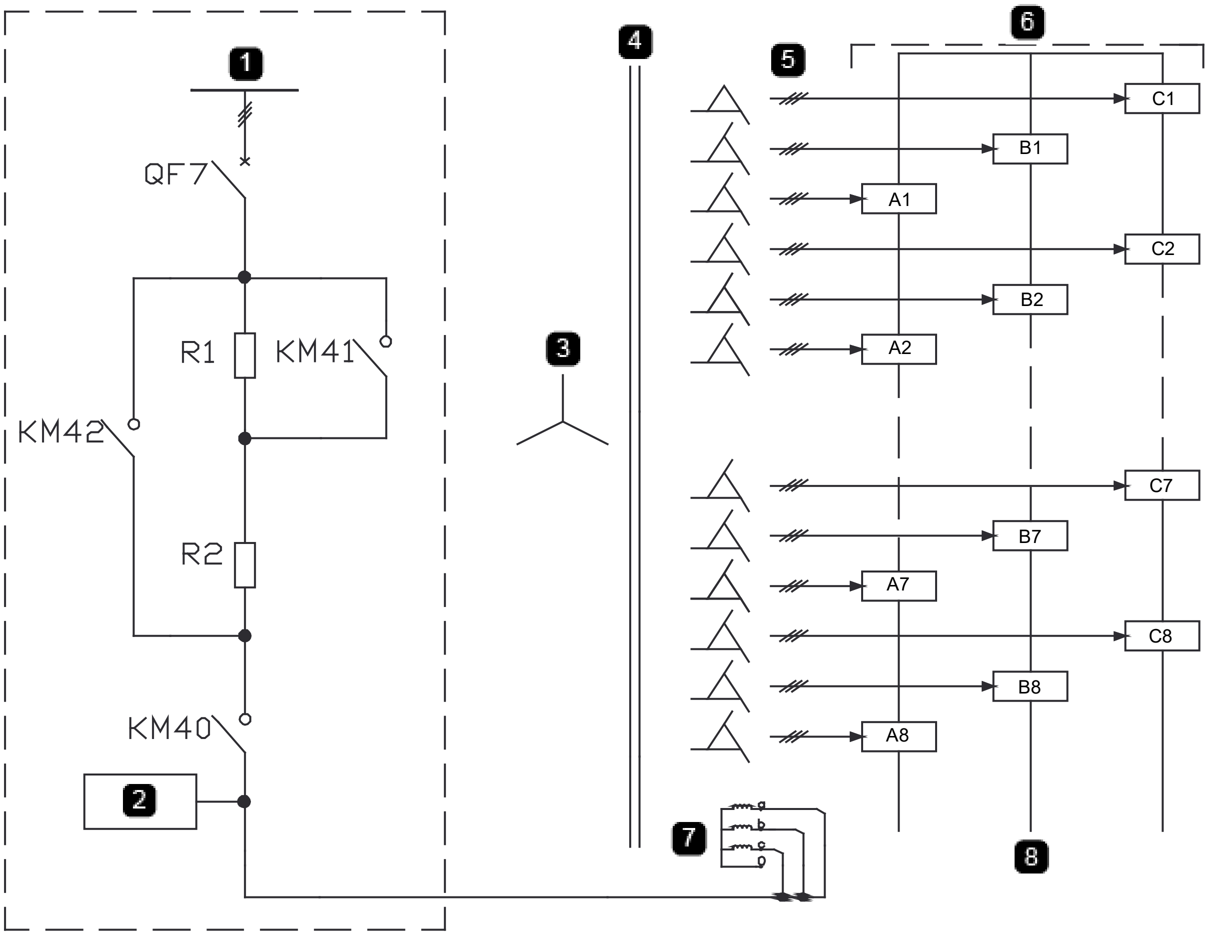
When the VFD requires power cells greater than 250 A, a pre-charging system is required. The pre-charge system has two working modes: pre-charge and cell detection.

Pre-charge mode: Used to pre-charge the capacitor of the power cell. By switching the number of current limiting resistors connected to the charging circuit, the power cell can be charged in three stages. The closing permission signal is typically issued after charging for 3.5 seconds, allowing the upstream medium voltage switchgear to close.

Cell detection mode: Used for cell self-test. The charging process is the same as the pre-charge mode, the only difference is that the third stage of charging will continue until the user presses the **MV BREAK** pushbutton on the cabinet to stop.

The pre-charging system is installed inside the VFD, and the power, resistance value, and quantity of resistors match the specifications of the VFD. The pre-charge primary circuit is shown in *Pre-charge system primary circuit diagram* on page 47.

Figure 3-21: Pre-charge system primary circuit diagram



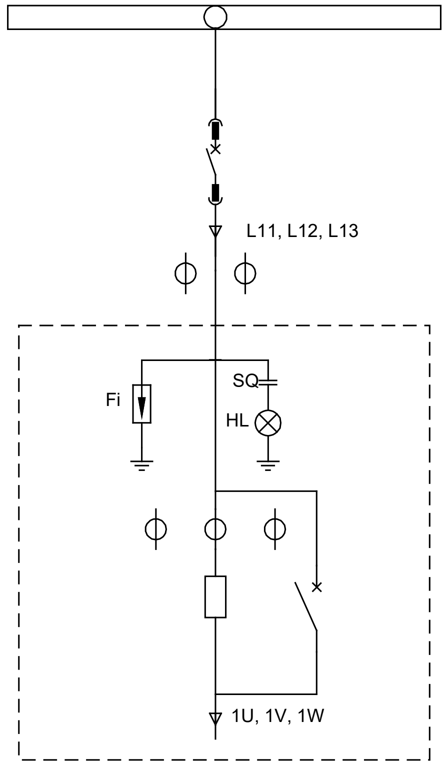
1	User three-phase nominal control voltage. Check system drawings for input voltage.		**5**	Transformer secondary winding
2	Voltage detection		**6**	Cells
3	11 kV transformer MV on input side		**7**	380 V or 480 V auxiliary winding
4	Phase-shifting transformers		**8**	VFD output

The pre-charge input side is connected to the 380 V or 480 V power supply, and the output side is connected to the auxiliary winding of the phase-shifting transformer. The output voltage of the pre-charging cabinet changes with the number of pre-charging resistors switched, and the secondary winding of the transformer will induce the corresponding voltage to charge the DC capacitor of the power cell.

Startup cabinet (optional)

Due to the magnetizing inrush current of the phase-shifting transformer, a large inrush current can occur whenever a large VFD is powered on. The startup cabinet can be configured to suppress the power surge current. The schematic of the startup cabinet is shown in *Starter cabinet primary circuit* on page 48. The width of the startup cabinet is typically 45-48 in (1.2 meters), which is installed on the left side of the VFD. The power, impedance value, and quantity of the inductors match the specifications of the VFD.

Figure 3-22: Starter cabinet primary circuit



Switchgear (optional)

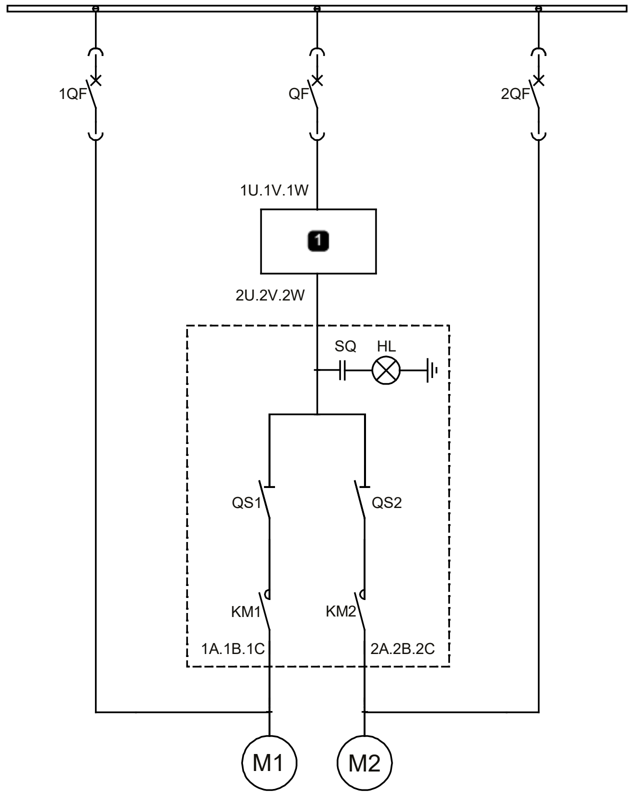
In practical applications, switchgear and VFDs are often used together. Switchgear cabinets are divided into bypass cabinets and line connection cabinets, where used in synchronous transfer applications.

- **Switch cabinet (multiple motor applications)**

The switch cabinet is suitable for one VFD and two motors. This method can be used when the application typically has one motor in use and one backup motor, or two motors with similar working conditions, improving the VFD utilization rate.

QS1 and QS2 in the automatic switch cabinet have no mechanical interlock, while KM1 and KM2, KM1 and 1QF, and KM2 and 2QF are electrically interlocked (see *Auto-switch cabinet single line diagram* on page 49).

Figure 3-23: Auto-switch cabinet single line diagram



1	VFD

NOTE

During operation of the VFD, **DO NOT** switch the output contactor.

- If you need to bypass the VFD to perform a DOL start, use a bypass cabinet.
- If you need to start multiple motors with the same VFD before bypassing them, use a synchronous transfer system. In this case, ensure that the normally closed contact of the VFD's operation signal is connected to the KM1 and KM2 opening circuits. This is to avoid operating errors which can cause damage to the power cells.

3.7 Selection of cable

Selection of power cable

The selection of power cables must be in strict accordance with the following requirements:

- Current capacity
- Cable manufacturer specifications
- Installation and routing method
- Voltage drop due to cable length, must be sized for less than 3% voltage drop
- Specifications for the power industry
- Compliance with EMC regulations
- Local electrical codes

NOTE

- Shielded cable is recommended use between the VFD and the motor.
- If the cable shields are too thin (i.e., the whole cross-sectional area of the cable shielding layer is less than 50% of the cross-sectional area of a single-phase conductor), a separate ground cable is needed to prevent overheating of the shield and also to prevent a difference in ground potential between the ends of the cables.
- Cross-sectional area of grounding cables should be larger than 0.6 sq in (16 mm^2) #4 AWG.

Selection of control, signal and communication cable

Recommended control, signal and communication wire:

- Analog input and output cables: select shielded twisted pair, cross-section 0.06~0.1 sq in (1.5~2.5 mm^2) (#14-16 AWG)
- Digital input and output cables: choose shielded twisted pair, cross-section 0.02~0.06 sq in (0.5~1.5 mm^2) (#16-20 AWG)
- Communication cables: Use professional communication cable required by related communication protocols or shielded twisted pair, cross-section 0.02~0.06 sq in (0.5~1.5 mm^2) (#16-20 AWG)

NOTE

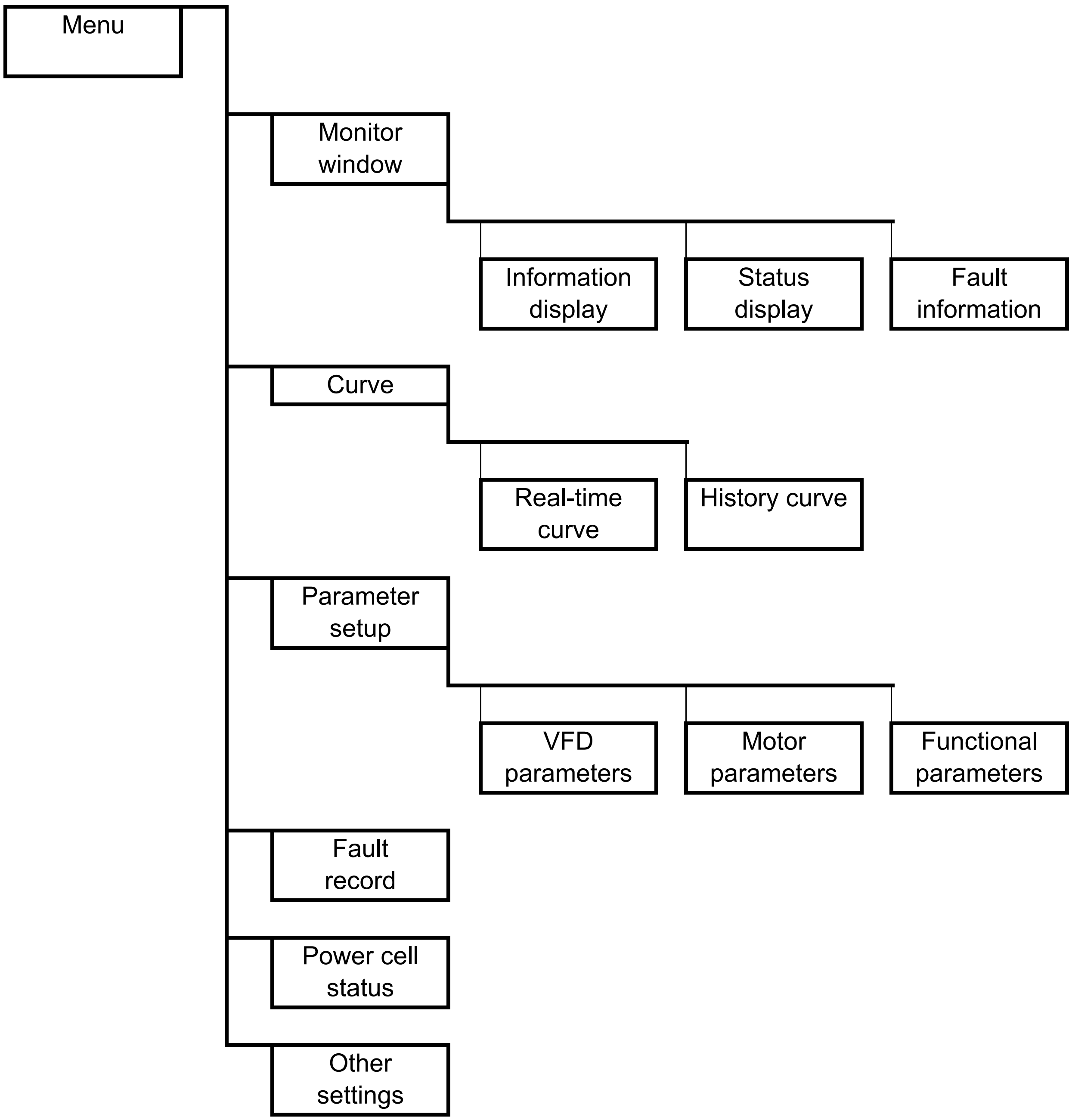
- High quality single shielded twisted pair wire or multiple shielded twisted pair wire should be used for control, signal and communication wiring.
- Control, signal, communication wires, and power wires and cables should all be routed separately in different cable channels, conduits or ducts. If cables must be mixed while routing, the distance between the signal wires and power cables should be greater than 12 inches (30 cm).
- Power wires or ground wires must not share a common shielded wire or ground connection with signal wires.
- Cables for different kinds of signals must not be routed together.
- Cable shield must connect to ground at a single location (star type ground configuration). Signal shields must be connected to the terminals in the low voltage compartment. Power wire shields must be connected to the cabinet ground bus bar. Shield wiring to ground terminal distance must be as short as possible.

4. HMI

The touchscreen is the interface used for parameter setting and information feedback.

The touchscreen is installed on the front of the cabinet door of the VFD or in a remote touchscreen cabinet and can be used to perform parameter setting, observe operation status, and for reading displayed data. The block diagram of the window menu is shown in *Block diagram of the window menu* on page 51.

Figure 4-1: Block diagram of the window menu



4.1 Touchscreen operation and display instructions

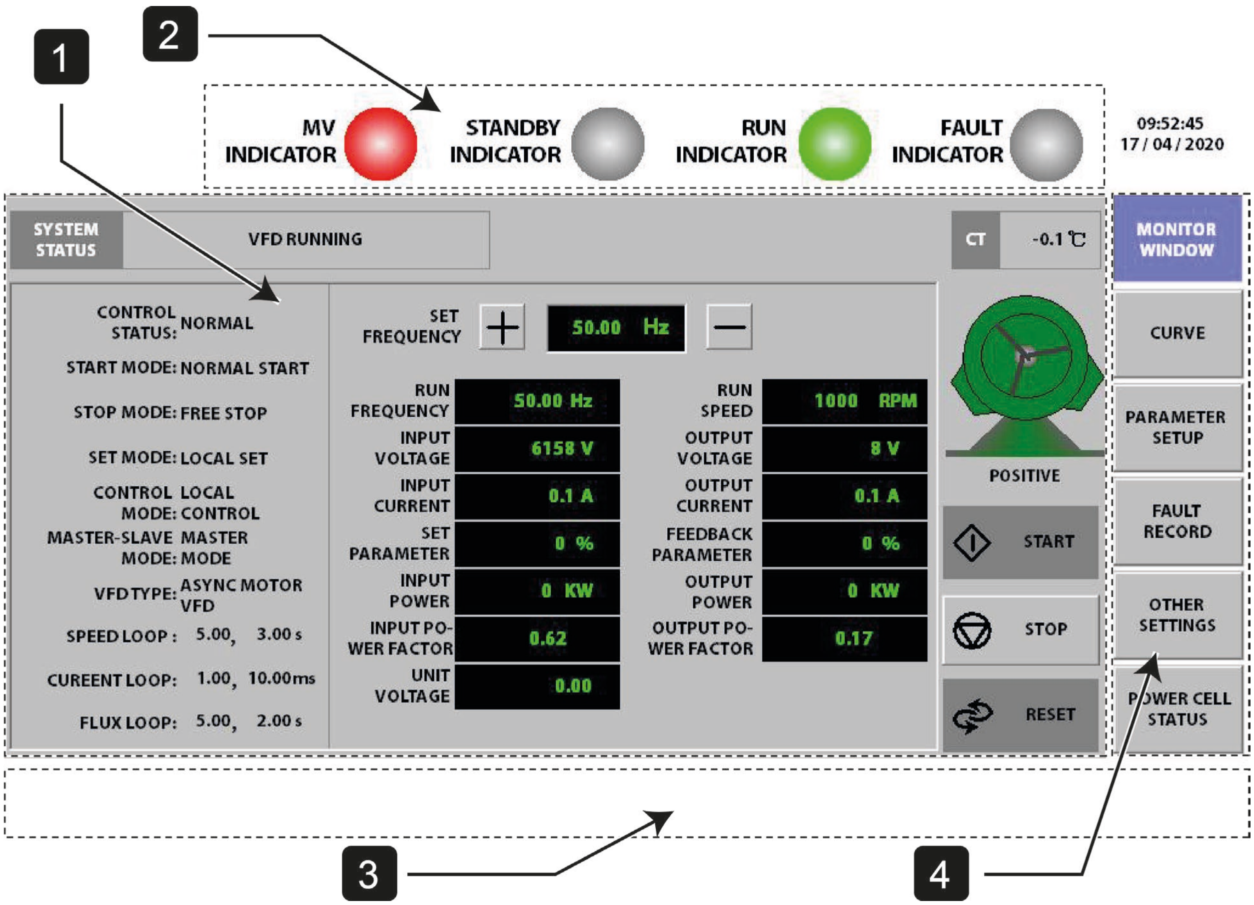
Select the language of the touchscreen: English (default), Chinese, French, German, Russian or Spanish.

Monitoring interface

The startup display is the monitoring interface by default, which can be divided into four areas (see *Monitoring interface* on page 52):

- Information display
- Status indication
- Fault information display
- window menu selection

Figure 4-2: Monitoring interface



1	Information display	**3**	Fault information display
2	Status indication	**4**	Display window selectors

The description of each area is as follows:

Table 4-1: Monitoring interface area description

Area	Description
Information display	Main display area, including key parameter display, VFD running status, VFD start-stop control, etc.

Area	Description
Status indication	• Medium voltage indicator: The indicator is on when VFD medium voltage is ready (Red) • Standby indicator: The indicator is on when system is ready (Green) • Run indicator: The indicator is on when VFD is running (Green) • Fault indicator: The indicator is on when a fault occurs (Red); the indicator flashes when an alarm occurs (Red).
Fault information display	When the system is faulted, this area appears red. When an alarm occurs in the system, this area appears yellow.
Display window selectors	By clicking the **MENU** button of each window, the content of the information display area changes to the appropriate window selection.

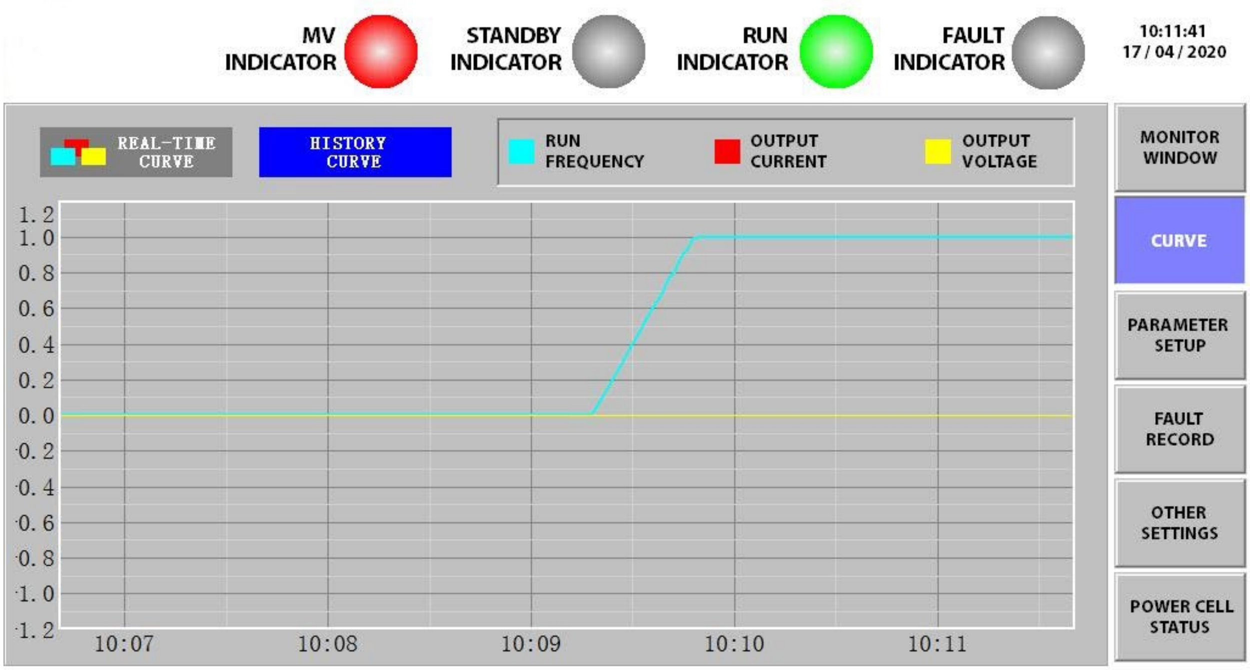
Trend curve

The trend curve is used to display the variable curves of the VFD. It is divided into real-time curve and historical curve. All variables are standard values.

- **Real-time curve**

Real-time display of the VFD's operating frequency, output current, output voltage, and other variables, the data is sampled at 100 ms. Each screen can display a waveform of 300 seconds in length (see *Real-time curve* on page 53).

Figure 4-3: Real-time curve



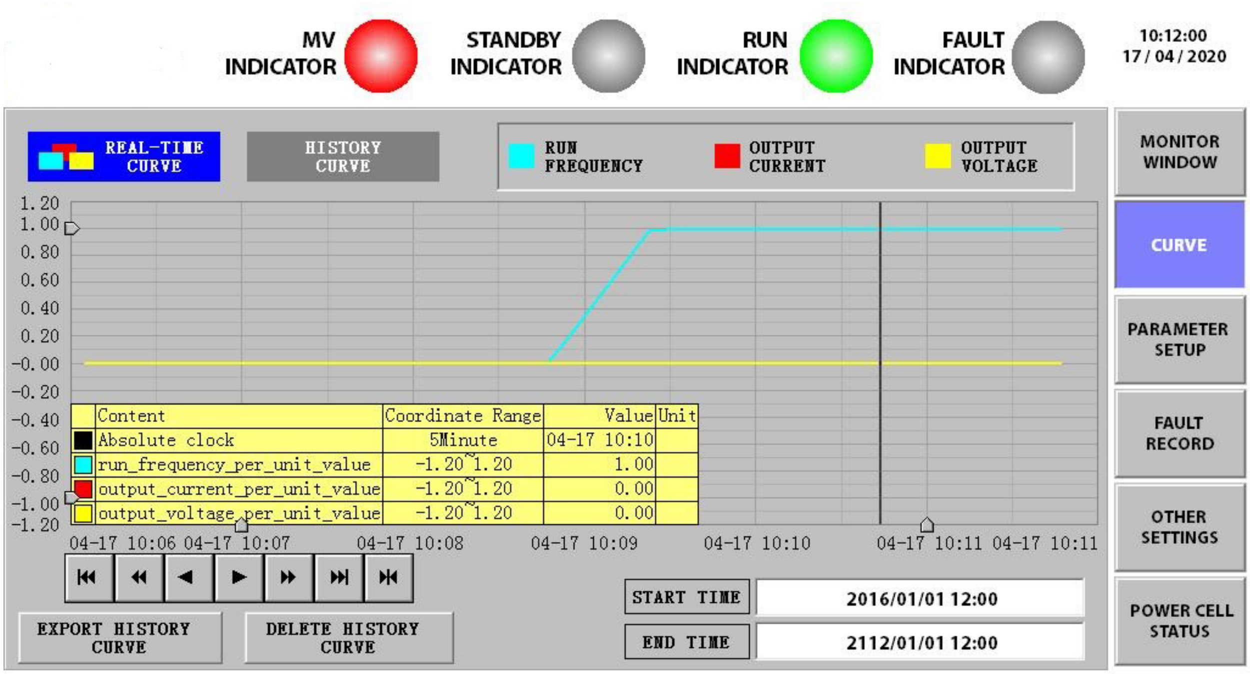
- **Historical curve**

Displays the output data of the VFD within the last 30 days. The curve data collection cycle is 5 seconds. Each screen can display the variable waveform of 300 seconds (see *Historical curve* on page 54). Save and delete historical curves by using the **EXPORT HISTORY CURVE** and **DELETE HISTORY CURVE** buttons.

If you want to query the historical records of a certain time period, you can use one of the following two methods:

- Directly adjust the arrow button positioning.
- Click on , set positioning time for quick query.

Figure 4-4: Historical curve

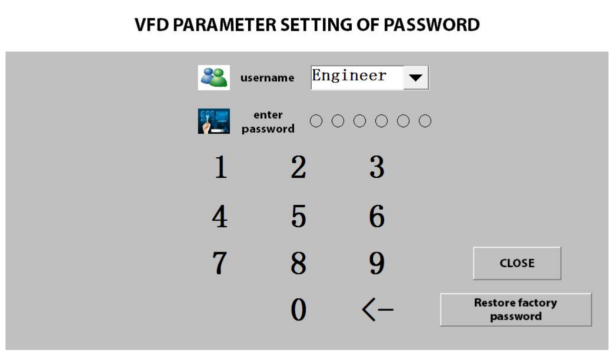


Parameter setting

The parameters that can be set are divided into three categories: VFD parameters, motor parameters, and function parameters. There are seven pages in total. See *Parameter description* on page 62 for detailed parameter descriptions.

The first time you enter the ‘Parameter setting’ window you will need to log in (see *Parameter setting login window* on page 54).

Figure 4-5: Parameter setting login window



The user password and permissions are shown in *List of user password permissions* on page 55.

Table 4-2: List of user password permissions

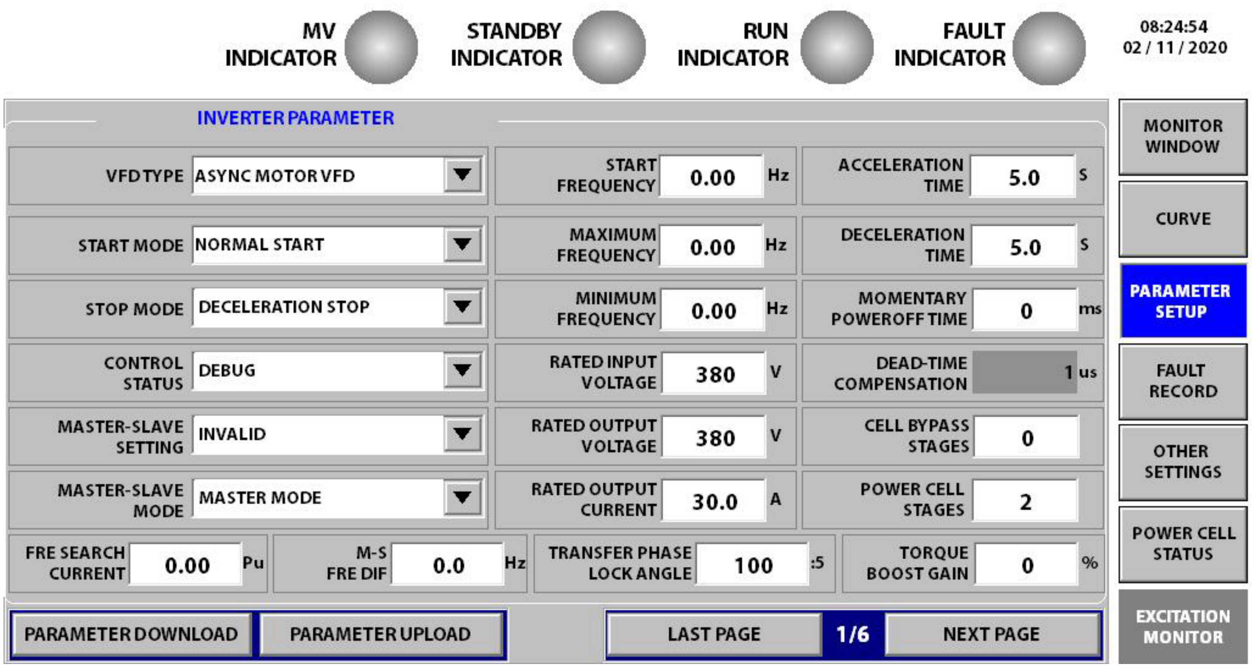
User	Rank	Password (6 digits)	Permission
Engineer	High	300048	All parameters
Operator	Low	123456 (initial password)	Selected parameters

NOTE

If there is no operation of the touchscreen within 10 minutes after login, the screen will time out and the parameter settings will be automatically locked.

After successfully logging in, you can perform parameter setting operations (see *Parameter setting window* on page 55).

Figure 4-6: Parameter setting window



There are three operations for parameter setting: **PARAMETER UPLOAD**, **PARAMETER DOWNLOAD**, and **RESTORE TO DEFAULT**. The function buttons are described in *Function button description* on page 55.

Table 4-3: Function button description

Function button	Description
RESTORE TO DEFAULT	All parameters are restored to factory settings. Note: To activate this button, you must set *Restore to default* to 'Enable'.
PARAMETER UPLOAD	Upload parameter values from the controller to the PLC and transfer values to the touchscreen.
PARAMETER DOWNLOAD	Transfer the parameter values of the touchscreen to the PLC and download to the controller.

NOTE

After changing each parameter value on the touchscreen, press **PARAMETER DOWNLOAD** to store the new value to the PLC and main controller. Before continuing, ensure that you get a confirmation message on the HMI. If not, the parameter will not be stored.

If the **PARAMETER DOWNLOAD** button doesn't appear on the current page, change to another parameter page.

Fault record

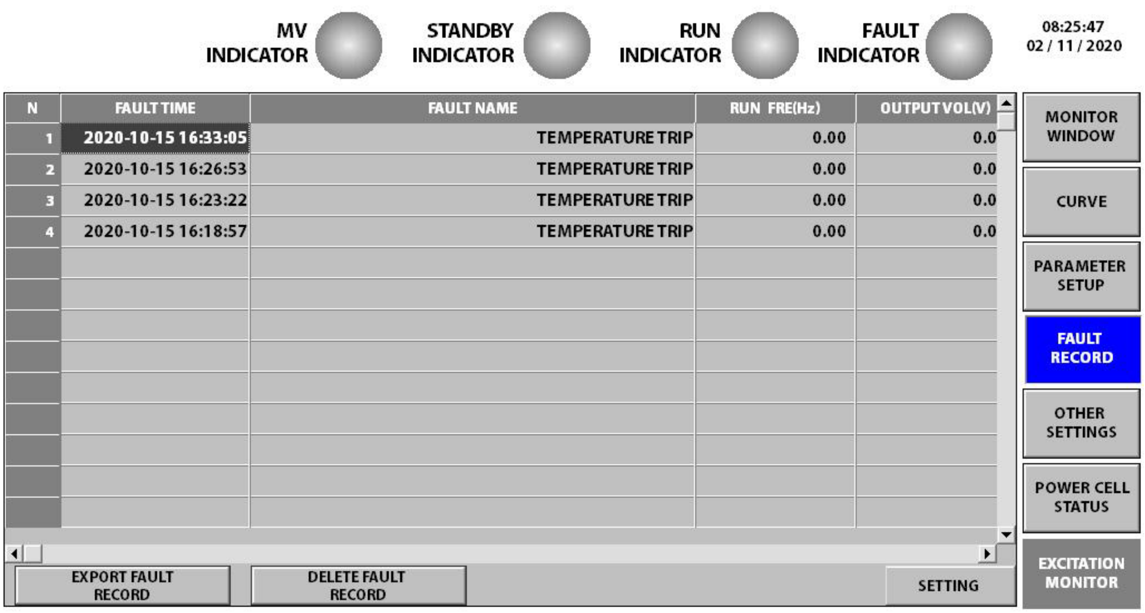
The fault record logs fault information that occurs when the VFD trips.

Through the **SETTING** button, you can quickly locate historical fault information (see *Fault record interface* on page 56).

With the **EXPORT EVENT RECORD** and **DELETE EVENT RECORD** buttons, you can save and delete historical data.

When the fault log is full, the oldest data will be overwritten.

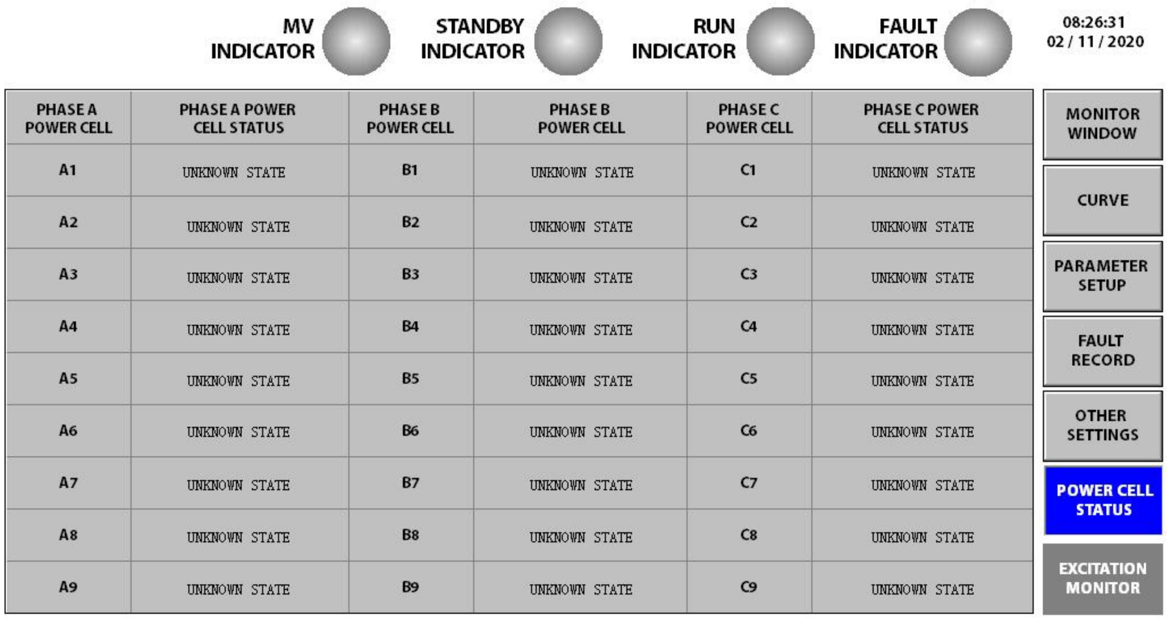
Figure 4-7: Fault record interface



Power cell status

The power cell status interface shows the real-time status of all power cells (see *Power cell status display interface* on page 57).

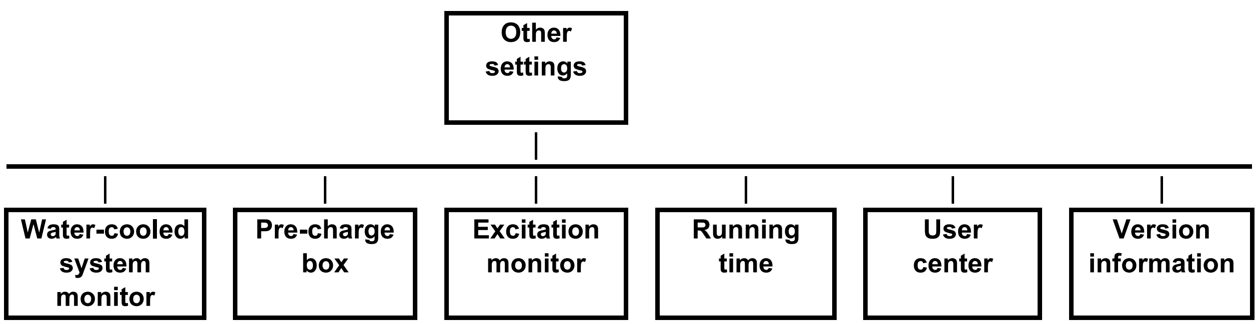
Figure 4-8: Power cell status display interface



Other settings

The 'Other settings' window interface structure is shown below:

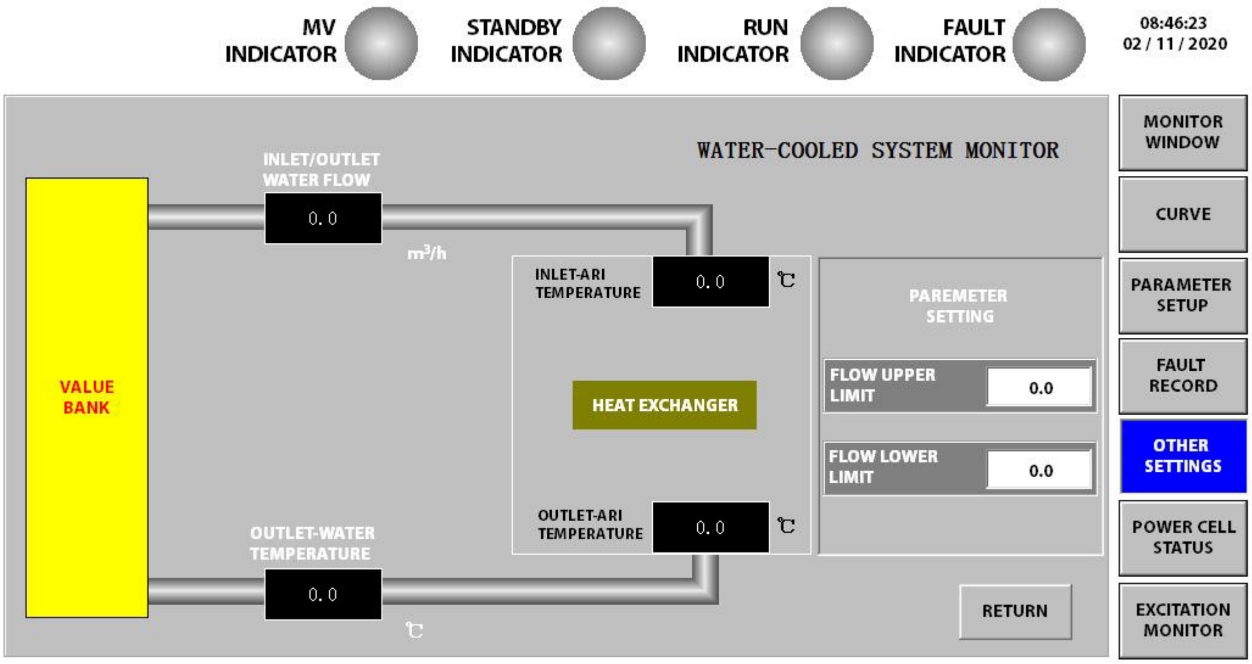
Figure 4-9: Other settings window function topology



- **Water-cooled system**

Applicable to water-cooled VFDs only. The touchscreen can monitor the temperature of the inlet and outlet air of the heat exchanger and the flow of the inlet and outlet water of the radiator in real-time (see *Water-cooled system monitor display interface* on page 58).

Figure 4-10: Water-cooled system monitor display interface



- **Pre-charge system**

The pre-charge function and pre-charge window on the touchscreen are only available if the VFD is equipped with a pre-charge system. If a pre-charge system is available, this information is displayed in the 'System status' field. The pre-charge process can be used to pre-energize the VFD or the power cells. This process is controlled and monitored through the pre-charging interface (see Figure 4-11) as follows:

Prerequisite: The touchscreen and the pre-charge system must detect a communication link between each other.

1. Click the **PARAMETER RESTORATION** button to complete the parameter setting and adjust the corresponding parameters according to the specific conditions.
2. Click the **SOFT START** button to launch a pre-charge operation. The pre-charge box will soft start and pre-energize the VFD before the line voltage is connected to the input terminals.

   Alternatively, click **POWER UNIT DETECTION** to perform a power cell detection operation. This function is similar to "pre-charge". It will energize the power cells and keep them energized via the 380~480 V control power, without switching the MV, for a limited period of time.

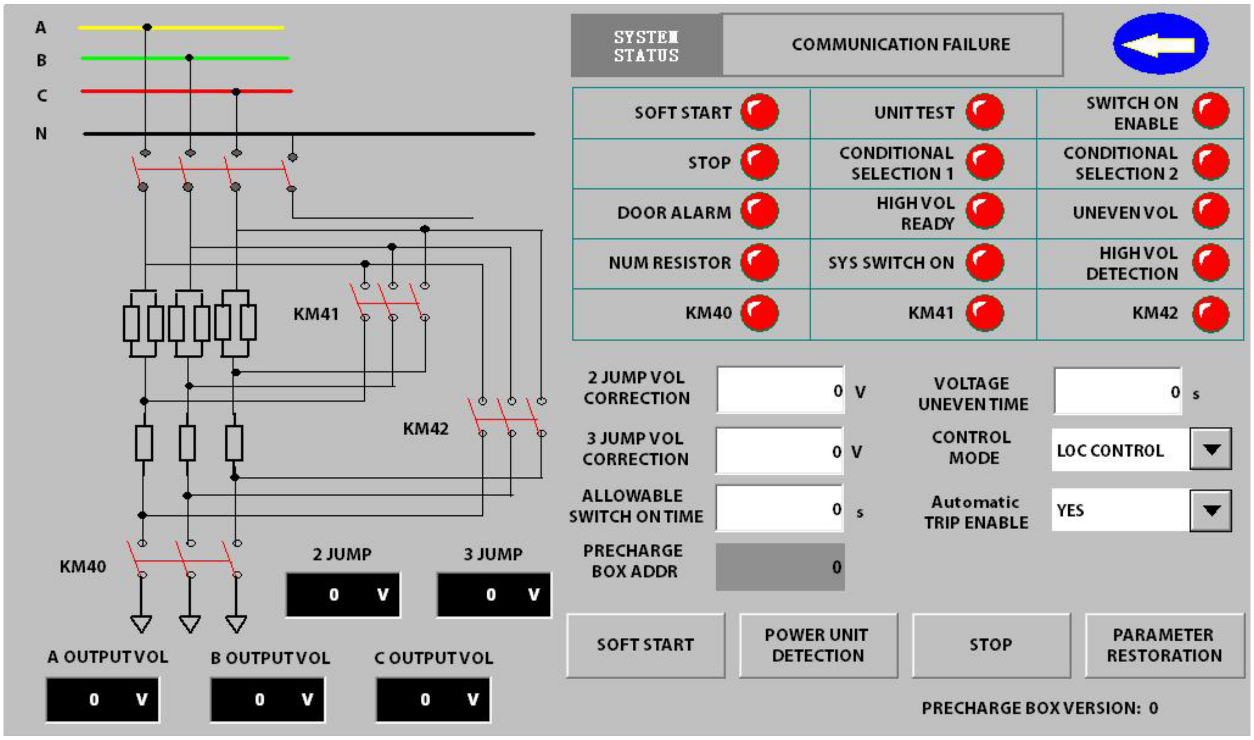
   If you want to stop the operation, click **STOP**.

NOTE

If the pre-charge fails, find the cause and clear the condition, then wait for five minutes before performing another pre-charge.

For detailed description of the pre-charging function, see the *Pre-charge Box Instructions*.

Figure 4-11: Pre-charging display



- **Synchronous motor field control**

When the VFD is used for synchronous motors, excitation adjustment is provided. This provides the following 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.

This interface is divided into three areas: excitation status, excitation options, and excitation parameter settings (see Table 4-4 and Figure 4-12).

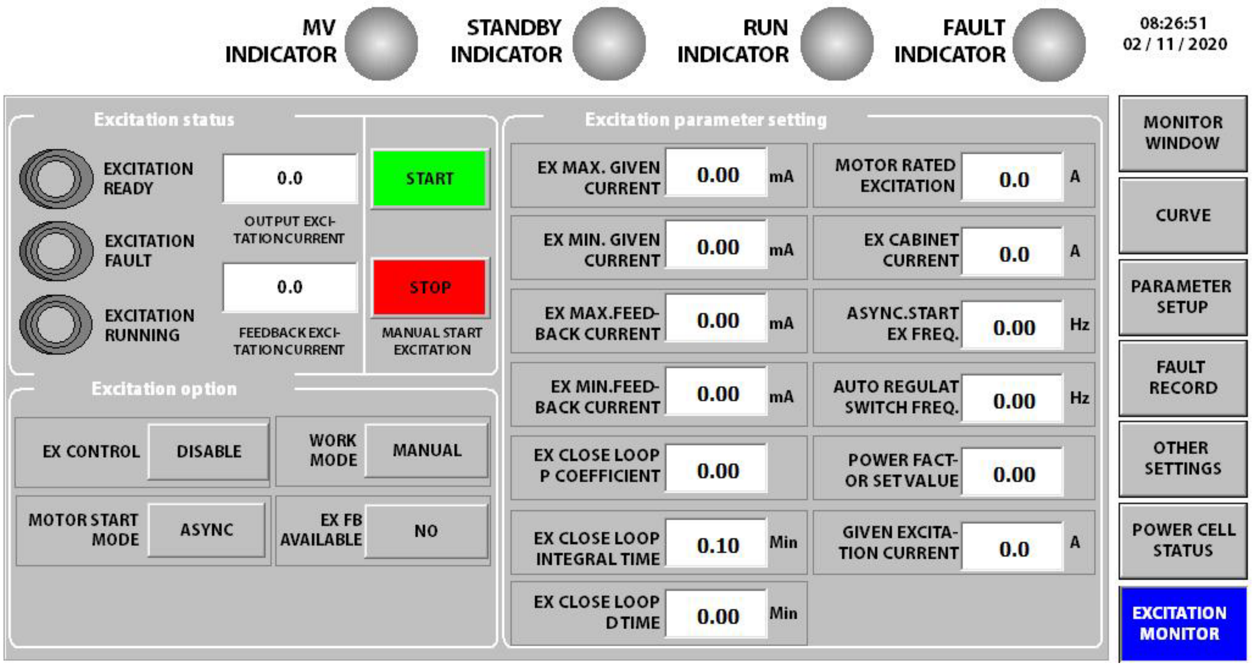
Table 4-4: Explanation of excitation adjustment function module

Function module	Description
Excitation status	Process status display and start-stop control
Excitation option	Startup mode and working mode configuration
Excitation parameter setting	Basic parameter and control parameter configuration

NOTE

For detailed description of the excitation adjustment function, see the *Excitation Adjustment Instructions*.

Figure 4-12: Excitation adjustment display interface

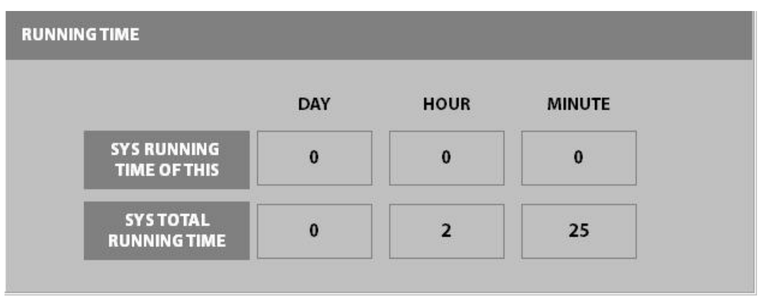


- **Motor running time**

The current motor running time of the system: the current motor running time of the system

Cumulative motor running time of the system: Cumulative motor running time since leaving the factory

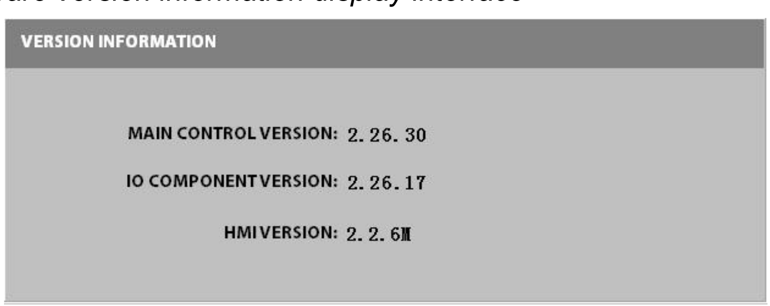
Figure 4-13: Running time feedback



- **Version information**

Once parameters are uploaded, this interface can display the software version of the control system. You can use it to check the drive's software version and whether the software versions match (see *Software version information display interface* on page 60).

Figure 4-14: Software version information display interface



NOTE

At the time of this manual release the most current software versions were:

- Main control version: 2.26.32
- IO component version: 2.26.32
- HMI version: 2.2.32M

- **User center**

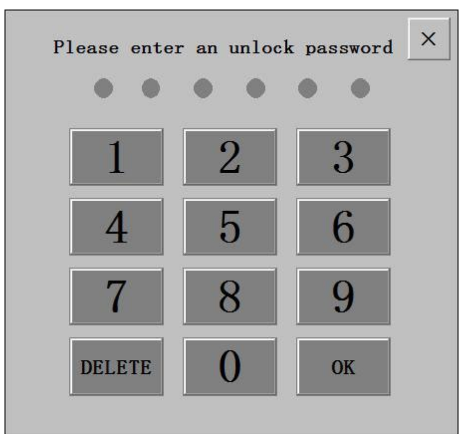
Screen saver setting: used to set whether to enable the screen saver and the delay before the screen saver becomes active. This function is enabled (range: 120-1600 seconds, see *Screen saver setting LCD display interface* on page 61).

Figure 4-15: Screen saver setting LCD display interface

- Password setting

Used to reset the login password (see *Password setting window* on page 61). After entering the unlock password, you can set a new password.

Figure 4-16: Password setting window



- Time information

The time setting information is updated simultaneously in the time display area in the upper right corner.

5. Parameter description

5.1 VFD parameters 1

VFD Type

Sets the control method of the VFD.

- For applications with less demanding loads, such as fan or pump loads, select 'Async motor VFD' or 'Async motor SVC'.
- For applications with one master and multiple slave drives, select 'Async motor VFD' or 'Async motor SVC'.
- For applications with high performance transient requirements, select sensorless vector control.
- For applications needing precise speed control, select vector control or encoder type.

Options:

Async motor VFD (V/Hz) (default)	Asynchronous motor unsensored V/Hz default operation
Async motor SVC	Asynchronous motor sensored vector control, with encoder feedback
Sync motor VFD (V/Hz)	Synchronous motor unsensored V/Hz operation
Sync motor SVC	Synchronous motor sensored vector control, with encoder feedback
Async sensorless VC	Asynchronous motor sensorless vector control (no encoder feedback)
Sync sensorless VC	Synchronous motor sensorless vector control (no encoder feedback)
Brushless DC sync motor VFD (V/Hz)	Brushless synchronous motor unsensored V/Hz operation
Permanent magnet sync motor VFD (V/Hz)	Permanent magnet motor unsensored V/Hz operation

Start Mode

Sets the start mode.

Options:

Normal start (default)	The VFD accelerates from *Start frequency* to *Motor rated frequency* according to the acceleration time curve. For synchronous motors, the drive will output in high torque mode at startup and switch to V/Hz mode when operation is stable above 5 Hz. Use *Torque boost gain* to set the start torque.

Speed start	Use for applications where the VFD will restart a motor that is still rotating. The VFD tracks the speed of the motor, then starts according to the detected frequency of the already rotating motor. This allows the motor to start without current transients. Speed start is suitable for restarting motors after line power failures and starting loads with large inertia such as fans. To use speed start, set *Stop mode* to ‘Free stop’ and set *Frequency search current* and *Frequency search direction* as required. Speed start can only be used without an encoder.
Parameter identification 1	Static motor parameter identification. Use this option if motor nameplate data is not available and the motor and load will not be disconnected before starting. The VFD will determine the motor’s stator resistance and leakage inductance and start the motor using open loop vector control. Suitable for open loop vector control of induction motors.
Parameter identification 2	Dynamic motor parameter identification. Use this option if motor nameplate data is not available and the motor will be disconnected from the load before starting. The VFD will determine the motor inertia and no-load current and start the motor using open loop vector control. Dynamic parameter identification uses a standardized value for stator resistance:

$$R_S\% = 100 \times \sqrt{3} \times R_S(\Omega) \times \frac{Motor\ rated\ current}{Motor\ rated\ voltage}$$

Stop Mode

Sets the stop mode.

Options:

Deceleration stop (default)	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 power cell voltage during deceleration to avoid overvoltage trips. If the power cell voltage is too high, the VFD will pause the deceleration. The actual deceleration time may therefore be longer than the programmed deceleration time.
Free stop	The VFD turns off output voltage immediately after receiving a stop command, and the motor coasts to a stop.

Control status

Selects between test and normal operation.

Options:

Debug (default)	Use for factory testing without medium voltage applied.
Normal	Use for normal operation with medium voltage applied.

Master-Slave setting

Enable or disable master/slave (multi-drive) operation. See *Multi-drive applications* on page 87.

Options:

Invalid (default)	Disable Master-Slave.
Valid	Enable Master-Slave.

Master-Slave mode

Sets whether this VFD will be the master or slave in a multi-drive application.

Options:

Master mode (default)
Slave mode

NOTE
A multi-drive system must have one VFD designated as master. All other VFDs must be slaves.

Frequency search current

Sets the motor current applied during frequency search that occurs during a “Speed start”. Set as a factor of *Motor rated current*.

NOTE
This parameter only applies when *Start mode* is set to ‘Speed start’.

Range:

0.10-1.00	Default: 0.40

Master/Slave frequency difference

Set to balance the power output in a multi-drive configuration.

- If there is a flexible connection between motors, the maximum master/slave frequency difference is 1.0 Hz.
- If the connection between motors is rigid, set to 0.

NOTE
This parameter only applies when *Master/Slave setting* is set to ‘Valid’.

Range:

0.0-1.0 Hz	Default: 0.5

Start frequency

Sets the initial output frequency of the VFD. 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.

Range:

0.0-5.0 Hz	Default: 0.2

NOTE
Setting the start frequency too high may cause the VFD to trip on ‘VFD overcurrent’ at start.

Maximum frequency

Sets the maximum output frequency that the VFD will operate at continuously. If the VFD runs more than 10% over the maximum frequency for longer than 0.5 seconds, the VFD will trip on System overspeed.

Range:

0.00-80.00 Hz Default: 50.00

Minimum frequency

Sets the minimum output frequency that the VFD will operate at continuously. During deceleration, the VFD will release control, shut off, and enter standby mode when it reaches the minimum frequency.

Range:

0.00-80.00 Hz Default: 0.00

Rated input voltage

This parameter is set at the factory to match the VFD’s specifications. Do not modify this setting.

Range:

380-15000 V Default: 6000

Rated output voltage

This parameter is set at the factory to match the VFD’s specifications. Do not modify this setting.

Range:

380-15000 V Default: 6000

Rated output current

This parameter is set at the factory to match the VFD’s specifications. Do not modify this setting.

Range:

30.0-3000.0 A Default: 77.0

Rated input current (ratio)

This parameter is set at the factory to match the VFD’s specifications. Do not modify this setting.

Range:

100-2000 :5 Default: 200

Acceleration time

Sets the time the VFD will take to accelerate to the motor rated frequency (see t1 in Figure 1-1 *Frequency time graph* on page 66).

Range:

5.0-6000.0 seconds Default: 30.0

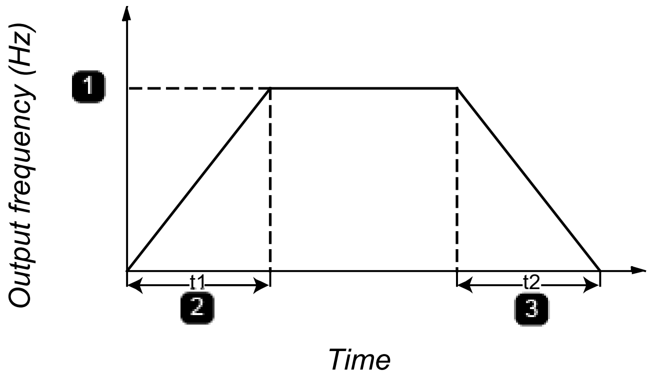
Deceleration time

Sets the time the VFD will take to decelerate from the motor rated frequency to zero speed (see t2 in Figure 1-1 *Frequency time graph* on page 66).

Range:

5.0-6000.0 seconds Default: 50.0

Figure 5-1: Frequency / Time graph



1	Motor rated frequency
2	Acceleration time (t1)
3	Deceleration time (t2)

NOTE

- If the acceleration time is too short, the VFD may trip on 'VFD overcurrent'
- If the deceleration time is too short, the VFD may trip on 'Power cell overvoltage'.

Momentary power-off time

Sets the maximum time that the VFD will continue running if input power is lost. See *Momentary power loss* on page 88.

Range:

0-2000 ms Default: 0

Dead time compensation

This parameter is used to compensate for the dead time effect of the power devices.

Range:

0-20 us Default: 1

NOTE

This parameter is set at the factory and generally does not need to be changed by the user.

Cell bypass stages

Set to match your hardware configuration. Use 0 if the VFD does not support power cell bypass.

Range:

0-2 Default: 0

CAUTION

Incorrect settings may damage the equipment.

Power cell stages

Set to match the number of power cells per phase of the VFD.

Range:

2-9 Default: 5

CAUTION

Incorrect settings may damage the equipment.

This parameter is set at the factory and generally does not need to be changed by the user.

Torque boost gain

Torque boost increases the output torque of the motor at slow speeds.

Range:

0-15% Default: 0

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.

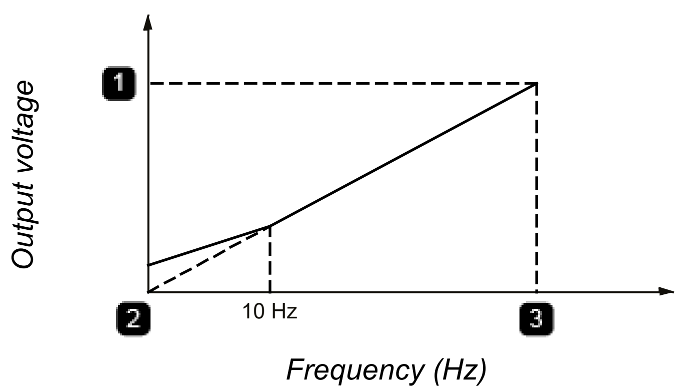
CAUTION

A high torque boost setting can generate high current levels during start and can cause the VFD to trip on overcurrent.

The behavior of torque boost differs depending on the setting of *VFD type*:

- Standard induction motor: Torque boost increases the output voltage while the VFD output is below 10 Hz. The output voltage increase can be calculated as *Motor rated voltage* * *Torque boost gain* * 0.5%.

Figure 5-2: Example: Voltage / frequency graph with Torque boost gain set to 15%



1	Motor rated voltage
2	Motor rated voltage * 7.5%
3	Motor rated frequency

- Standard synchronous motor: The VFD establishes DC orientation, then performs current loop control up to 5 Hz, then switches to V/Hz mode. Use the torque boost value to establish the starting current standard value of the DC orientation and the current loop operation. Use the equation below to calculate the equivalent torque boost value you need to set.

$$\text{Torque boost value (\%)} = \frac{\text{Starting current (A)}}{\text{Motor rated current (A)} \times \text{Current limit gain (\%)} \times 0.001}$$

5.2 VFD parameters 2

Single-phase ground protection enable

Enables or disables single-phase ground fault protection function.

Options:

Yes
No (default)

Single-phase ground protection action

Action taken if the VFD detects a single-phase ground fault.

Options:

Run (default)
Stop

Soft start enable

Enables or disables the VFD soft start function.

Options:

Yes
No (default)

Output voltage detection coefficient

Set according to motor nameplate data.

Range:

0.00% - 100% Default: 0.00%

Soft start mode

Sets the soft start mode to use.

Options:

1, 2, 3 Default: 0

5.3 Motor parameter 1

Motor rated frequency

Set according to motor nameplate data.

Range:

5.00-80.00 Hz Default: 50.00

Motor rated voltage

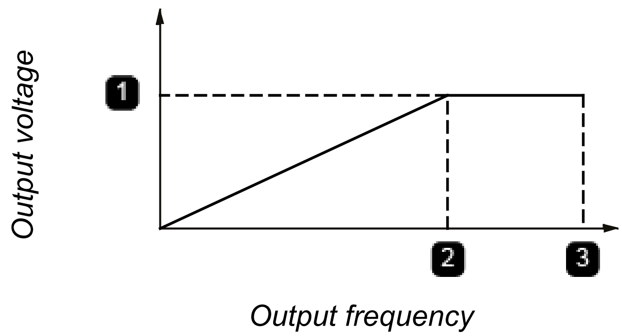
Set according to motor nameplate data.

Range:

380-15000 V Default: 6000

The relationship between the rated frequency of the motor and the rated voltage of the motor is shown in *Voltage/frequency graph* on page 67.

Figure 5-3: Voltage / Frequency graph



1	Motor rated voltage
2	Motor rated frequency (Hz)
3	Maximum frequency

NOTE

- If *Motor rated voltage* is set lower than the motor nameplate voltage, the VFD and motor will operate at reduced capacity.
- 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 rated current

Set according to motor nameplate data.

Range:

1.0-1600.0 A　　Default: 77.0

Motor rated speed

Set according to motor nameplate data.

Range:

0-3600 rpm　　Default: 980

Motor rated power

Set according to motor nameplate data.

Range:

1-60000 kW　　Default: 1000

Motor no-load current

Set according to motor nameplate data.

NOTE

If detailed motor nameplate data is not available, use parameter identification to allow the VFD to determine the motor characteristics. See *Start mode* on page 62.

Range:

0.000-50.000%　　Default: 25.000

NOTE

Setting this parameter to 0.0% will disable the automatic energy savings feature. The automatic energy saving feature reduces the motor voltage when there is less than full load applied to the motor.

Motor rotational inertia

Set according to motor nameplate or datasheet.

Range:

1.0-3000.0 $kg.m^2$ Default: 30.0

Stator leakage inductance

Set according to motor nameplate or datasheet.

Range:

0.000-50.000% Default: 16.000

Stator resistance

Set according to motor nameplate or datasheet.

Range:

0.000-25.000% Default: 0.1

Magnetic flux given

Sets the reference flux value that the VFD will create in the motor.

Range:

0.10-1.00 (Per unit) Default: 0.96

Magnetic flux proportional gain

These parameters control the behavior of the magnetic flux loop. Adjust *Magnetic flux proportional gain* and *Magnetic flux integral time* to improve the dynamic response characteristics of magnetic flux control.

NOTE

This parameter only applies when using a vector control mode.

Range:

0.50-20.00 Default: 5.00

Magnetic flux integral time

Fine-tunes the dynamic response characteristics of magnetic flux control.

NOTE

This parameter only applies when using a vector control mode.

Range:

0.10-20.00 seconds Default: 2.00

Speed proportional gain

These parameters control the behavior of speed control. Adjust *Speed proportional gain* and *Speed integral time* to improve the dynamic response characteristics of the speed control.

Increasing *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:

1. Gradually increase the gain setting, testing each time to ensure the system does not oscillate.
2. When the system is stable, gradually reduce the integration time so that the system response is faster.

Sometimes speed fluctuations occur in some low frequency bands, and at the same time motor current fluctuations can occur, which affects the stability of the system. Fine-tuning the speed gains can help avoid these variations. Once adjusted, the speed scaling settings are correct below 45 Hz.

NOTE
This parameter only applies when using a vector control mode.

Range:

0.50-20.00 Default: 5.00

Speed integral time

Fine-tunes the dynamic response characteristics of speed control.

Range:

0.10-20.00 seconds Default: 3.00

Current proportional gain

In vector control modes, these parameters control the behavior of the inner current loop. Adjust *Current proportional gain* and *Current integral time* to improve the dynamic response characteristics of the current loop.

CAUTION
Carefully monitor the output waveform when adjusting these parameters. Inappropriate parameter settings can distort the output circuit waveform.

If V/Hz control is being used in a multi-drive system, these parameters control the response characteristics of leader/follower power balance.

CAUTION
Inappropriate parameter settings can cause the VFD to trip on ‘Motor overcurrent’.

Range:

0.10-15.00 Default: 1.00

Current integral time

Fine-tunes the dynamic response characteristics of the current loop in vector control.

Range:

0.15-30.00 ms Default: 10.00

Transfer phase lock angle

For VFDs with a synchronous transfer system, the transfer phase lock angle is used for switching to and from the line adjustments.

- The smaller the transfer phase lock angle, the smaller the difference between the electrical angle of the power grid and the output electrical angle of the VFD. This minimizes the lower transient current during switching. However, a small transfer angle makes it difficult to achieve phase-locking and it may take longer for the transfer to occur.

- The larger the transfer phase lock angle, the greater the difference between the electrical angle of the power grid and the output electrical angle of the VFD. Achieving phase-locking is easier, but the transient motor current will be higher during switching.

Range:

0.5-5°	Default: 5

Current limit gain

Limits the VFD output current.

100% corresponds to motor rated current. For example, if *Motor rated current* is 61 A and *Current limit gain* is set to 100%, then the VFD maximum output current is 61 A. If *Current limit gain* is set to 120%, then the VFD maximum output current is 73.2 A.

NOTE

If this value is set to 100%, the VFD will not allow more than nominal current. If demand is higher, the VFD will reduce the speed without displaying any message. For this reason, it is recommended that you set this value to 110%.

Range:

100-200%	Default: 100

Over-excitation gain

Large load inertia during deceleration, especially at low output frequencies, can cause power regeneration to occur. This can cause capacitor overvoltage faults in the power cells. Enabling overexcitation can avoid this by dissipating some of the rotational energy back into the motor. This is done by placing the motor in an overexcited or high flux state. This can prevent the bus voltage from rising and prevents the VFD from tripping on ‘Overvoltage’.

Setting *Overexcitation gain* to a high value gives a stronger voltage control effect. If *Overexcitation gain* is set too high, the motor output current can become too high and may then cause overcurrent faults.

This feature can be used with overhauling or out-of-balance loads, such as ball mills to prevent overvoltage during operation. Consult factory for further information.

Range:

0-30%	Default: 0

Over-excitation frequency

Sets the frequency at which overexcitation will begin during deceleration.

Range:

1-30 Hz	Default: 20

5.4 Motor parameter 2

Curve selection

This parameter is used to select the V/Hz curve type for V/Hz operation.

A linear VF profile produces a constant torque output.

The power profiles produce a corresponding output voltage, where the output voltage is a function of output frequency of the form: Vout = mx(1.2, 1.5, 1.7, 2.0)

You can use a squared profile for variable torque loads to achieve energy savings while operating at lower speeds. However, if too little torque is produced at lower speeds, a more linear profile may be necessary.

Options:

Linear VF curve (default)	Produces a constant torque output.
1.2 power curve 1.5 power curve 1.7 power curve 2 power curve	Squared profiles: You can use these curves for variable torque loads. This can provide some energy savings while operating at lower speeds.
VF curve separation	

Frequency searching direction

Selects how the VFD will detect the present speed of the motor when using speed start. See *Start Mode* on page 62 for more information.

Options:

Residual voltage test (default)
Forward search
Reverse search
Bi-direction search

Motor rotation direction

Selects the VFD output phase sequence. This parameter is automatically recognized through the rotor positioning process and does not need to be set by the user.

Incorrect phase sequence setting will cause the VFD to fail to start normally.

Options:

Reverse	Use reverse/negative sequence (UWV).
Forward (default)	Use forward/positive sequence (UVW).

NOTE

This parameter only applies to vector control of synchronous motors when an encoder is installed.

Encoder pulse number

Set to match the actual encoder specification.

Range:

512-65535 p/r	Default: 1024

Load type

Sets how long the VFD will wait for excitation to be established.

Options:

Fan load (default)	Long excitation wait time. Suitable for most medium/heavy duty loads (not just “fan” loads).

Pump load	Short excitation wait time. Suitable for most light duty loads (not just “pump” loads).

Cell bypass model

Set to match your hardware configuration.

Options:

No cell bypass (default)	The VFD will not implement any cell bypass functionality.
Mechanical cell bypass	Select if you have power cells equipped with mechanical cell bypass. The VFD performs a self-test on the contactor during power-on and enters the standby state after the self-test passes. If the bypass contactor test fails, the VFD will trip on ‘Contactor fault’. For more information, see *Mechanical or* IGBT-based bypass on page 91.
IGBT cell bypass	Select if you have power cells equipped with the IGBT bypass function. If a power cell has a hardware failure during operation, the VFD will automatically isolate the power cell and use neutral point drift to keep the VFD running. For more information, see *Neutral point drift* on page 92.

CAUTION

Incorrect settings may damage the equipment. Consult factory.

This parameter is set at the factory and generally does not need to be changed by the user.

Auto-calculate speed loop

Check this box on the touchscreen to enable this auto-tuning routine.

Use the Auto-calculate feature if the motor data is not available to enter into the motor parameters or the application requires further tuning.

Options:

Checked

Unchecked (default)

Auto-calculate current loop

Check this box on the touchscreen to enable this auto-tuning routine.

Use the Auto-calculate feature if the motor data is not available to enter into the motor parameters or the application requires further tuning.

Options:

Checked

Unchecked (default)

Auto-calculate flux loop

Check this box on the touchscreen to enable this auto-tuning routine.

Use the Auto-calculate feature if the motor data is not available to enter into the motor parameters or the application requires further tuning.

Options:

Checked
Unchecked (default)

VF slip compensation

Check this box on the touchscreen to enable this auto-tuning routine.

Options:

Checked
Unchecked (default)

5.5 Function parameter 1

These parameters cannot be modified while the VFD is running, unless otherwise stated.

Restore to default

Sets whether the **Restore to default** button on the touchscreen is active.

Options:

Disable (default)	Disables the **Restore to default** button on the touchscreen.
Enable	Enables the **Restore to default** button on the touchscreen. The button becomes active. If you click on this button, all the parameters are reset to their default values.

Analog set loss

Selects the VFD's response if the reference frequency analog input signal is lost.

Options:

Disable	Sets the reference frequency to the lowest value (*Minimum frequency*).
Enable (default)	Retains the previously set value.

MV loss quick break

Selects whether the VFD will trip on 'High voltage power loss' if line voltage is lost.

Options:

Disable (default)	The VFD will not trip. If power is restored within *Voltage loss time delay*, the VFD will perform the action selected in *Self-start after MV loss*.
Enable	The VFD will trip on 'High voltage power loss'.

NOTE

The VFD will only attempt to restart if the power loss is shorter than *Voltage loss time delay*.

See also *Ongoing power loss* on page 88.

Self-start after MV loss

Selects whether the VFD will attempt to automatically restart after a loss of line voltage.

Options:

Disable (default)	The VFD will not automatically restart. It will return to standby state.
Enable	The VFD will attempt to return to its previous running state.

NOTE

The VFD will only attempt to restart if the power loss is shorter than *Voltage loss time delay*.

See also *Ongoing power loss* on page 88.

Remote start/stop mode

To enable this parameter setting, you must set *Control mode* to 'Remote control'.

Options:

Pulse mode
- terminals PLC-XS1T-1 and PLC-XS1T-10 on the interface board are defined as *pulse start*
- terminals XS1T-1 and XS1T-9 are defined as *pulse stop*

Level mode (default)
- terminals PLC-XS1T-1 and PLC-XS1T-10 on the interface board are defined as *level forward start/stop*
- terminals XS1T-1 and XS1T-9 are defined as *level reverse start/stop*

VFD reverse

Sets whether the motor can run in reverse. See *Reverse running* on page 87 for details.

Options:

Disable (default)	Disables reverse operation of the motor.
Enable	Enables reverse operation of the motor. Depending on how the reference frequency is set, the reverse operation steps can be different.

Analog output 1

Sets the analog output 1 function. The analog output 1 signal is connected to terminals 9 (I3) and 10 (M3) on the -XS18T terminal block.

Options:

Output frequency (default)
Output current
Power cell temperature
Excitation current
Output power
Output power factor
Output voltage

Analog output 2

Sets the analog output 2 function. The analog output 2 signal is connected to terminals 11 (I4) and 12 (M4) on the -XS18T terminal block.

Options:

Output frequency
Output current (default)
Power cell temperature
Excitation current
Output power
Output power factor
Output voltage

Analog feedback loss (Analog speed input loss)

Indicates what action is taken if the analog input speed reference setpoint value signal is lost.

Options:

Disable	The speed reference becomes 0.
Enable (default)	The speed reference maintains the original set value it had at the time of signal loss.

Control mode set by remote

Sets whether the VFD local/remote control mode is active.

Options:

Disable (default) — Disables VFD remote control.

Enable — The control source of the VFD is selected by digital input and remote control is enabled. You can then set parameter *Control mode* to either:

- 'Local control': occurs when the *remote control enable* digital input on the interface board is open/de-energized
- 'Remote control': occurs when the *remote control enable* digital input on the interface board is closed/energized

Switch given selection (Digital input speed selection)

Selects which digital inputs will set the VFD's reference frequency. See *Digital input setting* for more information.

This parameter only applies if *Set mode* is set to 'DI set'.

Options:

Speed section 3 (default)
Speed section 7

Table 5-1: Digital input setting

Speed mode selection	Switch selection			Frequency set		
	switch3#	switch2#	switch1#	13	12	11
Speed section 3	001			f1		
	010			f2		
	100			f3		
Speed section 7	001			f1		
	010			(2* f1+ f2)/3		
	011			(2* f2+ f1)/3		
	100			f2		
	101			(2* f2+ f3)/3		
	110			(2* f3+ f2)/3		
	111			f3		

NOTE
You can modify this parameter while the VFD is running.

VFD-grid switch permit

Sets whether synchronous transfer switch is enabled. See *Synchronous transfer* on page 86 for details.

Options:

Disable (default)
Enable

Control mode

Sets which start/stop control mode applies to the VFD.

Options:

Local control (default)	Select this option to start and stop the VFD using the icons on the touchscreen monitoring interface.
DCS control	Select this option if the VFD start and stop commands are controlled via a fieldbus network.
Remote control	Select this option if the VFD start and stop commands are controlled via a remote control signal on the interface board (see *Remote start/stop mode*). Both 2-wire and 3-wire control are supported.

NOTE
You can modify this parameter while the VFD is running.

Set mode

Selects the method for setting the speed reference of the VFD:

Options:

Local set (default)	Set the frequency directly on the touchscreen by entering a number.
AI set	Set the frequency through the analog input speed reference set signal on the interface board (XS18T) and the settings of parameters *Maximum frequency* and *Minimum frequency*. Under open loop control, the analog set signal ranges from 0 Hz to the highest allowable frequency. Under closed loop control, the analog set signal ranges from 0% to 100%.
DI set	Set the frequency through the 3- or 7- position DI signal on the interface board (digital input settings 1~3). When no digital input switch is closed, the set frequency is the lowest frequency. When the multi-stage switches are closed, the set frequency is set as selected by parameter *Switch given selection*. **NOTE**: This is only valid in open loop operation (reference setting is not used in closed loop operation).

DCS set	Set the frequency (or set parameter) through the fieldbus network interface. The highest set frequency possible is defined by the *Maximum frequency* parameter.

NOTE
You can modify this parameter while the VFD is running.

5.6 Function parameter 2

All parameters in this screen can be modified while the VFD is running, unless otherwise stated.

Resolution of set frequency

Sets the resolution of the set frequency.

Range:

0.01-1.00 Hz	Default = 0.10

Skip frequency 1 L ~ *Skip frequency* 2 U

Use these parameters to set skip frequency bands to avoid inherent resonance points of the mechanical system during variable speed operation.

Range:

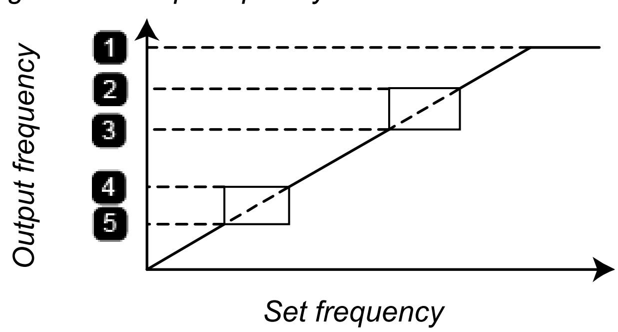
0.00~80.00 Hz	Default = 51.00

During acceleration or deceleration, the output frequency will pass through the skip regions; however, the skipped frequencies will prevent constant operation at any of the skip frequency points.

To define a skip frequency region, you must set two parameters for each skip frequency point: the upper limit frequency (U) and the lower limit frequency (L).

- If the speed reference is within one of the skip frequency regions, the VFD will automatically adjust the output frequency to the upper limit of the skip frequency.
- Within the same skip frequency region, the upper limit frequency value must be greater than the lower limit frequency value.
- If you define two skip frequency points, the setting of skip frequency 2 must be greater than skip frequency 1 (see *Skip frequency* on page 79).

Figure 5-4: Skip frequency



1	Max. frequency	
2	Skip frequency region	*Skip frequency 2 U*
3		*Skip frequency 2 L*
4	Skip frequency region	*Skip frequency 1 U*
5		*Skip frequency 1 L*

Input voltage gain

Enter the correction factor for the input voltage measured value. If the measured input voltage is smaller than the actual value, increase this parameter setting. To lower the indicated measurement, decrease this parameter setting.

Range:

50~200	Default = 100

Maximum set current

Sets the maximum current value for the highest frequency at full scale (or 100% of the set value under closed loop control).

Range:

10.00~25.00 mA	Default = 20.00

Minimum set current

Sets the minimum current value for 0 Hz (or 0% of the set value under closed loop control).

Range:

0.00~8.00 mA	Default = 4.00

DI set 1

If *Set mode* is set to 'DI set', the digital inputs control the speed command. See parameter *Switch given selection* for details.

Range:

0.00~80.00 Hz	Default = 10.00

NOTE

This parameter cannot be modified while the VFD is running.

DI set 2

If *Set mode* is set to 'DI set', the digital inputs control the speed command. See parameter *Switch given selection* for details.

Range:

0.00~80.00 Hz	Default = 30.00

NOTE

This parameter cannot be modified while the VFD is running.

DI set 3

If *Set mode* is set to 'DI set', the digital inputs control the speed command. See parameter *Switch given selection* for details.

Range:

0.00~80.00 Hz	Default = 50.00

NOTE

This parameter cannot be modified while the VFD is running.

Maximum feedback current

Sets the analog feedback range. *Maximum feedback current* corresponds to a 100% input.

Range:

10.00~25.00 mA Default = 20.00

Minimum feedback current

Sets the analog feedback range. *Minimum feedback current* corresponds to a 0% input.

Range:

0.00~8.00 mA Default = 4.00

Voltage loss time delay

Sets the delay time before the VFD trips on a 'High voltage power loss' fault if MV power is lost.

A setting of 100 seconds disables power loss protection.

For more information on the VFD's response to power loss, see *Power outage ride-through* on page 88.

Range:

1~100 seconds Default = 1

NOTE
You cannot modify this parameter while the VFD is running.

Process close loop P coefficient

Sets the P control proportional coefficient. When *Run mode* is set to 'Close loop', the speed reference is calculated by the built-in PID process controller. Please consult factory for further information.

Range:

0.00~50.00 Default = 10.00

NOTE
This parameter cannot be modified while the VFD is running.

Process close loop I time

Sets the I control integral time. When *Run mode* is set to 'Close loop', the speed reference is calculated by the built-in PID process controller. Please consult factory for further information.

Range:

0.01~20.00 minutes Default = 10.00

NOTE
This parameter cannot be modified while the VFD is running.

Process close loop D time

Sets the D control differential time. When *Run mode* is set to 'Close loop', the speed reference is calculated by the built-in PID process controller. Please consult factory for further information.

Range:

0.00~20.00 minutes	Default = 0.00

NOTE
This parameter cannot be modified while the VFD is running.

Timing dust removal time

Sets when the reminder to clean the VFD air filters is displayed.

Range:

15~30000 days	Default = 30

NOTE
For this reminder to operate, you must set *Ventilation filter cleaning* to 'Remind'.

Ventilation fan stop time

After the VFD stops running and returns to the idle state, this parameter allows the cooling fans to continue to run for a set amount of time. This feature can be used to cool down the VFD after operation.

Range:

0~30 minutes	Default = 30

VFD address

Sets the node address of the VFD when communicating with the VFD via Modbus.

Range:

1-247	Default = 1

NOTE
You cannot modify this parameter while the VFD is running.

5.7 Function parameter 3

All parameters in this screen can be modified while the VFD is running, unless otherwise stated.

Run mode

Sets the VFD's operation mode.

Options:

Open loop (default)	Allows you to set the operating frequency of the VFD directly using various methods (see *Set mode*).
Closed loop	The operating frequency of the VFD is generated by the built-in PID controller.

NOTE
You can modify this parameter while the VFD is running.

Top fan control

This determines if the VFD built-in cooling fans run when the drive is sitting idle and is cool.

NOTE
The fans always run while the drive is running or when the internal temperature of the drive is high.

Options:

Stop (default)	The fans remain turned off when the drive is sitting idle and cool.
Start	The fans are always turned on, even if the drive is sitting idle and cool.

Minor fault energized

Sets whether the VFD trips or continues to run when an alarm occurs.

Options:

Disable (default)	The VFD will trip when an alarm occurs.
Enable	The VFD continues to run when an alarm occurs.

Baud rate

Sets the serial baud rate of the Modbus connection when communicating with the VFD via Modbus.

Range:

1200
4800
9600 (default)
19200
38400

NOTE
You cannot modify this parameter while the VFD is running.

Cooling method

Sets the cooling method used for the VFD.

Options:

Air-cooled (default)
Water-cooled

Ventilation filter cleaning

Sets whether you will get a reminder to clean the ventilation filters.

Options:

Ignore (default)	No reminder will be issued to clean the ventilation filters.
Remind	Sets a reminder to clean the ventilation filters. Use parameter *Timing dust removal time* to set the reminder time.

Cab door light/heavy fault choice

Sets whether an open cabinet door (if door switches are included) will trigger an alarm or a fault.

This setting applies to the power cell door and transformer cabinet door.

Options:

Light fault (default)	The VFD will report a door open alarm and will continue to operate.
Heavy fault	An open door will cause the VFD to shut down.

Communication mode

Selects the fieldbus network used for communications with the VFD.

Options:

Modbus (default)
Profibus
Profinet

NOTE
The VFD is always a slave node on the fieldbus network. The fieldbus system itself is the master node.

NOTE
You cannot modify this parameter while the VFD is running.

Groups of motor parameter

The VFD can store four different motor parameter groups 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. Select the motor parameter group that the VFD will use.

Options:

Group 1 (default)
Group 2
Group 3
Group 4

NOTE
You cannot modify this parameter while the VFD is running.

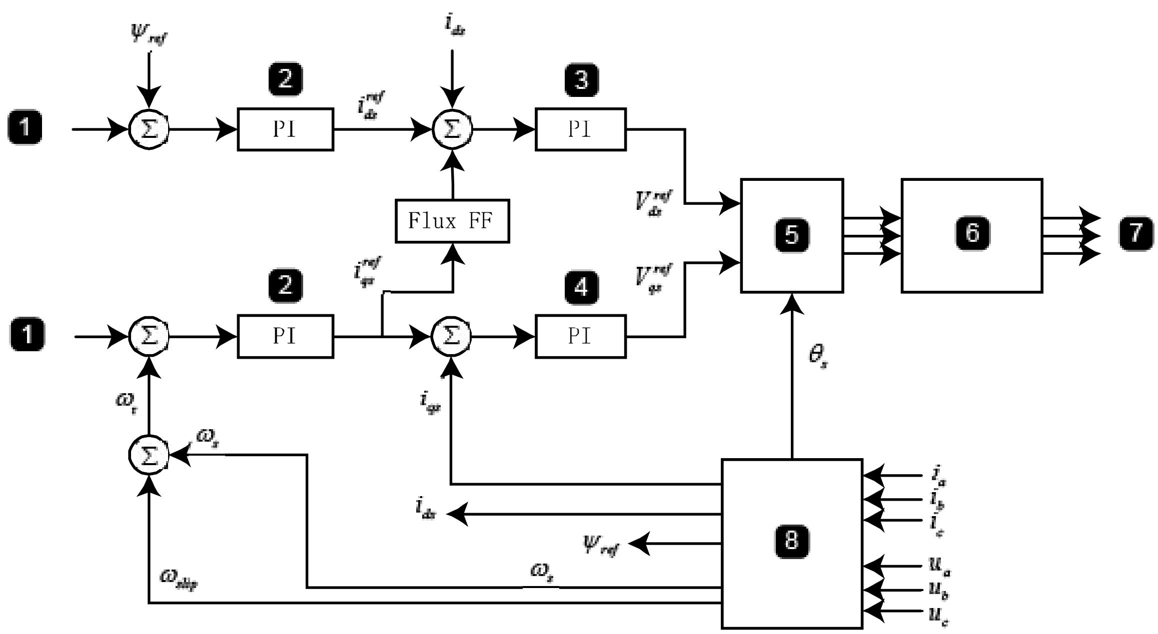
6. Operation

The VFD includes a comprehensive range of operating functions to meet the needs of many different applications.

6.1 Open loop vector control

The MV VFD offers high-quality, reliable open loop vector control to easily accelerate and decelerate motors. Open loop control simplifies installation by allowing the VFD to estimate motor performance characteristics, instead of requiring external sensors. Open loop control is suitable for most induction (asynchronous) motor applications. The VFD uses the motor model and measured voltage and current to estimate the rotor slip, magnetic flux, synchronization angle and other internal motor parameters. This provides performance close to vector control with speed feedback.

Figure 6-1: Block diagram of open loop vector control for an induction motor



1	Magnetic flux given		**5**	Park inverse transformation
2	Magnetic flux regulator		**6**	Dead time compensation and modulation
3	Excitation current regulator		**7**	Voltage command
4	Torque current regulator		**8**	Motor model estimate

The VFD uses the motor model, measured stator voltage u_a、u_b、u_c and stator current i_a、i_b、i_c to calculate magnetic flux ψ_{ref} , synchronous speed ω_s , synchronous electrical angle θ_s and slip ω_{slip}.

The coordinate transformation of the stator current using the synchronous electrical angle gives the flux current i_{ds} and torque current i_{ds} in the stator coordinate system.

The magnetic flux regulator performs proportional and integral (PI) regulation according to the difference between the programmed and calculated magnetic flux values (*Magnetic flux given* and ψ_{ref}) to generate an excitation current reference value i_{ds}^{ref} .

The excitation current regulator performs PI regulation according to the difference between the excitation current reference value and the calculated magnetic flux current to generate the voltage output reference for the d axis (V_{ds}^{ref}).

The speed regulator performs PI regulation according to the difference between the given speed and the actual calculated speed ω_r to generate a given torque reference current i_{ds}^{ref}.

The torque current regulator performs PI regulation according to the difference between the given torque current i_{ds}^{ref} and the calculated torque current to generate the voltage output reference for the q axis (V_{ds}^{ref}).

The dq axis voltage outputs (V_{ds}^{ref}) are subjected to a reverse coordinate transformation and dead-time compensation modulation according to the synchronous angle θ_s to obtain a voltage output command for all the phases.

6.2 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:

- Up-transfer / VFD to grid: the VFD starts the motor then transfers the motor to the incoming line
- Down-transfer / grid to VFD: the VFD synchronizes to the motor then transfers it off the incoming line and on to the VFD

VFD to grid

The VFD starts the motor, synchronizes the frequency and phase angle relative to the power grid, then transfers the motor to the incoming line and disconnects the VFD.

After receiving the switching command, the VFD detects the incoming line frequency on the input side and uses this frequency as the output speed command to achieve frequency matching. When the input frequency matches the output frequency, the VFD uses incoming line phase information from the input and output side Phase Locked Loops (PLL) to phase match to the incoming line. When the frequency, amplitude, and phase of the VFD output match the grid, the touch screen displays that the phase lock is successful, and the transfer can be completed. Once the transfer is successful, the VFD output contactor opens and the VFD stops.

Use parameter *Transfer phase lock angle* to set the accuracy required for phase locking.

Grid to VFD (incoming line to VFD)

The VFD synchronizes to a motor that is already running, then transfers the motor from the incoming line to VFD control.

The VFD initially runs under no load and monitors the incoming line. When the VFD is synchronized to the line, it will phase lock then disconnect the motor from the line and connect it to the VFD.

NOTE

Before attempting synchronous transfer, ensure the system parameters are correctly configured. The speed curve, speed limit or the setting of *Set mode* can change the output frequency of the VFD during synchronous transfer, which can cause the transfer to fail.

Synchronous transfer requires additional equipment such as a synchronous switch cabinet, a reactor cabinet, and a synchronous transfer sampling board.

6.3 Multi-drive applications

The VFD can be used in multi-drive 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.

One VFD is designated master of the system and all others are slaves. The master communicates with the slave via optical fibers. The master will transmit information on running, speed, torque, etc. to the slave in real-time, and the slave will respond to the data commands from the master according to its own measured data.

To enable multi-drive operation, set *Master-Slave setting* to 'Valid' and set *Master-Slave mode* appropriately for each VFD.

6.4 Speed start

The VFD can start a motor that is already rotating.

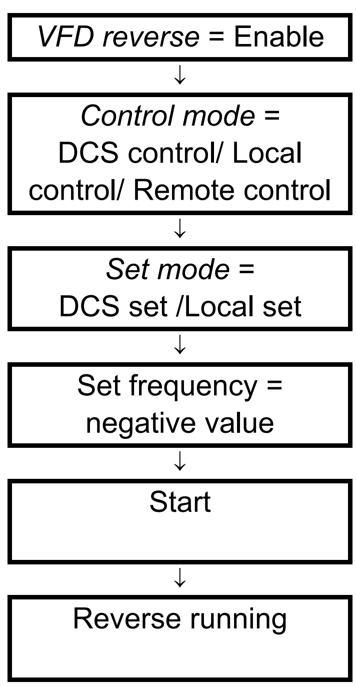
When *Stop mode* is set to 'Free stop' and *Start mode* is set to 'Speed start', the VFD will detect the motor's speed before starting. The VFD will then output voltage at the same frequency as the motor's rotating frequency and continue to accelerate the motor with minimal speed and torque pulsations.

6.5 Reverse running

The VFD can run a motor in the reverse direction. Reverse running is available when *VFD reverse* is set to 'Enable'. Operation depends on the setting of *Set mode* and *Control mode*.

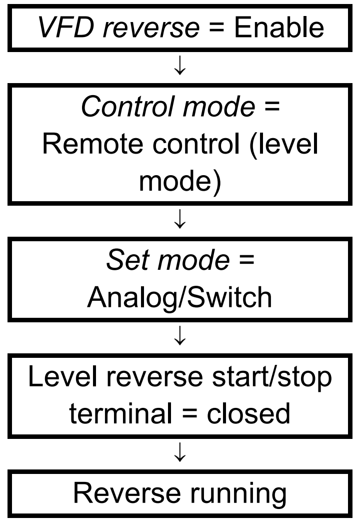
With *Set mode* set to 'Local set', you can run the VFD in reverse using the touchscreen or network controls. To do so, set the frequency to a negative value. If *Control mode* is set to 'Remote control', and *Remote start/stop mode* is set to 'Level mode', start/stop control is performed by the level forward start/stop signal on the interface board.

Figure 6-2: Reverse running flowchart: Set mode = Local



For analog reference or switch reference, set *Control mode* to 'Remote control' and *Remote start/stop mode* to 'Level mode'. You can then control the motor to start and stop in reverse through the level reverse start/stop signal terminal on the interface board.

Figure 6-3: Reverse running flowchart: Set mode = AI set or DI set



6.6 Power outage ride-through

Momentary power loss

If line voltage drops while the VFD is running, the drive will decelerate the motor to regenerate power and continue to run. The VFD continues to operate normally up to the duration set in *Momentary power-off time.* The VFD can be configured to trip or attempt to restart if line voltage is not restored within the *Momentary power-off time*.

Power outage ride-through (PORT) requires that control power must be maintained on the VFD during a medium voltage power loss event. While short duration outages can be tolerated natively, disruptions longer than 5-10 cycles must use a UPS to maintain control over the VFD system.

Ongoing power loss

The VFD's response to ongoing power loss depends on the settings of parameters *MV loss quick break, Voltage loss time delay* and *Self start after MV loss*.

- If *MV loss quick break* is set to 'Enable', the VFD will fault on 'High voltage power loss'.
- If *MV loss quick break* is set to 'Disable', the response depends on the duration of the power loss and the setting of *Self-start after MV loss*:

VDF state before power loss	Power loss duration	*Self-start after MV loss*	VFD state after power loss
Standby	Shorter than *Voltage loss time delay*	n/a	Standby
Standby	Longer than *Voltage loss time delay*	n/a	High voltage not ready
Running	Shorter than *Voltage loss time delay*	Enable	Running
Running	Shorter than *Voltage loss time delay*	Disable	Standby
Running	Longer than *Voltage loss time delay*	Disable	High voltage power loss

6.7 Motor overload protection

To prevent motor damage due to overload or long-term overcurrent operation, the VFD protects the motor using a preset inverse time motor thermal overload model:

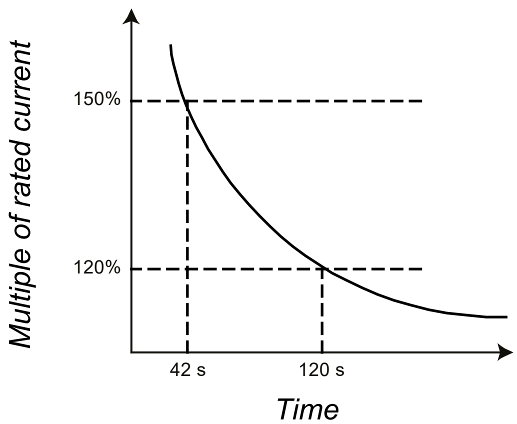
$$\int_{t0}^{t}\left[\left(\frac{I}{I_N}\right)^2-1\right]dt \geq k$$

Where:

- I is the instantaneous value of the motor current
- I_N is the motor rated current
- t is the inverse time overcurrent protection time
- k is the set value of the protection constant.

When the motor current exceeds the rated current, the inverse time protection function is activated. The greater the motor current, the faster the protection response:

Figure 6-4: Inverse time protection graph



NOTE

Depending on VFD sizing in relation to the motor current, if the VFD output current exceeds 150% of cell rating the VFD will fault before the motor overload will reach maximum capacity.

Table 6-1: Correspondence between motor overload multiple and duration

Overload multiple	Duration (s)
110%	251
120%	120
130%	76
140%	55
150%	42
200%	18

6.8 Stall prevention

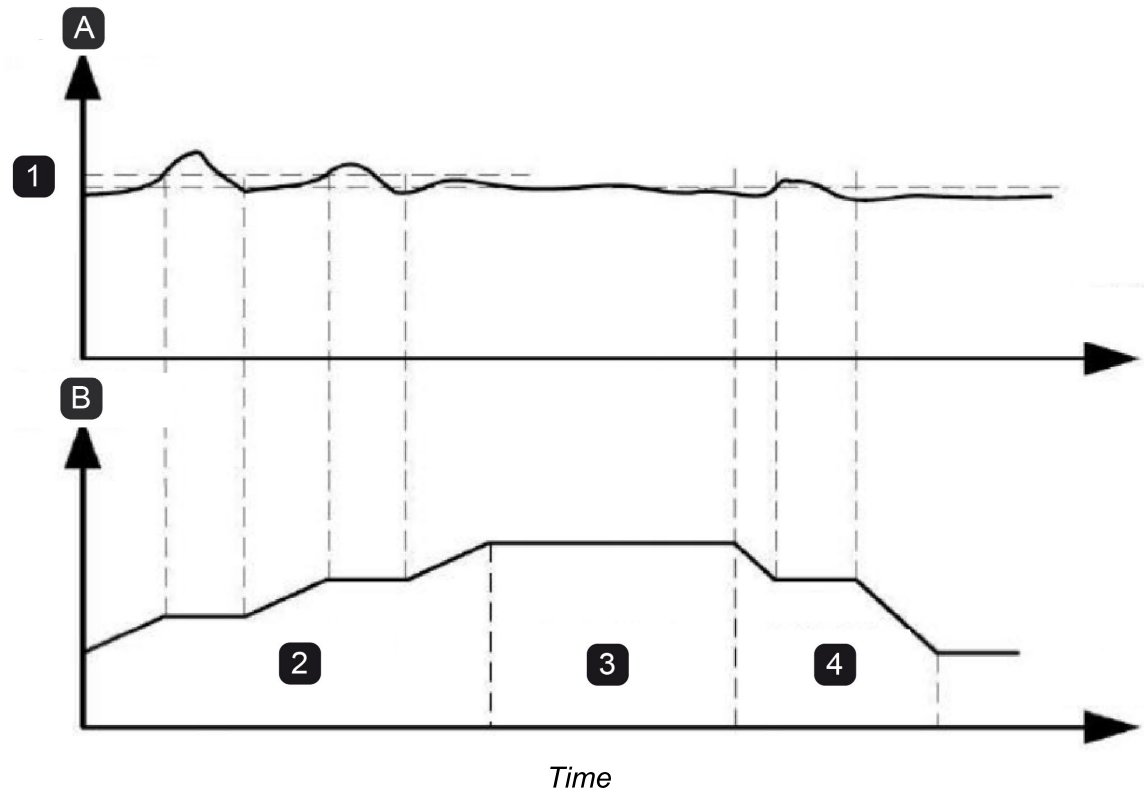
If the programmed acceleration or deceleration time is too short and the output frequency of the VFD changes much faster than the motor speed, the VFD will trip on ‘Overcurrent’ or ‘Power cell overvoltage’. This is also called a stall. To prevent stalling and to keep the motor running in a stable manner, the VFD monitors output current and power cell voltage, and adjusts the acceleration or deceleration rate.

Overcurrent

The maximum allowable current level is pre-set in the VFD. This cannot be adjusted by the user.

If current exceeds the maximum value during acceleration or deceleration, the VFD will hold its output frequency at the existing value and pause acceleration/ deceleration. Acceleration or deceleration resumes after the current drops below the overcurrent recovery point.

Figure 6-5: Overcurrent adjustment for stall prevention

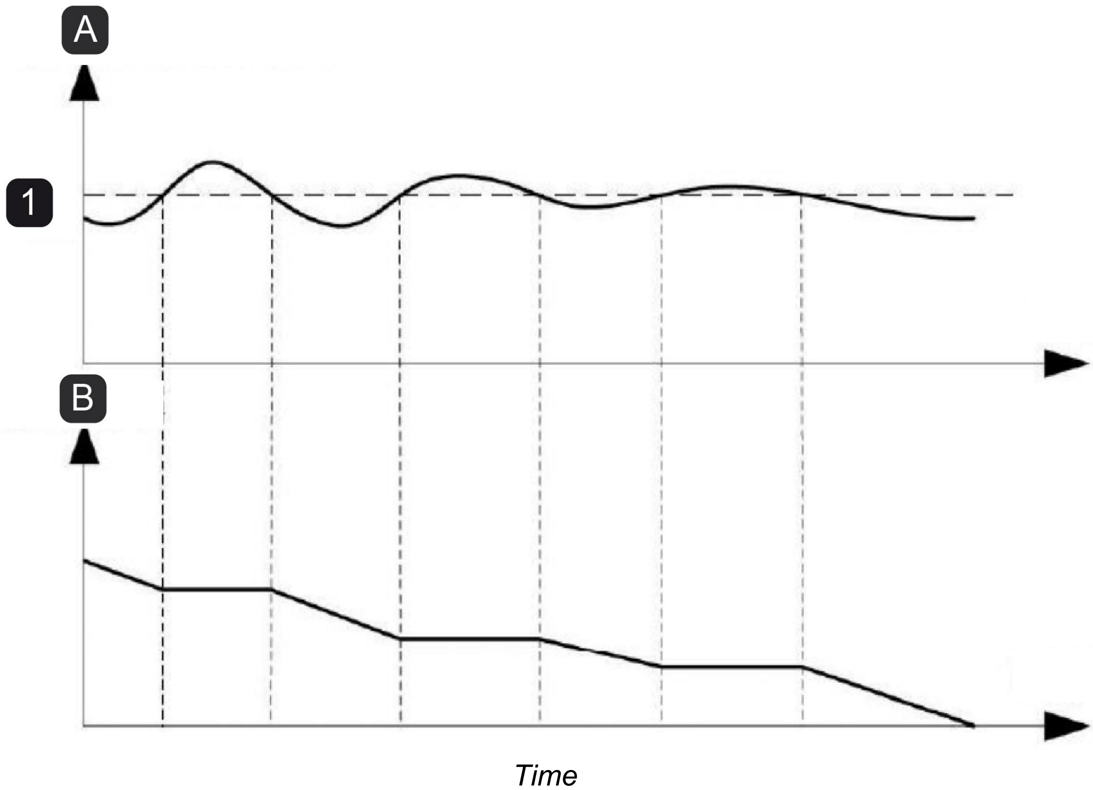


A	Output current
1	Overcurrent adjustment point / Overcurrent recovery point
B	Output frequency
2	Acceleration zone
3	Constant speed zone
4	Deceleration zone

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 bus voltage of the power cells. If voltage exceeds the preset power cell overvoltage trip point, the VFD pauses deceleration. When the bus voltage of the power cell is below the preset overvoltage trip point, deceleration resumes.

Figure 6-6: Overvoltage adjustment



A	Power cell DC bus voltage
1	Overvoltage adjustment point
B	Output frequency

6.9 Bypassed operation

The VFD can be completely bypassed if required, to allow critical applications to continue operating even if the VFD is damaged. When the VFD is bypassed, the motor operates directly from the incoming line.

Options are available for manual and automatic bypass. If the system can be shut down temporarily to bypass the VFD, use manual bypass. If the system must continue running uninterrupted, use automatic bypass.

6.10 Cell bypass methods

The power cells in each phase are connected in series. If one or more power cells fail, the failed cells can be bypassed in order to keep the site operating.

Mechanical or IGBT-based bypass

Depending on the power cell design, either a mechanical bypass is used or a IGBT is used to bypass a damaged cell. Mechanical bypass uses a contactor at the cell output and the IGBT method uses two IGBTs at the cell output. When the VFD detects a power cell failure, it immediately inhibits all H-bridge IGBT outputs and sends a bypass command to close the corresponding contactor or turn on the bypass IGBTs (so the power cell is separated from the output circuit). The VFD can then continue operation and run on a derated basis.

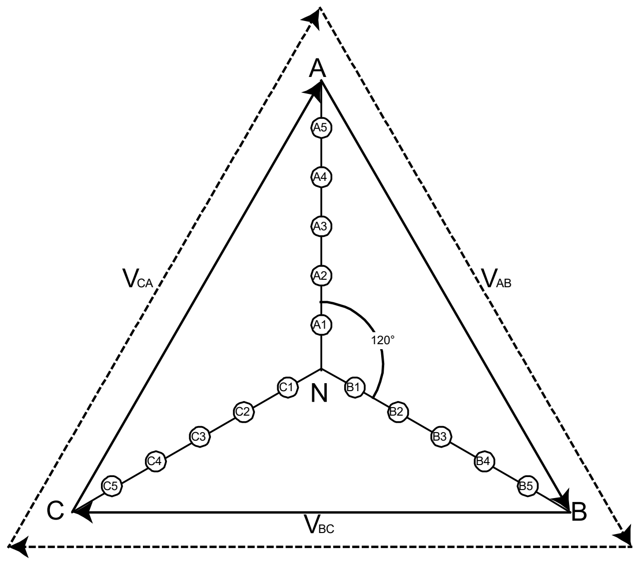
6.11 Neutral point shift

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. To keep the voltage output balanced across all three phases, many VFDs bypass one power cell on each phase. This greatly reduces the voltage output.

The MV VFD uses a neutral point shift to minimize the effects on voltage output. When a power cell fails, only that cell is bypassed. All other power cells continue to work normally to maximize the voltage output capacity.

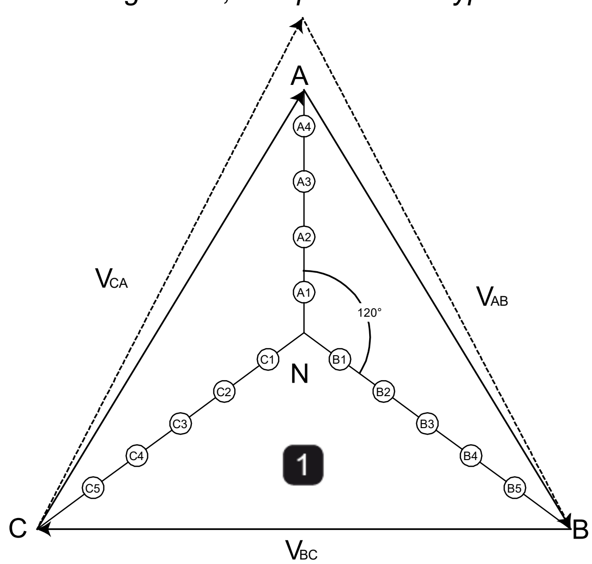
Phase angles for 5-stage VFD, normal operation shows a system in regular operation. Each phase has five cascading power cells and all power cells are operating normally. The voltage angles of each phase differ by 120°.

Figure 6-7: Phase angles for 5-stage VFD, normal operation



If one power cell fails and is bypassed, the output voltage becomes unbalanced (see *Phase angles for 5-stage VFD, one power cell bypassed*)

Figure 6-8: Phase angles for 5-stage VFD, one power cell bypassed

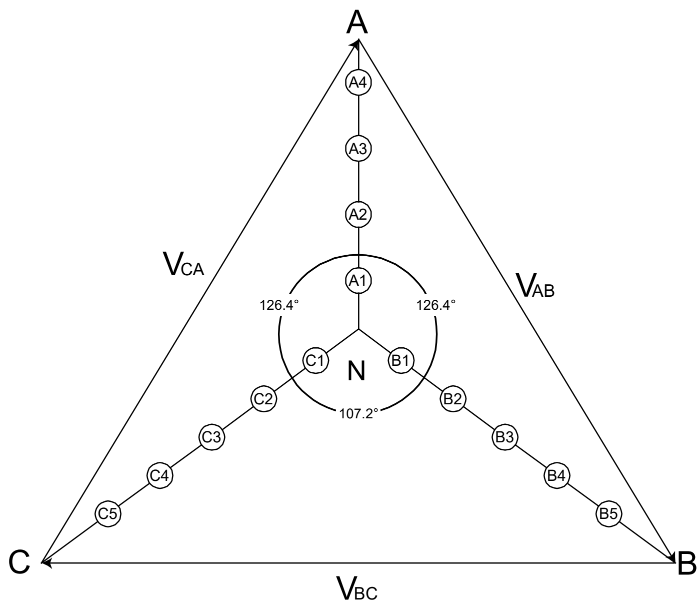


1	Imbalance after loss of A5 power cell

To overcome the reduction in phase A voltage, the MV VFD uses a neutral point shift algorithm. In this method, the neutral point of the power cell realigns and is not centered on the neutral point of the motor. The neutral point of the VFD output voltage can differ from the neutral point of the motor. Adjusting the phase angle of the output phase voltage changes the balance of the output line to line voltage. Therefore, although the number of power cells working in each phase is different and the output phase voltage is unbalanced, the line-to-line voltage is balanced and the motor can operate normally. This method is equivalent to injecting an unbalanced zero sequence component into the modulation waveform during PWM modulation.

In the diagram, 14 power cells are still working normally and can provide an output voltage equivalent to 92.9% of the nominal output voltage. The phase angle of the output phase voltages is adjusted so that the phase difference between phase A and phase B or C is 126.4°. This phase angle difference produces a balanced line to line voltage output.

Figure 6-9: Phase angles for 5-stage VFD using neutral point shift.



7. Transportation, storage and installation

7.1 Transportation and storage requirements

With proper packing, the MV VFD may be transported by airplane, truck, train, ship etc. The VFD should be stored in a ventilated room, with a temperature between -40 °C ~ 70 °C and with a non-condensing humidity no higher than 90%.

CAUTION

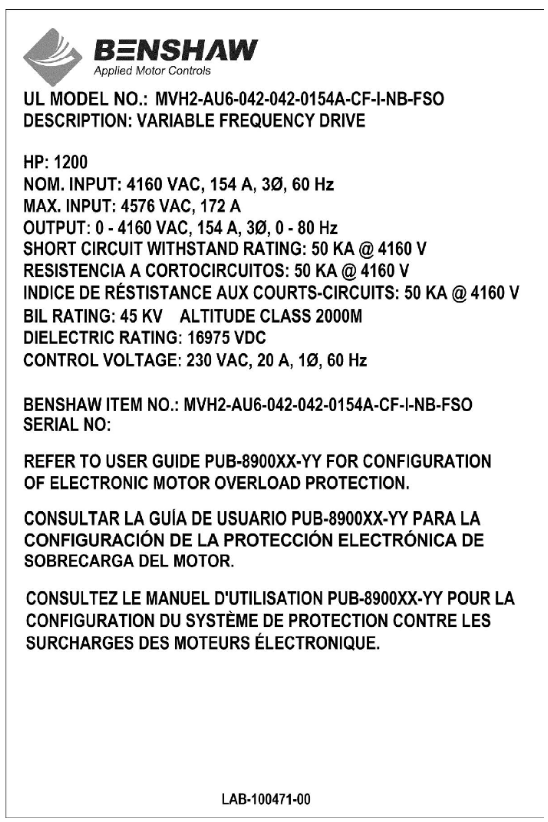
- During transportation, do not expose the VFD to rain, extended direct sunlight, dirt, high vibration or impact, invert the cabinet, or lay it on one side.
- Be aware of height limitations before and during movement of the equipment to its final position.
- Any cranes or lifting rigging should be of higher capacity than the weight of the MV VFD

7.2 Receiving inspection

Upon receiving the MV VFD:

1. Confirm the exterior packaging of the VFD is in good condition.
2. Unpack and confirm the cabinet surface of the VFD is in good condition and verify that there are no broken or shifted internal components.
3. Check the packing list to confirm all components are received.

Figure 7-1: Product nameplate


BENSHAW
Applied Motor Controls

UL MODEL NO.: MVH2-AU6-042-042-0154A-CF-I-NB-FSO
DESCRIPTION: VARIABLE FREQUENCY DRIVE

HP: 1200
NOM. INPUT: 4160 VAC, 154 A, 3Ø, 60 Hz
MAX. INPUT: 4576 VAC, 172 A
OUTPUT: 0 - 4160 VAC, 154 A, 3Ø, 0 - 80 Hz
SHORT CIRCUIT WITHSTAND RATING: 50 KA @ 4160 V
RESISTENCIA A CORTOCIRCUITOS: 50 KA @ 4160 V
INDICE DE RÉSTISTANCE AUX COURTS-CIRCUITS: 50 KA @ 4160 V
BIL RATING: 45 KV ALTITUDE CLASS 2000M
DIELECTRIC RATING: 16975 VDC
CONTROL VOLTAGE: 230 VAC, 20 A, 1Ø, 60 Hz

BENSHAW ITEM NO.: MVH2-AU6-042-042-0154A-CF-I-NB-FSO
SERIAL NO:

REFER TO USER GUIDE PUB-8900XX-YY FOR CONFIGURATION OF ELECTRONIC MOTOR OVERLOAD PROTECTION.

CONSULTAR LA GUÍA DE USUARIO PUB-8900XX-YY PARA LA CONFIGURACIÓN DE LA PROTECCIÓN ELECTRÓNICA DE SOBRECARGA DEL MOTOR.

CONSULTEZ LE MANUEL D'UTILISATION PUB-8900XX-YY POUR LA CONFIGURATION DU SYSTÈME DE PROTECTION CONTRE LES SURCHARGES DES MOTEURS ÉLECTRONIQUE.

LAB-100471-00

CAUTION

If there is any damage to the VFD, refuse shipment and immediately contact the carrier.

7.3 Handling

There are several acceptable methods for handling the VFD cabinets:

- Overhead crane lifting
- Hand chain hoist lifting
- Roller lifting
- High-capacity fork truck

Using an overhead crane or a hand chain hoist

⚠ **CAUTION**

- Confirm that the cables are of sufficient length and strength to support the load.
- DO NOT lift with cables directly on the lifting eyes. Use of a spreader bar is mandatory to prevent cabinet deformation damage!

Using rollers

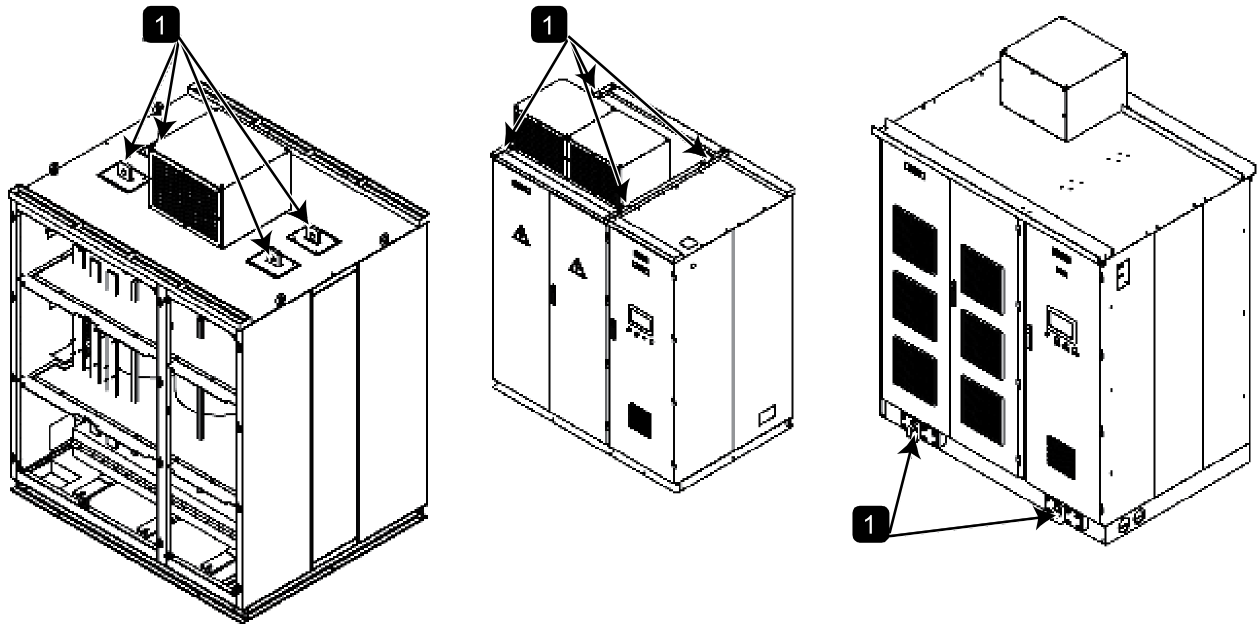
The use of rollers is suitable for narrow spaces where no crane or hand chain hoist can be used. Lay several rollers on the ground one by one, place the cabinet on the rollers and use a crowbar to move the rollers to the installation position.

⚠ **CAUTION**

- To avoid cabinet damage when any cabinet is hoisted, you must use all four rings at the same time.
- When lifting the power cell cabinet, the angle between the rope and the cabinet shall 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 *Schematic diagram of cabinet hoists* on page 96). 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 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.

Figure 7-2: Schematic diagram of cabinet hoists

Transformer cabinet top hoist | *Power cell cabinet top hoist* | *Power cell cabinet bottom hoist*



1	Lifting hoist

7.4 Installation environment

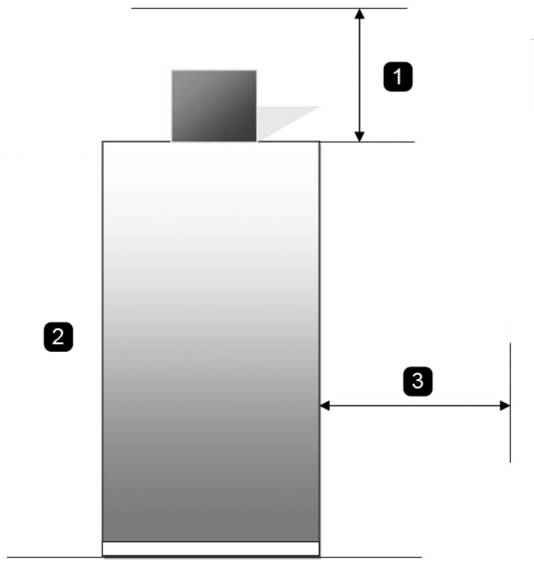
To make the MV VFD stable, reliable, and ensure long service life, the installation environment of the VFD must be as follows:

- 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, provisions must be made 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 accordingly to prevent such ingress of any vermin (including insects such as spiders).

To ensure the smooth flow of the cooling air (see *6 kV air-cooling plenum* on page 97 and *11 kV air-cooling plenum* on page 98), and ease of operation and maintenance, proper clearance must be provided around the VFD, see *Cabinet clearance* on page 97.

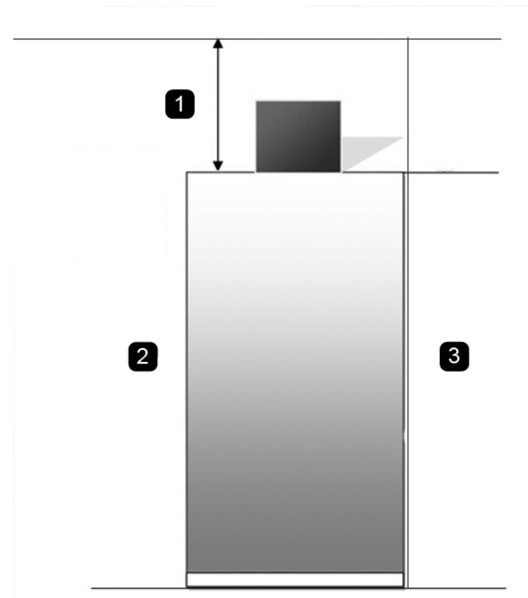
Figure 7-3: Cabinet clearance

Double side service zone



1	Top fan maintenance space (>55 in (1400 mm))
2	Front maintenance space (>63 in (1600 mm))
3	Back maintenance space (>63 in (1600 mm))

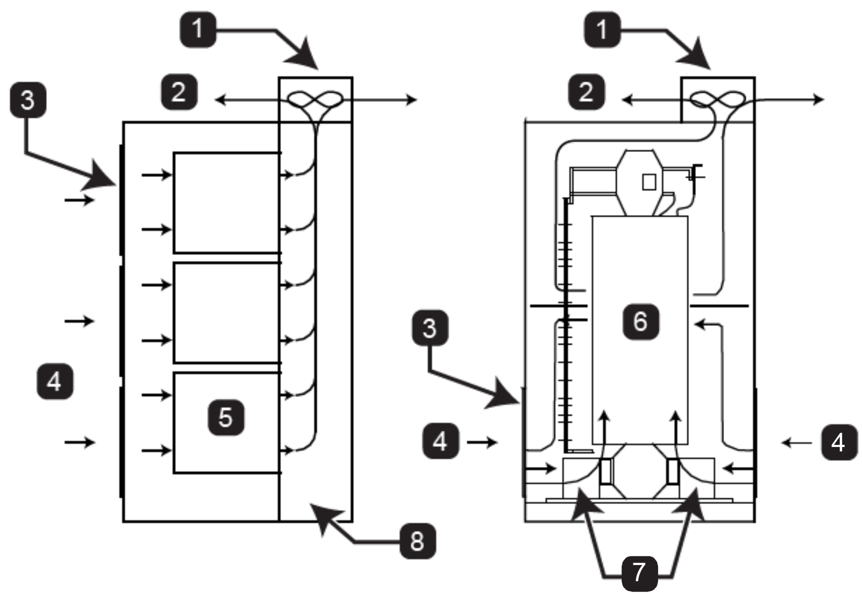
Single side service zone



1	Top fan maintenance space (>55 in (1400 mm))
2	Front maintenance space (>63 in (1600 mm))
3	Wall

Figure 7-4: 6 kV air-cooling plenum

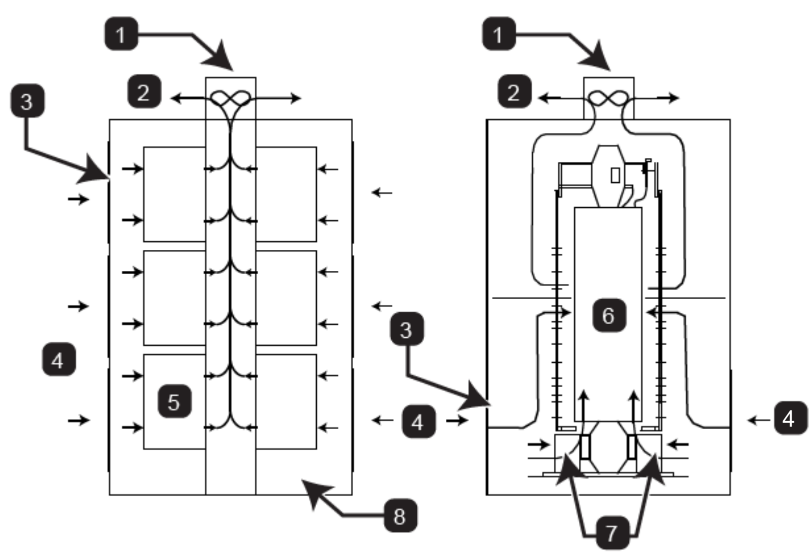
Control/power cell cabinet *Transformer cabinet*



1	Centrifugal fan		**5**	Power cell
2	Air outlet		**6**	Transformer
3	Filter (Front)		**7**	Bottom fan
4	Air inlet (Front)		**8**	Independent air duct

Figure 7-5: 11 kV air-cooling plenum

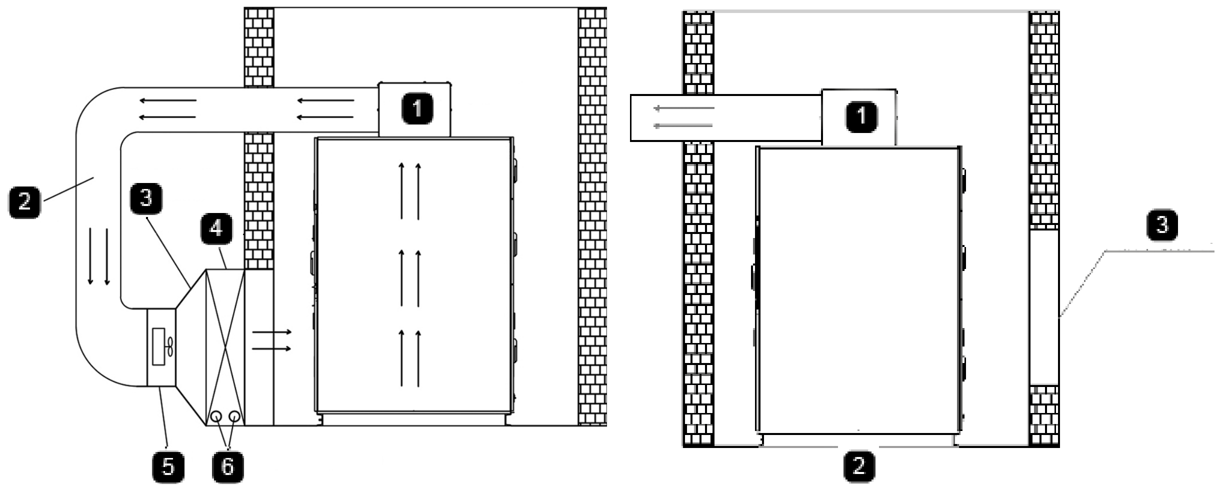
Control/power cell cabinet *Transformer cabinet*



1	Centrifugal fan		**5**	Power cell
2	Air outlet		**6**	Transformer
3	Filter (Front)		**7**	Bottom fan
4	Air inlet		**8**	Independent air duct

In case of high ambient temperatures or poor ventilation, it may be necessary to install a circulation fan or industrial air conditioning. To reduce the ambient temperature of the VFD, a concentrated ventilation duct can be installed by the customer. The hot air can be ejected outdoors by the centrifugal blower through the ventilation duct. The concentrated ventilation duct is directly connected to cooling blowers on the top of the cabinet (see *Air-water cooling diagram* on page 99). 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.

Figure 7-6: Air-water cooling diagram



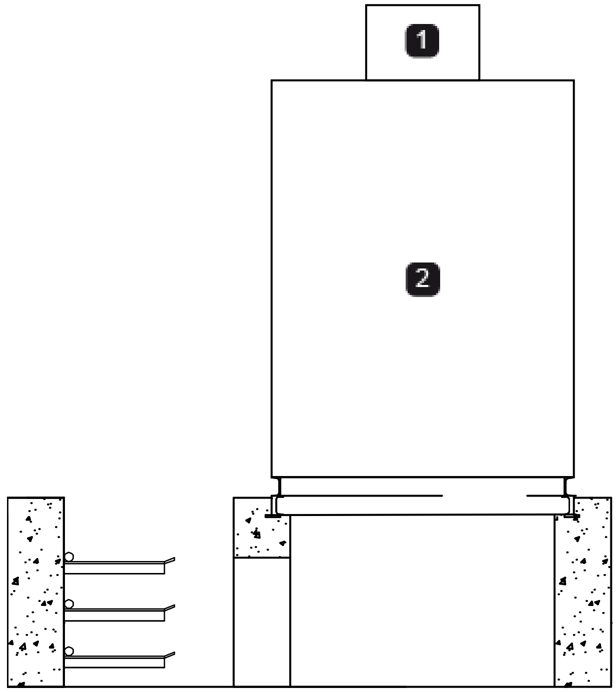
1	Top fan
2	Air duct
3	Air duct soft connection
4	Heat exchanger
5	Booster fan
6	Cooling water inlet/outlet

1	Top fan
2	Air duct
3	Air inlet (area > total area of all fan outlets)

For the 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 HP/1600 kW, it is made of 16# channel steel. For rated powers larger than 5364 HP/4000 kW, it is made of 18# joist steel.) Thus 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.

Figure 7-7: Cable channel/duct



1	Top fan	**2**	VFD

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 pre-charge cabinet is used for limiting the inrush currents of high power VFD systems.

If the selected accessories include bypass cabinet, pre-charge cabinet etc., the actual position is according to the specific project drawings.

8. Troubleshooting and maintenance

8.1 Overview

The general-purpose MV VFD has a complete fault monitoring and protection mechanism. Events can be divided into two categories:

- Alarms: When an alarm is active, the VFD will report the event but continues to operate. The VFD can be turned on, started, or running.
- Faults: When a fault occurs, the MV power will be removed immediately, the fault information will be recorded and the system will be latched in the fault state.

Before seeking service, you can first perform a self-inspection according to the alarm or fault name and the suggestions in this section. When seeking service, contact Benshaw or your local supplier.

8.2 Alarm events and alarm signal

When an alarm occurs, the system issues an alarm signal and displays the condition. The indicator light will blink.

NOTE

The VFD does not record alarms.

The alarm condition is cleared automatically when the condition causing the alarm goes away. When an alarm occurs during operation, the VFD will not stop. When an alarm occurs before medium voltage is applied in the VFD, two options can be selected. This can be set using the *Minor fault energized* parameter. If the parameter is set to ‘Enable’, MV power can be applied to the VFD. If set to ‘Disable’, MV power will not be applied.

Alarm messages include:

- Transformer overheat alarm
- Power cell cabinet overheat alarm
- Cabinet door interlock alarm
- Analog line drop
- Analog feedback loss
- Touchscreen non communication!
- Fan loss of power
- Fan alarm
- Clean the air filter
- Motor overload
- Controller communication fault
- Power cell bypass
- Water-cooling fault
- Excitation difference is too large
- Transformer heat exchanger leakage
- Power cell door alarm
- Transformer door alarm
- Cooling fan failure alarm

8.3 Fault items and fault signal

When a fault occurs, the system issues a fault signal indicating the fault condition and commands the medium voltage breaker or contactor to open. At the same time, the drive records the failure. The drive will remain in the fault state until reset. The VFD will change to a ready status after troubleshooting and resetting of the fault is complete.

When a fault occurs, the VFD will trip and the following messages can be displayed:

- Motor overcurrent
- VFD overcurrent
- Fuse fault
- IGBT drive fault
- Power cell over-heat
- Power cell overvoltage
- Fiber fault
- VFD instant tripping after power on
- Low frequency vibration while starting up
- Three-phase output unbalance
- Output to ground short circuit
- Input unbalance
- Input to ground short circuit
- Cabinet over-heat
- Transformer cabinet temperature
- Parameters setting error
- Contactor fault
- Debug mode HV-on forbidden
- System overspeed
- Excitation fault
- External fault
- High voltage power loss
- Controller is not enabled
- Incorrect input power display value
- Main control board version error
- Controller fault
- VFD start fault
- Bypass power fault
- Fiber upper fault (transmit)
- Fiber lower fault (receive)
- Power supply fault
- I/O board not ready
- Power cell fault
- Power cell door heavy fault
- Overvoltage fault
- Transformer door heavy fault

8.4 Normal problems processing

When a VFD trip occurs, the touchscreen will display related trip information. Based on this information, the operator can take appropriate measures to troubleshoot the failure.

VFD trip analysis

See *VFD trip flow chart* on page 103 to analyze the cause of the VFD trip.

Figure 8-1: VFD trip flow chart

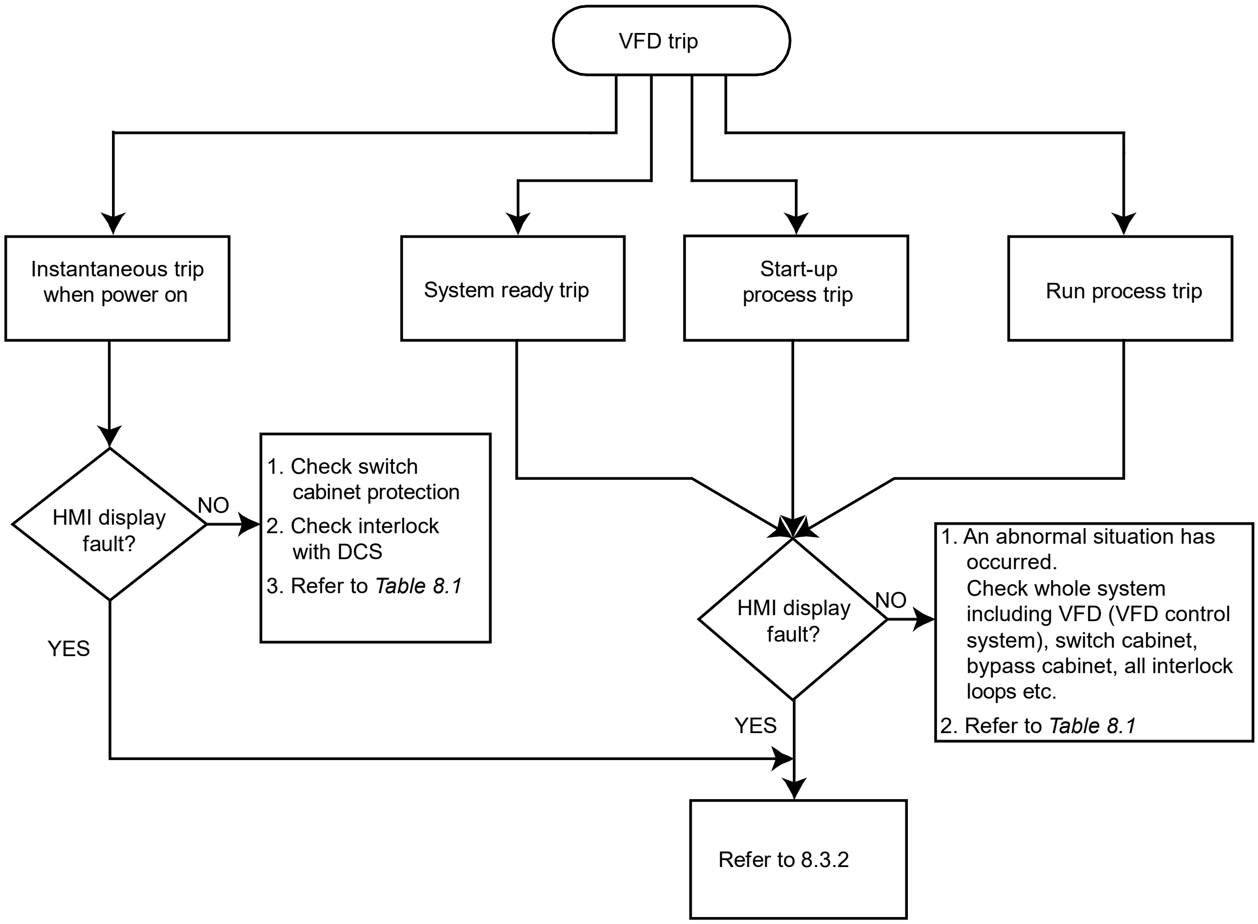


Table 8-1: Check before VFD power on

No.	Item		Key points
1	VFD & accessory equipment	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.
		Interlock wiring & control power	Check if cabinet control loop power supply is operating normally. Check if MV interlock switch wiring is correct.
		VFD	Check if the primary wiring from the transformer cabinet to the cell cabinet is correct. Check if VFD parameters are set correctly. Does the VFD status display ‘High voltage not ready’? Check whether fault indicator is on. Resolve fault condition before attempting to energize.

No.	Item		Key points
2	Load equipment	Primary wiring	Check if wiring from VFD to motor is correct.
		Motor	Check load. Check if the motor rotation is mechanically blocked. Check if it runs normally at rated frequency.
		Load	Check if motor or load cooling is operating normally.
3	File record	Project-specific parameters	Check if correct project parameters are set.

WARNING

- 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.
- To prevent personal injury caused by the residual voltage of the main circuit capacitors, wait at least 10 minutes after power shutdown or failure and confirm that power indication is off before performing maintenance and inspection.
- Only qualified electrical maintenance personnel should perform maintenance, inspection or replacement of parts.

List of alarms

Use this section to troubleshoot when the VFD reports an alarm. The alarm messages are listed in alphabetical order.

- **Analog feedback loss**

Possible cause	Suggested solution
Is the analog signal line present?	Check whether the analog signal wiring is correct and measure whether there is any signal.
The power supply is not powered.	Check whether there is power to the power supply.

- **Analog line drop (Analog speed reference drop)**

Possible cause	Suggested solution
Is the analog speed reference signal present?	Check whether the analog signal wiring is correct and verify if there is any signal.
The power supply is not powered.	Check whether there is power to the power supply.

- **Cabinet door interlock alarm**

Possible cause	Suggested solution
Is the indicator switch operating when cabinet door is closed?	Ensure the indicator switch is properly adjusted to make contact with the door.
Is the secondary wiring of the door switch open or damaged?	Ensure the secondary wiring is connected correctly to the door switch.
Is the I/O port input of interface board damaged?	Consult factory.

- **Clean the air filter**

Possible cause	Suggested solution
Is *Ventilation filter cleaning* time parameter set correctly?	Ensure the ventilation filter alarm protection is set correctly.
Are the filters dirty or blocked?	Replace the dust filters.

- **Controller communication fault**

Possible cause	Suggested solution
Is there a communication line connection error?	Ensure the internal wiring is correct. The communication cable between the PLC and the main controller must be plugged in properly: • The PLC end of the cable must be plugged into the PLC. • The main controller end of the cable must be plugged into the RS485 port on the AP4 board.
Has the power supply of the interface board failed?	Ensure the polarity is correct and the connections are secure.
Is the controller power supply correct?	Measure the power board voltage to be sure it is within the nominal 24 VDC range.
The main control board program version doesn't match.	Consult factory.
The main control is board damaged.	Consult factory.

- **Excitation difference is too large**

The protection value for this alarm is ≥10%.

Possible cause	Suggested solution
Are the parameter settings for the field excitation interface correct?	Ensure parameters are set correctly.
Is the field excitation deviation between given current and feedback current value exceed 10%?	Ensure the current deviation value is within the allowed range.

- **Fan alarm**

Possible cause	Suggested solution
This normally occurs if medium voltage is not being applied to the drive and *Top fan control* is set to 'Stop'.	When medium voltage is applied to the drive, the fans will activate and 'Fan Alarm' will automatically clear.
Is there a cabinet fan wiring error or fault?	Ensure the fan fault signal cable connection is correct.
Are the fan auxiliary contacts open?	Verify the fan auxiliary contacts operate correctly.
If *Minor fault energized* is set to 'Enable' and the fans are not running a fan alarm will occur.	Set *Minor fault energized* to 'Disable' and set *Top fan control* to 'Start'.

- **Fan loss of power**

Possible cause	Suggested solution
Is any of the following open/tripped: fan power circuit breaker, contactor, thermal relay?	Ensure the fan circuit breaker, contactor and thermal relays are operating normally. Ensure no fan overload condition exists.
Are the fan auxiliary contacts open?	Consult factory.

- **Motor overload**

Possible cause	Suggested solution
Has the motor current reached the protection value?	If the VFD is operating in an overloaded state, reduce the load, then observe the output current.
Is *Acceleration time* too short?	Increase *Acceleration time*.
Is *Deceleration time* too short?	Increase *Deceleration time*.
Are *Motor no-load current and Motor rated current* set correctly?	Ensure parameters are set correctly.
Is the mechanical load too high or has the motor stalled?	Resolve the mechanical fault.
Is the VFD model too small or undersized?	Check that the VFD model current rating is adequate for the motor load characteristics.

- **Power cell bypass**

Possible cause	Suggested solution
Is there a fuse fault?	Replace the power cell.
Is there an IGBT fault?	Replace the power cell.
Is there a fiber optic fault?	Replace the power cell.
Is there is a bypass contactor fault?	Replace the power cell.
Is the power cell overheated?	Replace the power cell.
Is there too much dust inside the power cell?	Replace the power cell.

- **Power cell cabinet overheat alarm**

The protection value for this alarm is 55 °C.

Possible cause	Suggested solution
Is one or more cooling fans not operating?	Ensure the fan circuit breakers, contactor and thermal relays are operating normally.
Are the filters dirty or blocked?	Check by placing a piece of paper on the filters. If it does not hold, the filters are dirty or blocked.
Has the VFD been operating in an overloaded state for a long period of time?	Reduce the load and then check the temperature displayed on the touchscreen.
Is the ambient temperature too high?	Reduce the ambient temperature by increasing the site air-conditioning/cooling.

- **Power cell door alarm**

Possible cause	Suggested solution
Is the door switch operating properly when cabinet door is closed?	Ensure the door switch is making good mechanical contact with the door.
Is the secondary wiring of the door switch open or damaged?	Check the secondary wiring to ensure it is connected correctly to the door switch.
Is the I/O port input of the interface board damaged?	Consult factory.

- **Touchscreen non communication!**

Possible cause	Suggested solution
Does the touchscreen receive 24 VDC power?	Check for 24 VDC supply to rear connector of touchscreen.
Is the communication network cable to the touchscreen disconnected?	Check the continuity of the network cable between the HMI and PLC.
Is the cable damaged or is there poor cable contact?	Ensure the network cable is plugged in.
Is the touchscreen port damaged?	Consult factory.

- **Transformer door alarm**

Possible cause	Suggested solution
Is the door switch operating properly when cabinet door is closed?	Ensure the door switch is making good mechanical contact with the door.
Is the secondary wiring of the door switch open or damaged?	Check the secondary wiring to ensure it is connected correctly to the door switch.
Is the I/O port input of the interface board damaged?	Consult factory.

- **Transformer heat exchanger leakage**

Possible cause	Suggested solution
Visually check whether the water leak is from the heat exchanger or some other location in the equipment.	Consult factory.

- **Transformer overheat alarm**

The protection value for this alarm is 115 °C.

Possible cause	Suggested solution
Is the temperature protection value set incorrectly on the transformer RTD monitor?	Ensure the temperature setting protection value is correct.
Is the thermal sensor resistance abnormal?	Check whether the thermal sensor in the transformer is damaged.
Is one or more cooling fans not operating?	Ensure the fan circuit breaker, contactor and thermal relays are operating normally.
Has the VFD been operating in an overloaded state for a long period of time?	Reduce the load and observe the transformer temperature.

Possible cause	Suggested solution
Is the ambient temperature too high?	Reduce the ambient temperature by increasing the site air-conditioning/cooling.

- **Water-cooling fault**

Possible cause	Suggested solution
Is the temperature too high?	Ensure parameters are set correctly. Check whether the external circulating water is turned on.
Is the conductivity too high?	Check whether the conductivity value exceeds the set value. Ensure the internal water deionization process is operating normally.
Is the water level too low?	Check if the water level is too low.
Is there is a wiring error?	Ensure the feedback wiring is correct and not damaged.

List of faults

Use this section to troubleshoot when the VFD reports a fault. The fault messages are listed in alphabetical order.

- **Will not run when given command to run**

Possible cause	Suggested solution
Is the 'VFD disable' signal input open?	Find out why the 'VFD disable' input is open. Ensure any pushbutton switches (E-stops) or interlock signals are in the closed circuit state.
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.

- **Cabinet overheat**

The protection value for this fault is 60 °C.

Possible cause	Suggested solution
Are the fans in the power cell cabinet operating normally?	Ensure the fan circuit breaker, contactor and thermal relays are operating normally.
Are the filters dirty or blocked?	Check by placing a piece of paper on the filters. If it does not hold, the filters are dirty or blocked.
Has the VFD been operating in an overloaded state for a long period of time?	Reduce the load and then check the temperature displayed on the touchscreen.
Is the ambient temperature too high?	Reduce the ambient temperature by increasing the air-conditioning and cooling in the area around the VFD.
Is the temperature feedback board damaged?	Consult factory.

- **Contactor fault**

Possible cause	Suggested solution
Is the power supply of the unit control board operating normally?	Consult factory.
Is the contactor damaged?	Consult factory.

- **Controller is not enabled**

Possible cause	Suggested solution
Is the connection between the controller and the PLC interface board open or damaged?	Check the wiring for open or bad connections.

- **Debug mode HV-on forbidden**

Possible cause	Suggested solution
Is the signal line of the XS3T-4 terminal on the interface board open?	Check whether the wiring is disconnected.
Is the interlock protection operating normally.	Correct as necessary.

- **Excitation fault**

Possible cause	Suggested solution
Is the field excitation system operational and not in a fault state?	Check whether the field excitation system is operational. Correct as necessary.
Is the interface board's field excitation fault I/O port signal line shorted?	Ensure the interface board wiring is correct.

- **External fault**

Possible cause	Suggested solution
External equipment connected to the VFD has caused the VFD to trip.	Investigate the cause of the external trip. Correct as necessary. Can be caused by the MV Reset input being held energized (high).

- **Fiber fault**

Possible cause	Suggested solution
Is the control board of the power cell operating normally?	Consult factory.
Are the fiber optic signal transmit and receive locations swapped?	Check the fiber connections.
Is there dust inside the fiber optic connector?	Remove dust with a dust-free cloth or canned compressed air.
Is there poor contact between the fiber optic plug and receiver?	Ensure the fiber optic plug is firmly in place.
Is the fiber optic cable broken along its length?	Replace the broken fiber cable. Compare relative fiber brightness to any adjacent cell.
Is the fiber optic connector damaged?	Check for damage to the fiber optic connector and ensure it is firmly held in place.

Possible cause	Suggested solution
Is the power cell board too dusty, causing the power cell to falsely report a failure.	Remove dust from the board and power cell.
Has any kind of power cell fault been reported?	Consult factory.
Is the fiber receiver board damaged or failed?	Consult factory.

- **Fuse fault**

Possible cause	Suggested solution
Did a phase lose input power?	Ensure the wiring of the incoming power is correct. Using adequate and safe MV measurement techniques, measure the input voltage to ensure that all three phases are present.
Is there an abnormal power outage?	Identify the cause of any abnormal power outage. Correct as necessary.
Are the power cell incoming cables loose or disconnected?	Ensure the three-phase incoming cable of the power cell is connected correctly.
Is the fuse open or blown?	Check the cell fuses. Consult factory.
Is the VFD cabinet properly grounded?	Ensure that the VFD cabinet ground intra-resistance is less than or equal to 0.1 Ω.
Is the power cell board too dusty, causing the power cell to falsely report a failure.	Remove dust from the board and power cell.

- **High voltage power loss**

Possible cause	Suggested solution
Was there an input voltage power loss when the VFD was running?	Check for any abnormal situation on the site power grid.
The parameter settings for *Momentary power-off time* may be incorrect.	Ensure parameters are set correctly.

- **IGBT / Cell drive fault**

Possible cause	Suggested solution
Is the power cell voltage detection board damaged?	Ensure the power cell voltage detection board and the detection board resistance wiring are correct.
Was there a sudden load change?	Find the cause of the load transient. Correct as necessary.
Has the VFD output ground wire been removed?	Ensure the VFD output circuit wiring is correct.
Is the motor insulation damaged?	Measure the connection cable and motor to verify the motor winding insulation is within the allowed range.
Has the motor load stalled?	Clear the mechanical fault.
Is the VFD cabinet properly grounded?	Ensure that the VFD intra-cabinet ground resistance is less than or equal to 0.1 Ω.

Possible cause	Suggested solution
Is the power cell board too dusty, causing the power cell to falsely report a failure.	Remove dust from the board and power cell.
One or more IGBTs or gate drive boards may be damaged.	Consult factory. Replace the power cell.

- **Incorrect input power display value**

Possible cause	Suggested solution
Is *Rated input current (ratio)* set correctly?	Set *Rated input current (ratio)* correctly.
Is KA1 relay open?	Ensure KA1 relay is operational (IEC designs only).
Are the input voltage and input current phase sequence correct?	Ensure the wiring for the input voltage and input current phase sequence is correct.

- **Input to ground short circuit**

Possible cause	Suggested solution
Are the input power wiring and grounding of the transformer correct?	Ensure the VFD's main circuit wiring is correct. Perform a dielectric test on the main transformer line to ground, then compare the result with values from the transformer supplier.
Is the input cable insulation damaged?	Measure the insulation resistance of the input cable and verify that it is within the allowed range.
Are the lightning arrestors (if installed) damaged?	Replace lightning arrestors if damaged. After replacing the lightning arrestors, perform an insulation resistance test (“megger”) to verify the transformer is still healthy.

- **Input unbalance**

Possible cause	Suggested solution
Is there an actual input power system voltage imbalance?	Measure the input voltage using proper and safe MV measurement techniques, correct cause of imbalance.
The signal I/O board version doesn't match the control system.	Consult factory.
The signal board I/O sampling resistances do not match.	Consult factory.

- **Low frequency vibration while starting up**

Possible cause	Suggested solution
Is the VFD output torque not enough at low speed?	Adjust the *Torque boost gain* parameters, monitor the output current and output voltage waveform if possible.
Is there a loss of VFD output phase or an open output connection?	Ensure the VFD output terminal is connected correctly.

Possible cause	Suggested solution
Is the VFD running in a current limiting situation?	Adjust the current limiting parameters of the VFD.
Is parameter *Acceleration time* set correctly?	Adjust *Acceleration time*.
Has any kind of power cell fault been reported?	Consult factory.
VFD internal controllers need to be tuned.	Consult factory.
Is there something causing vibration of the mechanical load?	Resolve issue with load.

- **Main control board version error**

Possible cause	Suggested solution
Are the parameters uploaded?	The fault will automatically clear once the parameters are uploaded. Upload the parameters using the HMI.
The program versions do not match.	Consult factory.

- **Motor overcurrent**

The protection value for this fault is 110-150%.

Possible cause	Suggested solution
Are the values for the motor parameters set correctly?	Ensure motor parameters are set correctly.
Is the mechanical load abnormal?	Resolve the mechanical fault.

- **Output to ground short circuit**

Possible cause	Suggested solution
Is the VFD output short circuited to ground?	Ensure the VFD output terminal wiring and motor connections are correct and undamaged.

- **Overvoltage fault**

Possible cause	Suggested solution
Is *Deceleration time* too short for a high inertia load?	Increase *Deceleration time*.
Is the incoming line voltage too high?	Retap the transformer accordingly.
Is the Sensorless Vector Control unstable, causing current oscillations in the power cells to pump up the DC bus voltage?	Improve tuning of the vector and related controllers

- **Parameter setting error**

Possible cause	Suggested solution
The parameter settings are incorrect when control mode is synchronous vector control.	Ensure parameters are set correctly.

- **Power cell overheat**

The protection value for this fault is 85 °C.

Possible cause	Suggested solution
Are the cooling fans operating normally?	Check by placing a piece of paper on the filters.
Are the filters dirty or blocked?	Check by placing a piece of paper on the filters. If it does not hold, the filters are dirty or blocked.
The power cell overheating has damaged the internal sensor.	Consult factory.
Has the VFD been operating in an overloaded state for a long period of time?	Check whether the motor load is too high. Reduce the load and observe the operation.
Is the ambient temperature too high?	Reduce the ambient temperature by increasing the air-conditioning and cooling in the area around the VFD.

- **Power cell overvoltage**

The protection value for this fault is 1190 VDC.

Possible cause	Suggested solution
Is *Deceleration time* too short?	Increase *Deceleration time* and adjust the coefficient of *Overexcitation gain* to reduce regeneration.
Does the input voltage exceed the maximum value?	Check if the input voltage is within the allowed range.
Is the output current oscillating?	Adjust the speed ratio parameter.
Are the hall-effect current sensors operating normally?	Ensure the hall sensors are intact and the wiring is correct.
Is there high reactive power flowing in the motor?	Consult factory.
Is there an unbalanced or overhauling load?	Consult factory.

- **System overspeed**

Possible cause	Suggested solution
Are the *Control mode* and common control parameters set incorrectly?	Consult factory.

- **Three-phase output unbalance**

Possible cause	Suggested solution
Is the output voltage of any power cell low?	Consult factory.
Does any power cell output only a half wave?	Consult factory.
The signal I/O board version doesn't match the control system.	Consult factory.
Is the motor wiring correct and without fault?	Ensure the VFD output terminal wiring and motor connections are correct and undamaged.

Possible cause	Suggested solution
Are the motor windings damaged (shorted or open)?	Check the motor for damage.

- **Transformer cabinet temperature trip**

The protection value for this fault is 130 °C (for the transformer itself).

Possible cause	Suggested solution
Is the temperature protection setting correct?	Correct as necessary.
Are the filters dirty or blocked?	Check by placing a piece of paper on the filters. If it does not hold, the filters are dirty or blocked.
Are the fans operating normally?	Ensure the fan circuit breaker, contactor and thermal relays are operating normally.
Has the VFD been operating in an overloaded state for a long period of time?	Reduce the load and observe the VFD temperature.
Is the ambient temperature too high?	Reduce the ambient temperature by increasing the air-conditioning and cooling in the area around the VFD.

- **VFD instant tripping after power on**

Possible cause	Suggested solution
Has the safety ground of the main circuit been removed?	Remove safety grounding before energizing the VFD.
Is the VFD ground connected correctly?	Ensure the main circuit ground wire is connected properly and a low impedance earth ground is present.
Are the protection settings for the power cabinet set too low?	Adjust the protection value of the power cabinet according to the site's supply capability.
Is there excessive inrush current to the transformer?	Consult factory.

- **VFD overcurrent**

The protection value for this fault is 150%.

Possible cause	Suggested solution
Was there a sudden load change?	Find the cause of the load transient. Correct as necessary.
Are *Start frequency*, *Acceleration time*, *Overexcitation gain* correctly set?	Ensure parameters are set correctly.
Is the main output circuit wiring wrong?	Ensure the VFD output circuit wiring is correct.
Is the control method set to asynchronous VFD with open loop vector control without first using the motor parameter identification feature?	Identify the motor parameters in the correct order of parameter identification.

Possible cause	Suggested solution
If the control mode uses an encoder, is there a wiring error with the encoder?	Check if the encoder signal cable is connected correctly.
Is the diode on the output voltage detection board damaged?	Consult factory.
Is the output current waveform OK?	Adjust the *Speed proportional gain* parameter to optimize the output current waveform.
Is the motor insulation damaged?	Measure the connection cable, ensure the motor winding insulation is within the allowed range.
Is there a hall-effect current sensor wiring error?	Ensure that the hall sensor wiring is correct and the measured hall sensor input and output voltages are within the allowed range. Consult factory.
Is *Deceleration time* too short?	Increase *Deceleration time*.
Is *Acceleration time* too short?	Increase *Acceleration time*.
Are all the power cells operating normally?	Consult factory.
Has the motor or auxiliary machinery stalled?	Replace the motor if damaged or clear the mechanical fault.
Is *Start frequency* set too high?	Ensure parameters are set correctly.
Is *Torque boost gain* set too large?	Ensure parameters are set correctly.
If lightning arrestors are fitted, are they incorrectly wired?	Ensure the peripheral electrical equipment wiring at the output of the VFD is correct (as per factory specifications).
Is the VFD model too small or undersized?	Check that the VFD model current rating is adequate for the motor load characteristics.

8.5 Power cell replacement

All the power cells within 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. After replacement, contact your supplier with regard to power cell repair.

WARNING

- Do not perform troubleshooting and maintenance on the VFD with power on. Ensure you power off VFD before opening the cabinet door and follow all lock-out/ tag-out safety procedures.
- To prevent personal injury caused by the residual voltage of the main circuit capacitors, wait at least 10 minutes after power shutdown or failure and confirm that power indication is off before performing maintenance and inspection.
- Only qualified electrical maintenance personnel should perform maintenance, inspection, or replacement of parts.

Replace the power cell as follows:

1. Stop the VFD and take it out of service.
2. Switch off the MV supply. Depending on the configuration, either open the disconnect, pull out the MV switchgear dolly, or isolate the VFD using the isolation knife-switch in the bypass cabinet (when equipped with a bypass cabinet).

3. Lock out the local or remote MV switch and connect the cabinet's grounding switch (if supplied).
4. Wait at least 10 minutes after MV power is removed. All cell indicator lights will be off.
5. Open the cabinet door.
6. Unplug the TX, RX fiber optic plugs from the faulted cell.
7. Disconnect the R, S, T input power cable and L1, L2 output connection bus or wire from the faulted cell.
8. Remove the screws connecting the faulty cell to its mounting track.
9. Pull out the faulty cell along its track, handle cell with care.
10. Remove the fiber optic rubber stoppers from the new cell, and place plugs into the faulted cell fiber optic connections.
11. Install the spare or replacement cell, tighten mounting hardware, and wire in reverse order of removal.
12. Re-power the VFD. Verify proper operation.

8.6 Maintenance

WARNING

- Do not perform 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.
- To prevent personal injury caused by the residual voltage of the main circuit capacitors, wait at least 10 minutes after power shutdown or failure and confirm that power indication is off before performing maintenance and inspection.
- Only qualified electrical maintenance personnel should perform maintenance, inspection, or replacement of parts.

Routine maintenance and inspection

Item	Inspect content	Tool	Judgment criteria
Operating environment	Temperature	Thermometer	-5~+40 °C Derate VFD for use between 40~50 °C, reduce rated output current by 1% for every 1 °C.
	Humidity	Hygrometer	5~95% non-condensing
	Dust, grease, water and drips	Visual inspection	No dust, grease, or water leaks
	Vibration	Dedicated tester	0.15 mm, 9~58 HZ, max. 3m/s2
	Gas	Dedicated tester, Sniff, Visual inspection	No odor, no abnormal chemical smell or smoke
VFD	Heat	Dedicated tester, Thermometer	Outlet temperature is normal
	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

Item	Inspect content	Tool	Judgment criteria
	Cooling duct	Visual inspection	No dirt or other foreign materials blocking the air duct
	Input current	Ammeter	Within normal working range (see nameplate)
	Input voltage	Voltmeter	Within normal working range (see nameplate)
	Output current	Ammeter	Within normal working range or allowed short-term overload range
	Output voltage	Voltmeter	In the rated range for connected motor
Motor	Heat	Dedicated tester, Sniff	No abnormal high temperature or overheating and no burning odor
	Sound	Hearing, dedicated sound meter.	No abnormal sound or vibrations
	Vibration	Dedicated tester	No abnormal vibration

Regular maintenance

Perform regular maintenance on the VFD every three to six months according to the use conditions.

Item	Inspect content	Tool	Judgment criteria
VFD	Main circuit terminals	Screwdriver	Bolts and screws properly tightened, no damage to the cable or lugs
	PE/Ground terminal	Screwdriver, wrenches/torque wrench	Screws tightened, no damage to the cable
	Control circuit terminals	Screwdriver, torque screwdriver	Wires inserted, screws properly torqued, no damage to the wires or cables
	Internal connection cables, connectors	Screwdriver, torque screwdriver	Cables firmly inserted; connectors latched
	Mounting screws	Screwdriver/sleeve	Screw fastening
	Dust/dirt	Vacuum cleaner, compressed air	No dust, dirt, or fibers present
	Foreign matter	Visual inspection	No foreign matter in any cabinets or duct work
Motor	Insulation test	Insulation tester	No abnormal readings

NOTE

- The regular maintenance interval is every three to six months. If the VFD is in a dusty environment, the filter should be cleaned or changed regularly.
- Check the tightness of all the incoming and outgoing cables of the transformer, the incoming and outgoing cables of the power cell, and the control cables within the first month of operation of the VFD. Then check and tighten them every three to six months thereafter. Use a vacuum cleaner to remove the dust from the cabinet at the same time.
- Record the running condition of the VFD (see *VFD run record* on page 118). When a fault trip occurs, record the fault condition, find out the cause and resolve issue before powering on again.

Table 8-2: VFD run record

Record time	Indoor temperature	Transformer temperature	Cell cabinet temperature	Run frequency	Output current	Output voltage	Fault type & description

Spare VFD and power cell maintenance

- Make sure that spare cells have the two fiber optic rubber plugs inserted into TX/RX ports to prevent dust contamination of the fiber optic transceivers.
- For cells with electrolytic type capacitors, operate the spare cells every six months.
- When the VFD is stored for a long period of time, the power-on test should be run every six months. The power-on time during that test should be no less than one hour. When power is applied, a voltage regulator should be used to slowly increase the voltage to the rated value.

9. Modbus communications protocol

9.1 Definition and allocation of address codes

To ease control and management of the VFD, all parameters and operation state variables of the VFD are visible and available through the communication interface. You can deliver different functional codes and address code messages through the host, operate the VFD, acquire the state information and set the relevant functional parameters of the VFD.

NOTE

The default setting required for RS-485 communications is:

- Parity: None
- Data bits: 8
- Stop bits: 1
- Protocol: Modbus RTU

Address range of Modbus communication message: 0x00 – 0x79.

The address range 0x27 – 0x3D contains functional parameters. You can change these parameters. However, some parameters cannot be changed when the VFD is in the running state.

The address range 0x3E – 0x63 contains system parameters. These parameters can only be changed when the VFD is in the standby state. When writing parameters, stay within the parameter setting ranges.

VFD control parameter address code assignment table

Name	Operation mode	Modbus register	Range/Increments
Start frequency	R/W	40001	Min. - max. frequency
Set parameter	R/W	40002	0-100%
Start/stop control	R/W	40003	Start: 00FF Stop: 0F00
Feedback parameter	Read only	40004	0.01%
Run frequency	Read only	40005	0.01 Hz
Input voltage	Read only	40006	1 V
Input current	Read only	40007	0.1 A

VFD status address code assignment table

All parameters in this table are Read Only.

- **VFD status address code assignment table**

Name	Modbus register	Range/Increments
Input power	40008	1 kW
Input power factor	40009	0.01
Output voltage	40010	1 V
Output current	40011	0.1 A
Output power	40012	1 kW

Name	Modbus register	Range/Increments
Output power factor	40013	0.01
Run speed	40014	1 rpm
Power cell temperature	40015	0.1 °C

<table>
<tr><th>Name</th><th>Modbus register</th><th colspan="5">Increments / Description</th></tr>
<tr><td rowspan="9">VFD status</td><td rowspan="9">40016</td><td>High bit</td><td>Running status</td><td colspan="3">Main control initiative
1: Main control ready
2: PLC ready
4: System standby
5: VFD running
6: Excitation status
7: Rotate load
8: Stop status
10: Fault status
11: Sync transfer: VFD to grid
12: Sync transfer: grid to VFD
13: Parameter identification</td></tr>
<tr><td rowspan="8">Low bit</td><td rowspan="8">System status</td><td>Bit</td><td>0</td><td>1</td></tr>
<tr><td>7</td><td>Main control board version error</td><td>Main control board normal</td></tr>
<tr><td>6</td><td>Locked phase success</td><td>Phase lock failure</td></tr>
<tr><td>5</td><td>Parameter setting correct</td><td>Parameter setting error</td></tr>
<tr><td>4</td><td>I/O board ready</td><td>I/O board not ready</td></tr>
<tr><td>3</td><td>Normal</td><td>System overspeed</td></tr>
<tr><td>2</td><td>Normal</td><td>VFD overcurrent</td></tr>
<tr><td>1</td><td>Normal</td><td>Power cell fault</td></tr>
<tr><td></td><td></td><td></td><td></td><td>0</td><td>Normal</td><td>High voltage not ready</td></tr>
<tr><td></td><td></td><td>Bit</td><td>0</td><td colspan="3">1</td></tr>
</table>

Name	Modbus register	Increments / Description		
Fault	40017	15		
		14		
		13		Transformer door heavy fault
		12		Power cell door heavy fault
		11		Controller is not enabled
		10		Debug mode HV-on forbidden
		9		
		8		
		7		Power cell fault
		6		
		5		High voltage power loss
		4		Motor overcurrent
		3		VFD overcurrent
		2		Overtemperature
		1		Transformer overtemperature
		0		External fault
Status monitoring	40018	**Bit**	**0**	**1**
		15		
		14		
		13		
		12		
		11		
		10		Water-cooling
		9		Touchscreen communication fault
		8		Power cell bypass
		7		Analog feedback loss
		6		Analog set loss
		5		Motor overload
		4		Transformer door alarm
		3		Power cell door alarm
		2		Power cell cabinet overheat alarm
		1		Transformer overheat alarm
		0		Fan alarm
System running time	40019	Low byte: Minute High byte: Hour		
	40020	Day		
System total running time	40021	Low byte: Minute High byte: Hour		
	40022	Day		

Name	Modbus register	Increments / Description
Main control version	40023	
Interface component version	40024	

Name	Modbus register	Increments / Description			
A1B1	40025	**Byte**	**Name**	**Mechanical cell bypass**	**IGBT cell bypass**
C1A2	40026	High byte	A1,C1,B2,A3, C3,B4,A5,C5, B6, A7,C7,B8, A8,C9	0: Normal 1: Fuse fault 2: Overtemperature 3: IGBT drive fault 5: Fiber upper fault 6: Busbar overvoltage 7: Fiber lower fault	0: Normal 1: Fuse fault 2: Overtemperature 3: IGBT drive fault 4: Power supply fault 5: Undervoltage fault 6: Overvoltage 7: Fiber fault
B2C2	40027				
A3B3	40028				
C3A4	40029				
B4C4	40030				
A5B5	40031				
C5A6	40032	Low byte	B1,A2,C2,B3, A4,C4,B5,A6, C6,B7,A8,C8, B9		
B6C6	40033				
A7B7	40034				
C7A8	40035				
B8C8	40036				
A8B9	40037				
C9	40038				

VFD command parameter address code assignment table

All parameters in this table are Read/Write.

Name	Modbus register	Description		
Parameter control group	40039	**Bit**	**0**	**1**
		15		
		14		
		13		
		12		
		11		
		10		
		9		
		8		Upload failed
		7		Download failed
		6		Upload success
		5		Download success
		4		Parameter upload (pulse signal)

Name	Modbus register	Description		
		3		Parameter download (pulse signal)
		2		Restore to default
		1	Restore to default - Disable	Restore to default - Enable
		0	Parameter setup disable	Parameter setup enable

Function parameter address code assignment table

All parameters in this table are Read/Write.

Name	Modbus register	Description			
		Bit	**Name**	**0**	**1**
Parameters group 1	40040	15	*Communication mode*	Modbus	Profibus
		14	*Cab door light/heavy fault choice*	Light fault	Heavy fault
		13	*Ventilation filter cleaning*	Ignore	Remind
		12	*Cooling method*	Air-cooled	Water-cooled
		11	*VFD-grid switch permit*	Disable	Enable
		10	*Minor fault energized*	Disable	Enable
		9	*Top fan control*	Stop	Start
		8	*Switch given selection*	Speed section 3	Speed section 7
		7	*Control mode set by remote*	Disable	Enable
		6	*Analog feedback loss*	Disable	Enable
		5	*Remote start/stop mode*	Pulse mode	Level mode
		4	*VFD reverse*	Disable	Enable
		3	*Self-start after MV loss*	Disable	Enable
		2	*MV loss quick break*	Disable	Enable
		1	*Analog set loss*	Disable	Enable
		0	*Run mode*	Open loop	Close loop

Name	Modbus register	Description		
		Byte	**Name**	**Descriptions**
		High	*Set mode*	0: Local set 1: AI set 2: DI set 3: DCS set
		Low	*Control mode*	0: Local control 1: DCS control 2: Remote control
Analog output	40042	High	*Analog output* 1	0: Output frequency 1: Output current 2: Power cell temperature 3: Excitation current 4: Output power 5: Output power factor 6: Output voltage
		Low	*Analog output* 2	

Name	Modbus register	Description/Range		
		Byte	**Name**	**Descriptions/Range**
Modbus parameter	40043	High	*VFD address*	1-247
		Low	*Baud rate*	0: 1200 1: 2400 2: 4800 3: 9600 4: 19200 5: 38400
Skip frequency 1 - lower limit	40044	0.00-80.00 Hz		
Skip frequency 1 - upper limit	40045	0.00-80.00 Hz		
Skip frequency 2 - lower limit	40046	0.00-80.00 Hz		
Skip frequency 2 - upper limit	40047	0.00-80.00 Hz		
Input voltage gain	40048	50-200		
DI set 1	40049	0.00-80.00 Hz		
DI set 2	40050	0.00-80.00 Hz		
DI set 3	40051	0.00-80.00 Hz		
Voltage loss time delay	40052	1.0-100.0 seconds		
Minimum set current	40053	0.00-8.00 mA		
Maximum set current	40054	10.00-25.00 mA		

Name	Modbus register	Description/Range
Minimum feedback current	40055	0.00-8.00 mA
Maximum feedback current	40056	10.00-25.00 mA
Process close loop P coefficient	40057	0.00-50.00
Process close loop I time	40058	0.01-20.00 minutes
Process close loop D time	40059	0.00-20.00 minutes
Resolution of Set Frequency	40060	0.01-1.00 Hz
Timing dust removal time	40061	15-30000 Day
Ventilation fan stop time	40062	0-30 minutes

System parameter address code assignment table

All parameters in this table are Read/Write.

<table>
<tr><th>Name</th><th>Modbus register</th><th colspan="4">Description/Range</th></tr>
<tr><td>Start frequency</td><td>40063</td><td colspan="4">0.00-5.00 Hz</td></tr>
<tr><td>Maximum frequency</td><td>40064</td><td colspan="4">0.00-80.00 Hz</td></tr>
<tr><td>Minimum frequency</td><td>40065</td><td colspan="4">0.00-80.00 Hz</td></tr>
<tr><td>Current limit gain</td><td>40066</td><td colspan="4">100-200%</td></tr>
<tr><td rowspan="3">Parameters group 3</td><td>40067</td><td>Byte</td><td colspan="2">Name</td><td>Range</td></tr>
<tr><td></td><td>High</td><td colspan="2">Cell bypass stages</td><td>0-1</td></tr>
<tr><td></td><td>Low</td><td colspan="2">Power cell stages</td><td>2-9</td></tr>
<tr><td rowspan="3">Parameters group 4</td><td>40068</td><td>Byte</td><td colspan="2">Name</td><td>Range</td></tr>
<tr><td></td><td>High</td><td colspan="2">Dead time compensation</td><td>0-20 us</td></tr>
<tr><td></td><td>Low</td><td colspan="2">Torque boost gain</td><td>0-15%</td></tr>
<tr><td>Acceleration time</td><td>40069</td><td colspan="4">5.0-6000.0 seconds</td></tr>
<tr><td>Deceleration time</td><td>40070</td><td colspan="4">5.0-6000.0 seconds</td></tr>
<tr><td>Momentary power-off time</td><td>40071</td><td colspan="4">0-2000 ms</td></tr>
<tr><td rowspan="9">Parameters group 5</td><td rowspan="9">40072</td><td>Bit</td><td>Name</td><td>0</td><td>1</td></tr>
<tr><td>15</td><td></td><td></td><td></td></tr>
<tr><td>14</td><td></td><td></td><td></td></tr>
<tr><td>13</td><td></td><td></td><td></td></tr>
<tr><td>12</td><td></td><td></td><td></td></tr>
<tr><td>11</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td><td></td></tr>
<tr><td>9</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th>Name</th><th>Modbus register</th><th colspan="4">Description/Range</th></tr>
<tr><td rowspan="8"></td><td rowspan="8"></td><td>7</td><td></td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Control status</td><td>Debug</td><td>Normal</td></tr>
<tr><td>3</td><td>Stop mode</td><td>Deceleration stop</td><td>Free stop</td></tr>
<tr><td>2</td><td>Master-Slave mode</td><td>Master mode</td><td>Slave mode</td></tr>
<tr><td>1</td><td>Master-Slave setting</td><td>Invalid</td><td>Valid</td></tr>
<tr><td>0</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Parameters group 6</td><td rowspan="3">40073</td><td>Byte</td><td>Name</td><td colspan="2">Description</td></tr>
<tr><td>High</td><td>VFD type</td><td colspan="2">1: Async motor VFD
2: Async motor SVC
3: Sync motor VFD
4: Sync motor SVC
5: Async sensorless VC
6: Sync sensorless VC
7: Brushless DC sync motor VFD
8: Permanent magnet sync motor VFD</td></tr>
<tr><td>Low</td><td>Start mode</td><td colspan="2">0: Normal start
1: Speed start
2: Parameter identification 1
3: Parameter identification 2</td></tr>
<tr><td>Rated input voltage</td><td>40074</td><td colspan="4">380-15000 V</td></tr>
<tr><td>Rated output voltage</td><td>40075</td><td colspan="4">380-15000 V</td></tr>
<tr><td>Rated output current</td><td>40076</td><td colspan="4">31.0-1600.0 A</td></tr>
<tr><td>Rated input current (ratio)</td><td>40077</td><td colspan="4">100-2000 :5</td></tr>
<tr><td>Transfer phase lock angle</td><td>40078</td><td colspan="4">0.5-5.0 °</td></tr>
<tr><td>Groups of motor parameter</td><td>40079</td><td colspan="4">0: Group 1
1: Group 2
2: Group 3
3: Group 4</td></tr>
</table>

<table>
<tr><th>Name</th><th>Modbus register</th><th colspan="4">Description/Range</th></tr>
<tr><td>Motor rated voltage</td><td>40080</td><td colspan="4">380-15000 V</td></tr>
<tr><td>Motor rated current</td><td>40081</td><td colspan="4">1.0-1600.0 A</td></tr>
<tr><td>Motor rated frequency</td><td>40082</td><td colspan="4">5.00-80.00 Hz</td></tr>
<tr><td>Motor rated speed</td><td>40083</td><td colspan="4">0-3600 rpm</td></tr>
<tr><td>Motor rated power</td><td>40084</td><td colspan="4">1-60000 kW</td></tr>
<tr><td>Motor rotational inertia</td><td>40085</td><td colspan="4">1.0-3000.0 kg.m^2</td></tr>
<tr><td>Motor no-load current</td><td>40086</td><td colspan="4">0.000-50.000 %</td></tr>
<tr><td>Stator resistance</td><td>40087</td><td colspan="4">0.000-25.000 %</td></tr>
<tr><td>Stator leakage inductance</td><td>40088</td><td colspan="4">0.000-50.000 %</td></tr>
<tr><td rowspan="7">Function word 2</td><td rowspan="7">40089</td><td>Bit</td><td>Name</td><td>0</td><td>1</td></tr>
<tr><td>15</td><td></td><td></td><td>Auto-calculate speed loop</td></tr>
<tr><td>14</td><td></td><td></td><td>Auto-calculate current loop</td></tr>
<tr><td>13</td><td></td><td></td><td>Auto-calculate flux loop</td></tr>
<tr><td>12</td><td></td><td></td><td>VF slip compensation</td></tr>
<tr><td>11-4</td><td>Spare</td><td></td><td></td></tr>
<tr><td>3-1</td><td>Excitation time</td><td colspan="2">1-16 seconds</td></tr>
<tr><td>Magnetic flux given</td><td>40090</td><td colspan="4">0.10-1.00 pu</td></tr>
<tr><td>Speed proportional gain</td><td>40091</td><td colspan="4">0.50-20.00</td></tr>
<tr><td>Speed integral time</td><td>40092</td><td colspan="4">0.10-20.00 seconds</td></tr>
<tr><td>Magnetic flux proportional gain</td><td>40093</td><td colspan="4">0.50-20.00</td></tr>
<tr><td>Magnetic flux integral time</td><td>40094</td><td colspan="4">0.10-20.00 seconds</td></tr>
<tr><td>Current proportional gain</td><td>40095</td><td colspan="4">0.10-15.00</td></tr>
<tr><td>Current integral time</td><td>40096</td><td colspan="4">0.15-30.00 ms</td></tr>
<tr><td>Encoder pulse number</td><td>40097</td><td colspan="4">0: 512
1: 1024
2: 2048
3: 4096
4: 8192
5: 16384
6: 65535</td></tr>
<tr><td>Frequency search current</td><td>40098</td><td colspan="4">0.10-1.00 pu</td></tr>
<tr><td>Motor rotation direction</td><td>40099</td><td colspan="4">0: Reverse
1: Forward</td></tr>
</table>

<table>
<tr><th>Name</th><th>Modbus register</th><th colspan="4">Description/Range</th></tr>
<tr><td rowspan="5">Function word 3</td><td rowspan="5">40100</td><td>Bit</td><td>Name</td><td>0</td><td>1</td></tr>
<tr><td>15-13</td><td>Curve selection</td><td colspan="2">0: Linear VF curve
1: 1.2 power curve
2: 1.5 power curve
3: 1.7 power curve
4: 2 power curve
5: VF separation curve</td></tr>
<tr><td>12-8</td><td>Overexcitation frequency</td><td colspan="2">1-30 Hz</td></tr>
<tr><td>7-3</td><td>Overexcitation gain</td><td colspan="2">1-30 %</td></tr>
<tr><td>2-0</td><td>Cell bypass model</td><td colspan="2">0: No cell bypass
1: Mechanical cell bypass
2: IGBT cell bypass</td></tr>
<tr><td>Master-Slave frequency difference</td><td>40101</td><td colspan="4">0.0-1.0 Hz</td></tr>
</table>

Excitation parameter address code assignment table

Name	Operation mode	Modbus register	Range
Power factor set value	R/W	40103	0.5-0.98
Auto-regulate switch freq.	R/W	40104	25.00-50.00 Hz
Async. start ex freq.	R/W	40105	0-50.00 Hz
Motor rated excitation	R/W	40106	0.1-1600.0 A
Ex min. given current	R/W	40107	0-20.00 mA
Ex max. given current	R/W	40108	0-20.00 mA
Ex min. feedback current	R/W	40109	0-20.00 mA
Ex max. feedback current	R/W	40110	0-20.00 mA
Ex cabinet current	R/W	40111	0-1600.0 A
Given excitation current	R/W	40112	0-1600.0 A
Feedback excitation current	Read only	40113	0.1 A
Excitation current	Read only	40114	0.1 A

Water-cooling parameter address code assignment table

All parameters in this table are Read Only.

Name	Modbus register	Increments
Inlet-Outlet water flow	40118	0.1 m^3/h
Outlet-water temperature	40119	0.1 °C
Inlet-air temperature	40120	0.1 °C
Outlet-air temperature	40121	0.1 °C

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