Super Energy-Saving Medium-Voltage AC Drive

MV510 Series

User Manual

Please be sure to hand in this user manual to customers.

Manual No: 4KD72X002W01 VER 02

Version History

REV	DESCRIPTION
00	Initial
01	Table 1-1 Variation range of voltage rating changes from -20% ~ +15% to -10% ~ +10%.
02	Table 1-1 Parameters change

Contents

Chapter I System Introduction

1.1 Preface

Thank you for choosing our MV510 series products and becoming a user of our company! We will provide you with the best technology and highest quality products!

TECO Electric And Machinery Co., Ltd. was established in mainland China by Antai International Invest (Singapore) Private Ltd. which belongs to a global well known TECO Group on July 1, 2000. The company is located in National High and New Technology Industry Development Zone in Wuxi, Jiangsu province with total investment of $24 million and the registered capital is $16.5 million. The company has international standard workshop, first-class product quality, and professional employees. The target is 2.5 billion RMB for future annual output value.

Currently, the company has about 1000 employees working in production, sales and marketing, research personnel of industrial control, low voltage products, and electronic equipment, including Elements Branch and Electronics Branch. Elements Branch has great production management capability, highly qualified automation technology, advanced production equipment, and a professional sales team. The mainly manufacture and sale low voltage products, and also manufacture power distribution products. Elements Branch offers a wide range of low voltage products. Products have reliable quality, reasonable price, and high customer rating. Power distribution products also have outstanding performance, reasonable price, and good market acceptance. To meet the market requirement, new products are developed to ensure market competitiveness.

Electronics Branch has the most advanced equipment and assembly line, the implementation of decentralized control and centralized management in the new control system as the center, the technical personnel with high level of electronic technology and rich experience, and with the latest electronic technology as the foundation, according to the demands of producing, providing a flexible production system the VFD more flexible. The production of industrial products has won the recognition of industry, production and sales.

MV510 series products are developed and produced by our company with

independent intellectual property rights, with no power grid pollution. MV510 series products can be used in a variety of different areas of the industrial environment, and a variety of complex occasions can meet the motor speed control and energy saving requirements.MV510 series products belong to high voltage equipment, and users must comply with some safety precautions. In order to make you more convenient and efficient to use our products, please read this user manual carefully before operating them.

1.2 System Overview

MV510 series products are manufactured at TECO Electric And Machinery Co, Ltd. MV510's topology is multiple-level cascaded. In other word, multiple low voltage VFDs called power cells are used to be connected in series to create medium voltage output, and the system doesn't need any boosting transformer in output side.

The input isolation transformer adopts a phase-shift transformer. Due to the topology of the drive, the input waveform is close to a sine wave with very low input harmonics affecting the power grid.

The carrier phase-shifted PWM technology is used to generate the needed output voltage and make the output voltage waveform very close to an ideal sine wave. So, the MV510 system can be directly connected to a medium voltage motor without an output AC filter.

1.3 System Characteristic

MV510 series medium voltage variable frequency system has the following advantages:

System integration design includes the input isolation transformer, power cells and control unit. Users only need to connect the medium-voltage input, medium-voltage output, low-voltage control power and control signal wires. The entire system is tested in the factory before shipping out.

Input conforms and be superior to IEEE519 ~ 1992 standards for voltage distortion and current distortion of the most stringent requirements.

VFD is medium-medium structure with medium voltage directly output. It doesn't need output boosting transformer. Output is to adopt modules series with phase-shifting PWM mode. Under full modulation, the number of output phase

voltage levels is 2*N+1, line voltage level is 4*N+1 (N is the number of the series power cells per phase.)

When operating in 30% ~ 100% of the load, power factor is higher than 0.96.(No power factor compensation VFD is required.)

The system can output sinusoidal current and voltage waveform without any output filter. Without special requirements for the motor, the VFD can drive normal asynchronous motor, and the motor can be used without de-rating. With soft-start function, no voltage drop due to the motor start-up shock, ensure motor can work with safety and long-term operating.

With resonance frequency jump function, the VFD output waveform will not cause the motor resonance.

The VFD has no requirement for the output cable length, and the motor will not be affected by the common-mode voltage and dv/dt.

The VFD has very strong adaptability to input voltage fluctuation, operating with full load in ±10%.The VFD can continue to run without tripping (30% drop in voltage). For 40% voltage reduction, VFD can operate in a short time.VFD does not trip against power grid instantaneous loss of 5 cycles to full load operation, or longer time to light load operation.

During 30% to 100% rated load, the efficiency can be achieved 96% and above.

Modular structure of power cell can be interchangeable and easy in maintenance. Power modulation automatic bypass function further improves the reliability of the operation.

The connection between power cell module and the main control system is to adopt the optical fiber for upgrading the communication speed and the anti-interference ability. The security becomes very outstanding.

Control system uses digital computer control system with self-diagnostic function.

Speed range: 0-100% continuously adjustable, frequency accuracy: ±0.5%, acceleration or deceleration time 0.1 ~ 6500.0 seconds (according to load conditions it can be set.), the critical speed can be skipped.(a total of 3 groups can be arbitrarily set.)

Overload ability is 120% 1 min, or the customized requirements.

Using HMI panel with Chinese or English display, easy to learn, easy to grasp and operation. The touch screen can display the working condition, working parameter, and fault type and fault point of VFD at any time for easy analysis and searching.

1.4 System Model

1.4.1 Product Model

Model number of medium voltage variable drive is shown as below:

MV510 - HA0 / 100 - S00

① ② ③④ ⑤ ⑥⑦

① MV:TECO medium voltage series drive

② Series number：510 Asynchronous (Motor) series，

512Synchronous (Motor)series

③ Input voltage level:

A-2.4kV, B-3kV,C-3.3kV,D-4.16kV,E-6kV,

F-6.6kV,G-7.2kV,H-10kV,J-11kV,K-13.8kV,X- others

④ Output voltage rating:

24-2.4kV, 33-3.3kV,42-4.16kV,66-6.6kV,A0-10kV,B0-11kV,

C0-13.8kV, etc.

⑤ Current rating：075,120, etc.

⑥ S: Standard，B: Power Cell Bypass

⑦ Customization coding

Example:

MV510-E60/100-S00 shows the MVD of TECO Electric & Machinery Co.,Ltd. with 6kV input voltage, 6kV output voltage, and 100A rated current power cell.

1.4.2 Product Label

Product nameplate of TECO Electric And Machinery Co, Ltd. for MV510 series drive is shown as below.

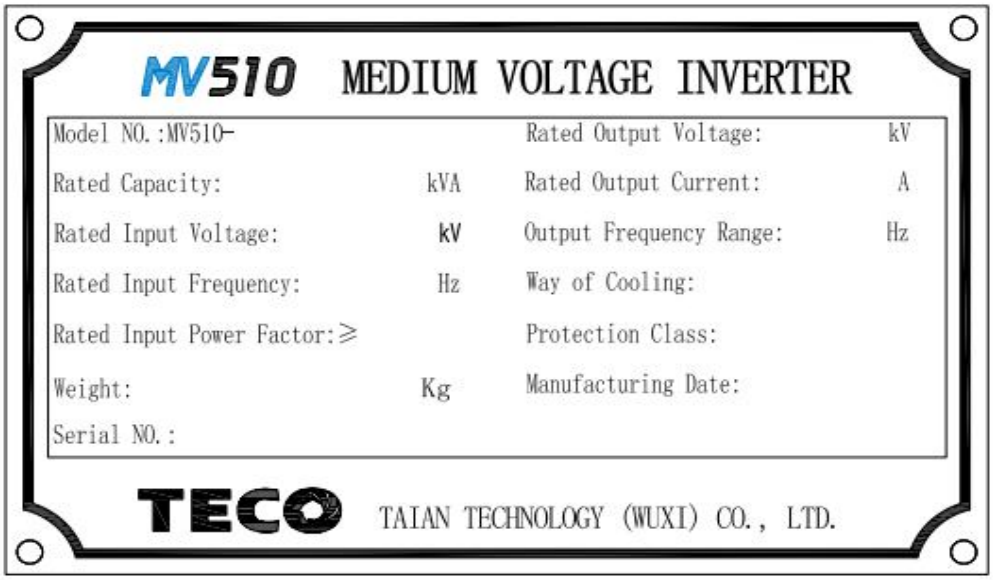

Figure 1-1 Product nameplate

Product nameplate includes the following:

- Product model, specifications, product number, etc.
- Technology specification
- Product use scope and degree of protection
- Manufacturer, manufacturing date, etc.

1.5 System Hardware

MV510 series drive cabinet outline depends on voltage level, power, model and other related factor. The main structure includes basic control cabinet, power cell cabinet, transformer cabinet, and bypass cabinet. Figure 1-2 shows typical complete assembly of a medium voltage VFD cabinet.

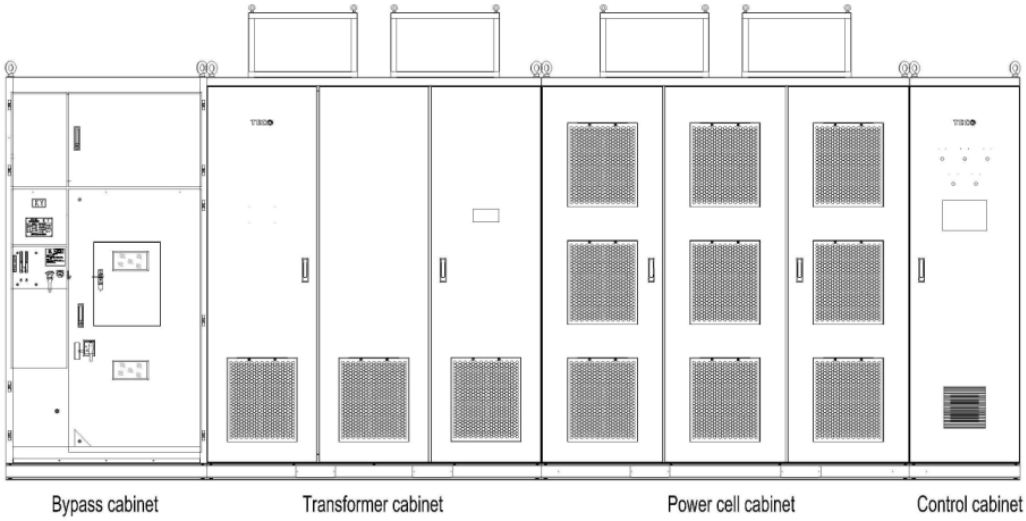

Figure 1-2A typical outlines drawing of MV510 series drive

1.5.1 Control Cabinet

This cabinet includes main control system, electric control system, user I/O terminals, communication and remote control function.

1.5.2 Power Cell Cabinet

Each unit is with a three-phase AC input and a single-phase inverter output. The input is respectively connected with the secondary output of the phase-shifting transformer, and the power cell output of each phase is connected in series to constitute the VFD main circuit, output PWM waveform to directly drive high-voltage motor.

Power cell is designed in modularized configuration. Power cells are easily swappable, and they only require front access which makes the installation and maintenance easy. Each power cell contains its own control board and communicates with the main control system via optical fiber communication. This is the only connecting between the main control and power cell. Each power cell and main control systems are entirely isolated.

1.5.3 Transformer Cabinet

With phase-shifting transformer, the primary winding is a high-voltage directly input, and the secondary winding for each power cell provides AC input voltage. Secondary winding adopts phase-shifting technology to make the harmonic pollution to the grid very small. Therefore the total harmonic in input side of the grid is reduced to 4% or less, directly meeting the IEEE519-1992 harmonic suppression

standards.

1.5.4 Bypass Cabinet

User can choose Bypass Cabinet as required. Bypass function can be implemented in case of VFD failure. The connection of power cables is from Bypass cabinet to Transformer cabinet for input high voltage, and from Bypass cabinet to motor for output voltage. Different equipment can be configured according to users' requirements, such as manual bypass cabinet or automatic bypass cabinet.

1.6 Specification

MV510's voltage range is 2.4kV ~ 13.8kV and rated current is 37A ~ 800A. The following table lists will show you the public electrical and mechanical specifications of MV510 series drives.

Table 1-1 General specifications of MV510 series drives

VFD rated capacity	250~10000kW/315~12500kVA ※
Input voltage rating	2.4kV~13.8kV（-10%～+10%）※
Rated frequency	50Hz/60Hz（-10%~+10%）
Modulation technology	CPS-SPWM
Control mode	380VAC~480VAC（3P4W），25~30kVA(depend on power level)
Power control	380VAC，5-30kVA(depend on power level)
Input power factor	>0.95(Above 20% load)
Efficiency	>98% (excluding transformer)
Output frequency	0Hz～120Hz
Frequency resolution	0.01Hz
Instantaneous over-current protection	180% Immediate protection
Overload capacity	120% 60sec.
Current limiting protection	10%-150% setting
Analog input	2 loops 4～20mA(extensible)
Analog output	4 loops 4～20mA(extensible)
Communication	Modbus RTU(optional)、Profibus DP(optional)、 TCP/IP(optional)
Deceleration time	0.1sec.～6000sec. (related to the load)
Digital I/O	12 loops DI / 9 loops DO(can expanded)
Environment temperature	-5～+40℃
Storage/transportation temperature	-40～+70℃
Cooling way	Forced air cooling
Environment humidity	<90%, no condensation ※
The installation elevation	<1000m，Higher altitudes 1000m，For every 100 m derating1% increase
Dust	Non-conductive, non-corrosive，<6.5mg/dm^3
Protection grade	IP30,IP31(customized)
Cabinet color	RAL7035(customized)

※ Please consult with TECO Co. Ltd. for the information beyond the above table.

Chapter II Precautions

2.1 General

When MV510 Series VFD is operated or used, safety precautions and relevant operating instructions must be strictly followed. Any incorrect operation may cause personal injuries and equipment damages. In order to prevent any electric shock or burn accident from happening and protect the equipment, be sure to read this manual before using the VFD. Besides, when operating the equipment, be sure to follow the requests in the safety signs and labels on the product.

2.2 Safety Precautions

Note: The product is high voltage electrical equipment. Please use it with attention!

Personal safety is sufficiently considered in the design of the VFD. However, just like other high voltage equipment, some safety regulations must be followed during its operation.

(1) Operators and maintainers of the VFD must have been specially trained, achieved the qualification certificate for operating and using electrical equipment, and carefully read this user manual.

(2) Be sure to install safety protection fence (with the warning board of high voltage danger). Don't move it away during the VFD operation.

(3) Be sure to follow high voltage operating instructions during maintenance, like wearing insulating gloves, insulating shoes and safety glasses. Be sure to have other staff at site for protection during work.

(4) It is prohibited to place inflammable materials beside the VFD.

(5) All of bypass cabinet, transformer cabinet and unit cabinet of the VFD are high voltage danger area. Please close and lock the cabinet doors before turning power on. Be sure not to open the cabinet doors for work or operation, unless for maintenance or safety inspection. Otherwise, please don't casually open the cabinet doors.

(6) Control cabinet and other cabinets adopt optical fiber isolation technique and have no high voltage but still only trained and authorized personnel are allowed to operate them.

(7) Be sure absolutely not to touch the inside of equipment with wet hands.

(8) Don't open cabinet doors and more seriously don't touch any part inside the equipment within 15 minutes after main power supply is switched off.

Relevant safety precautions are mentioned in other chapters and sections of this manual. These safety precautions must be followed to prevent personal injuries and equipment damage from happening.

2.3 Usage Precautions

(1) Application environment shall accord with the technical condition requirements of the product.

(2) Conduct the installation strictly following the installation steps provided in this manual.

(3) Operating and using staff of the product must be operating and using staff of electrical equipment who has received professional training.

(4) Products will unavoidably and constantly accumulate dust and different kinds of impurities during operation so regular clean and maintenance must be conducted on the product.

(5) After the product operates for certain time, fan vibration and other mechanical vibration may cause electrical contact parts becoming loose so as to cause poor contact and even the damage of parts, components and complete machine, which leads to users' inconvenience and loss. As a result, after the product operates for certain time, maintenance, clean and inspection shall be conducted to prevent loss from happening.

(6) Ground resistance shall be frequently inspected to see if it accords with equipment operation requirements and the requirements in national standards. Dangers may happen if ground resistance doesn't accord with requirements.

(7) Recording system of equipment operation status and application maintenance system shall be established.

(8) Make sure the motor stays still before starting the VFD.

(9) Follow the order of switching on/off power supply. For the startup process, first provide control power, and then on the high-voltage power supply. For stop process, the motor stops totally, and then turn off high voltage powers

supply and at last turn off control power supply.

(10) During the VFD operation, its user shall supervise the load operation status all the time and timely switch off the VFD if any abnormal status happens.

(11) Be sure good indoor ventilation and maintain environment temperature within the range of 0-40℃.

(12) Be very careful when handling or measuring the parts inside the VFD, and pay attention not to make short circuit among instrument wires or touch other terminals.

(13) It's forbidden to forcibly switch off the fan's power supply during the system operation, which will cause superheat and damage VFDs.

(14) Fault maintenance by users shall be limited to recording fault phenomenon and changing units if necessary and further repair work shall be handed over to our company.

(15) Be sure to replace power cell beyond 15 minutes after switching off high voltage power supply and confirm all the indicators on VFD units are off.

Chapter III Site Installation Instructions

3.1 Appearance and Weight

In this section, we mainly introduce basic appearance of different parts of MV510 Series VFD. We take Model MV510-E60/100-S00 (automatic bypass) VFD for example to introduce various parts as follows. See specific outline dimensions of configured VFD in the outside drawing that our company provides to corresponding project.

3.1.1 Control Cabinet and Power Cell Cabinet

Approximate weight: 2750kg (including the weight of power cells)

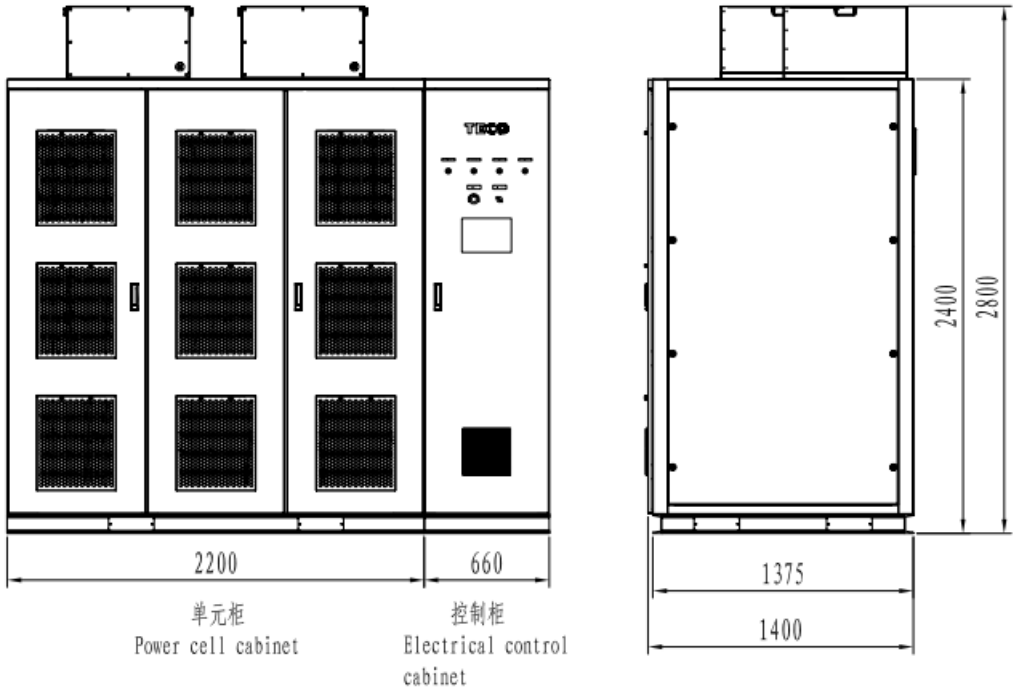

Figure 3-1 Outside Drawings of Control Cabinet and Power Cell Cabinet

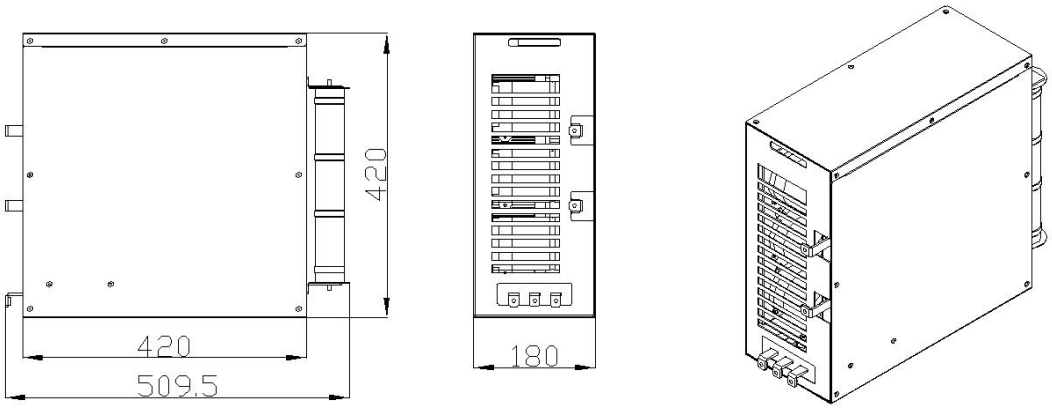

Figure 3-2 Outside Drawing of Power Cell

3.1.2 Transformer Cabinet

Approximate weight: 3270kg (including transformer weight)

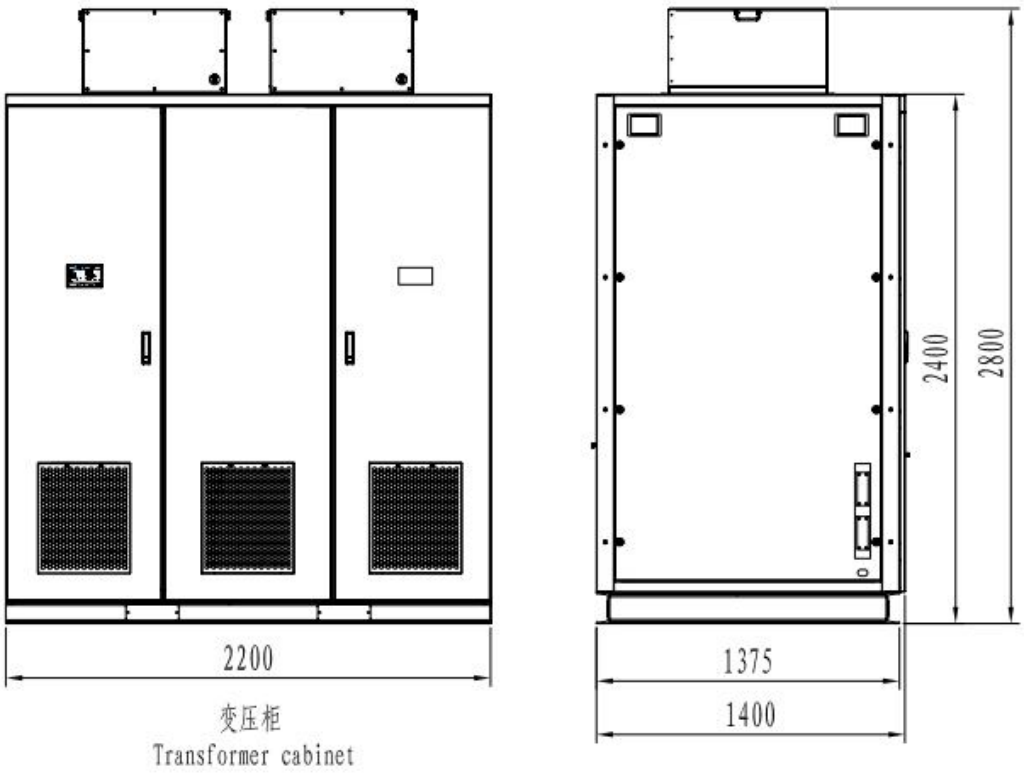

Figure 3-3 Outside Drawing of Transformer Cabinet

3.1.3 Bypass Cabinet (Optional, Automatic Bypass Cabinet)

Approximate weight: 600kg

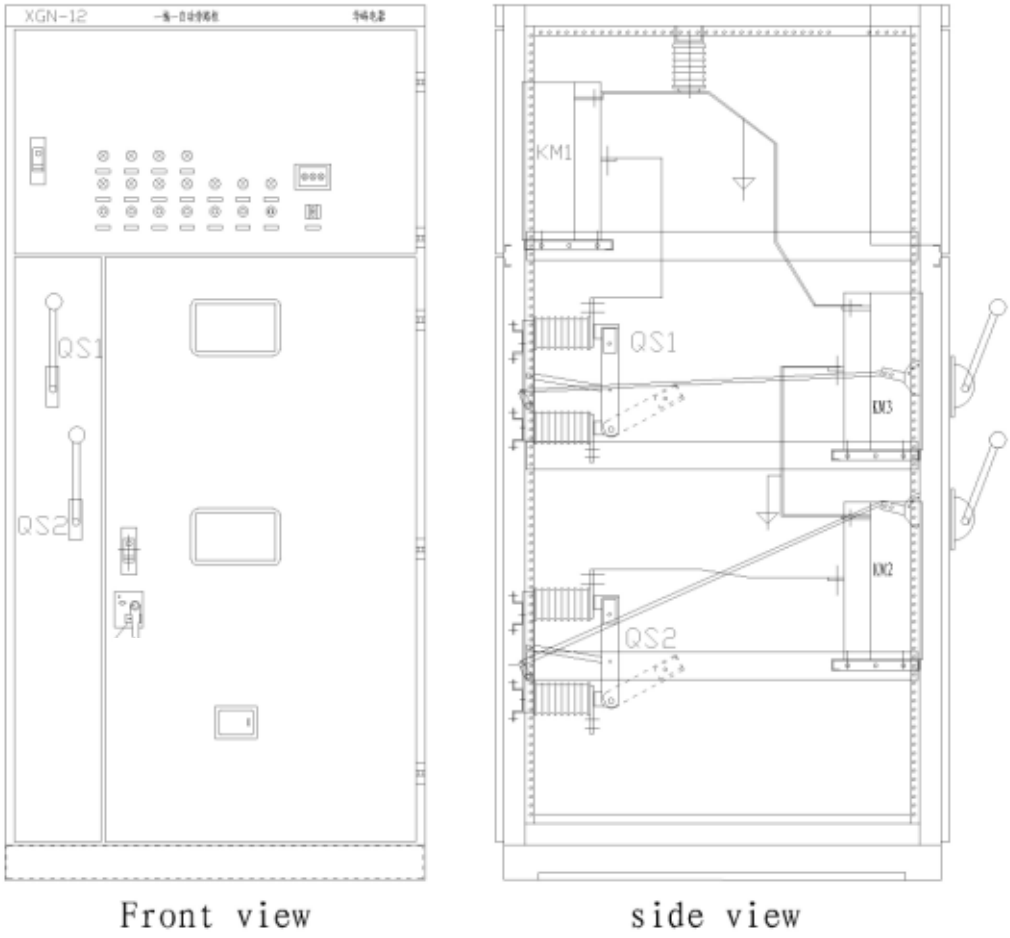

Figure 3-4 Outside Drawing of Automatic Bypass Cabinet

3.2 Installation Requirements

3.2.1 Installation Environment

Accord with the following environment indexes

S/N	Item	Requirement
1	Environment temperature	The temperature shall be within the range of 0℃~40℃
2	Environment humidity	It shall not be over 90% at the lowest temperature and no condensation will happen for temperature change
3	Altitude	1000m Lower than altitude 1000m
4	Atmosphere	Between 860~1060hPa

5	Indoor air quality	In the room where the equipment is installed, the air conditions shall be kept at normal aerial dust standard, especially for iron particles and organic particles, like organic silicon		
6	Corrosion factors	Corrosion factors		Density or quantity
		Corrosive gases	Hydrogen sulphide （H_2S）	≤0.001PPM
			Sulphur dioxide（SO_2）	≤0.05PPM
			Chlorine（CL_2）	≤0.1 1PPM
			Ammonia gas（NH_3）	≤0.1 1PPM
			Nitrogen dioxide（NO_2）	≤0.02PPM
			Nitric oxide（NO_X）	≤0.02PPM
			Ozone（O_3）	≤0.002PPM
			Acid mist of chlorine hydride（HCL_1）	≤0. 1mg/m^3

Note:

- Please use dust collector to clean the room where the equipment is placed so as to prevent more dusts.
- Please don’t use silicone waxes in the room where the equipment is placed, which will influence the motor.
- When external cables (grounding cable, main circuit cable and control cable) are connected into equipment cabinet, please confirm if the cable holes are sealed with stannic oxide. If the holes for connecting in cables are not sealed, air will get into the equipment and the installation environment mentioned above will be not safe, which will cause severe damage to the equipment.

3.2.2 Storage Environment

Please confirm the following different indexes related environment condition in the place where the equipment is stored:

- The equipment shall be placed indoor.
- Environment temperature shall be kept in the range of -40℃～70℃and there shall be no dramatic temperature changes.
- It’s suggested to store the equipment at a place where the humidity is in the range of 50%～60%. If the storage environment can’t reach it, store the equipment at a place with the humidity not over 90% and no condensation

will happen so as to prevent condensation.

- Store the equipment at a place without dust.
- Store the equipment at a place without much vibration or shock.
- Store the equipment at a place without corrosive gases.
- Keep the equipment far away from the interference of strong electromagnetic field.

3.2.3 VFD Layout

(1) Place the equipment with back side to wall or other equipment

If the equipment is placed with back side to wall or other equipment, the space requirement on VFD room is as follows:

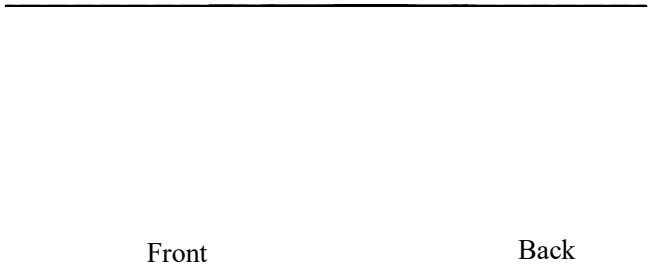

Figure 3-5 Maintenance Space and Ventilation Opening of VFD

(2) Place the equipment face to face

If the equipment is placed face to face, the space requirement on VFD room is as follows:

Figure 3-6 Maintenance Space and Ventilation Opening of VFD

After the construction is completed, it is requested that the doors, windows and ventilation openings of VFD room shall be completed with installation.VFD room shall have prevention measures against rain, snow, sands and dusts. Its roof and floor are completed with construction, and have no leakage.

3.2.4 Equipment Foundation

(1) Installation requirements for foundation box iron

Foundation box iron's dimensions accord with foundation drawing requirements. It is higher than toweled floor by 5~10mm, welding quality conform to requirements, strength and stiffness reach the load requirements of equipment. Equipment dimensions and weight are provided both on delivery package and user drawing.

- Horizontal tolerance

Datum length in horizontal standard has the tolerance of 1mm for every 1000mm.

Figure 3-7 Horizontal Tolerance Drawing

- Vertical tolerance

Front and back datum in vertical standard has the tolerance of 1mm for every 1200mm of cabinet depth.

Figure 3-8 Vertical Tolerance Drawing

- Parallel tolerance

Datum length in maintenance standard has the tolerance of 1mm for every 1000mm.

Figure 3-9 Parallel Tolerance Drawing

(2) General appearance of foundation

After foundation construction is completed and floor work is finished, there shall be no ponding or sundries in the room, embedded parts and preformed holes shall conform to design requirements, and embedded parts shall be fixed firmly. General appearance drawing of foundation is as shown in Figure 3-10, see detailed foundation drawing in the drawings attached to the VFD.

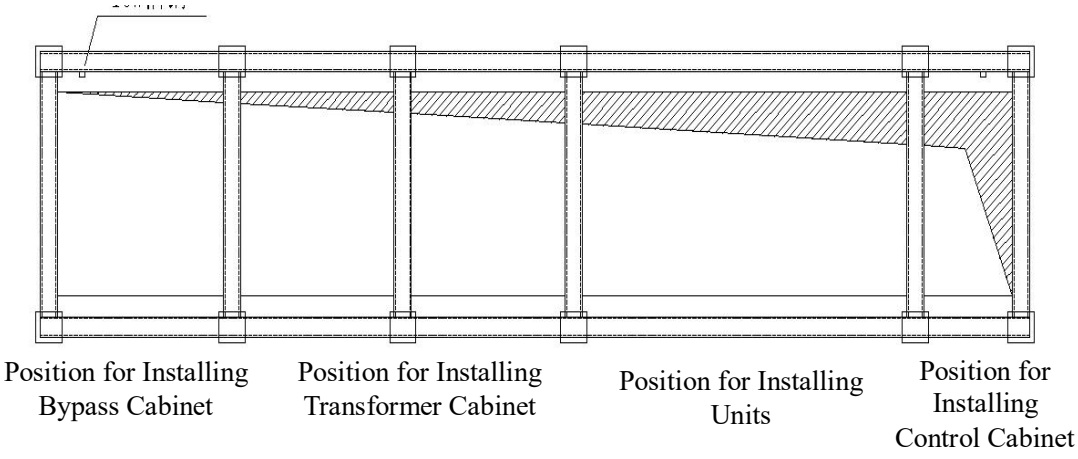

Figure 3-10 General Appearance of VFD Foundation

3.2.5 Equipment Grounding

Foundation box iron adopts steel for reliable grounding and see its minimum specifications in Table 3-1,overlap welding shall be adopted, see overlap length in Table 3-2 and connect it with grounding main line, conduct anti-corrosion measures, grounding resistance shall be lower than 4Ω. Concrete foundation shall be cured with flat surface and its strength reaches load bearing requirements.

Table 3-1 Minimum Specifications of Steel Grounding Part

Type	Specs	Unit	Over ground		Under ground
			Indoor	Outdoor	AC current circuit
Steel rod	Diameter	mm	6	8	10
Steel flat	Section	mm²	60	100	100
	Thickness	mm	3	4	4
Steel angle	Thickness	mm	2	2.5	4
Steel tube	Tube wall thickness	mm	2.5	2.5	3.5

Table 3-2 Overlap Length Specifications

Overlap Method	Overlap Requirement
Steel flat	2 times of width
Steel rod	6 times of diameter
Steel flat and steel rod	6 times of steel rod diameter
Steel flat and steel tube	Two sides of contact position and arc shape (or right angle shape) are made by steel strip

Steel flat and steel angle	The clip or arc shape (or right angle shape) are made by steel strip

3.3 Installation Process

3.3.1 Acceptance Check

Correct acceptance check procedures are as follows:

- Before opening any box, carefully count the box quantity referring to delivery list, and check if any packaging boxes are deformed or broken, or get wet for rain or splash.
- After opening the boxes, carefully check the goods in the boxes referring to delivery list, check if any part or document is missing, or doesn't match the list.
- If any part is damaged or doesn't match delivery list, please timely notify our company about it. We will handle the situation as soon as possible.

3.3.2 Estimated Weight

Because MV510 Series High Voltage VFD changes with the user's specific application, exact weight of equipment is related to the equipment capacity and chosen optional parts. The equipment's outline dimension and weight are provided both on its delivery package and in its user drawings.

3.3.3 Transportation

Note: It's strictly prohibited to transport the transformer cabinet with the lifting ring on the top of VFD cabinet, otherwise severe accident will happen. Those lifting rings are designed to transport empty cabinet in plant.

MV510 Series High Voltage VFD goes through individual assembly, integrated test, separate packaging and delivery in plant. Usually it has 4 parts, including control cabinet, unit cabinet, transformer cabinet and bypass cabinet. Each of them must be transported and installed by integration. Base box iron at the cabinet bottom has forklift holes for the convenience of forklift transport so with actual site situation:

- Lift with a crane or chain hoist
- Forklift
- Steel rolling

3.3.4 Cabinet Connection and Fixation

After the VFD cabinet is in right place, control cabinet, unit cabinet, transformer cabinet and bypass cabinet shall be connected together, and each cabinet shall be connected to foundation box iron.

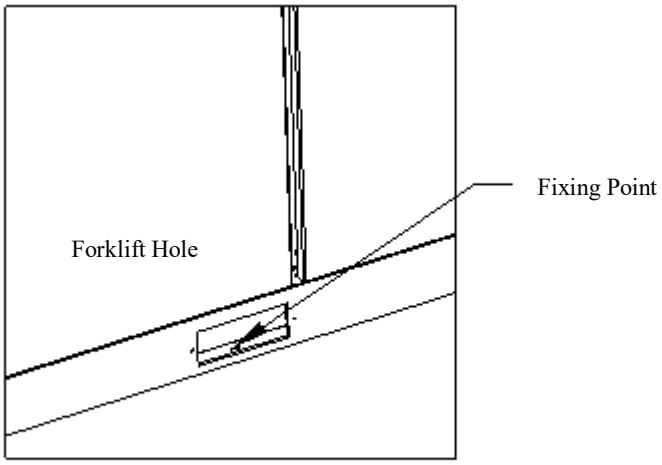

Figure 3-11 Fixing the Cabinet

Note:

- When the cabinets are transported and installed, safety measures shall be taken, such as shock prevention, damp prevention, prevention of frame deformation and prevention of paint damage.
- After the cabinets are in right places, connect them. See allowable deviations in perpendicularity, horizontal deviation, cabinet face deviation and the joint between cabinets in Table 3-3.
- See the minimum safety clearances between live parts side to side and face to face as well as between live parts and cabinet door in Table 3-4. Cabinet bodies and doors shall be reliably grounded, spot welding shall be conducted from the transformer and cabinet bodies to foundation box iron to guarantee reliable grounding.
- Fasteners used in the installation shall be galvanized standard parts.

Table 3-3 Allowable Deviation for Cabinet Body Installation

Item		Allowable Deviation (mm)
Perpendicularity (each meter)		<1.5
Horizontal deviation	Tops of adjacent two cabinets	<2
	Tops of the cabinets in one row	<5
Cabinet face deviation	Edges of adjacent two cabinets	<1
	Faces of the cabinets in one row	<5
Joints between Panels		<2

Table 3-4 Safety Net Distance

Range of Application	Rated Voltage		
	3kV	6kV	10kV
Side to side and face to face	75	100	125
Live parts to the door	105	130	155

3.3.5 Installation of Power Cells

- Confirm if power cells are damaged or become damp before installing them.
- Open side plates of power cells to check if any inside fasteners become loose before installing the units.
- Power cells shall be transported carefully, prevent sundries, especially metal articles, from falling into them during installation.
- When installing the power cell with rated current lower than 200A, two people can directly install in into unit cabinet, for installing the power cell with rated current higher than 200A, people can do it with the lift truck configured in the company.
- Power cells shall be installed neatly, in place, close to air channel side and tightly on back wind shield.
- Tighten power cells with screws after they are installed in place.

3.3.6 High Voltage Insulation Test on VFD

After the VFD is in place and before primary cables are connected, high voltage insulation test shall be conducted on the high voltage part of the VFD according to high voltage standard, including bypass cabinet and transformer cabinet.

(1) High voltage insulation test on bypass cabinet (with live displayer removed)

High voltage insulation test for bypass cabinet is mainly on high voltage components in the cabinet, like high voltage isolators and high voltage insulators.

If the VFD's rated voltage is 6kV, site test values of bypass cabinet are:

S/N	Test Item	Power Frequency Withstanding Voltage (Effective Value)	Time
1	Between three phases	AC32kV	1min
2	Between three-phase and ground	AC32kV	1min

If the VFD's rated voltage is 10kV, site test values of bypass cabinet are:

S/N	Test Item	Power Frequency Withstanding Voltage (Effective Value)	Time
1	Between three phases	AC42kV	1min
2	Between three-phase and ground	AC42kV	1min

(2) High voltage insulation test on transformers (with temperature probe removed from coils):

If the VFD's rated voltage is 6kV, site test values of the transformer are:

S/N	Test Item	Power Frequency Withstanding Voltage (Effective Value)	Time
1	High voltage---low voltage and ground	AC17kV	1min
2	Low voltage---high voltage and ground	AC17kV	1min
3	Between different groups of low voltage (totally 3 groups)	AC17kV	1min

If the VFD's rated voltage is 10kV, site test values of the transformer are:

S/N	Test Item	Power Frequency Withstanding Voltage (Effective Value)	Time
1	High voltage---low voltage and ground	AC24kV	1min
2	Low voltage---high voltage and ground	AC24kV	1min
3	Between different groups of low voltage (totally 3 groups)	AC24kV	1min

3.3.7 Electrical Wiring

Conduct the wiring inside the VFD only if the VFD passes high voltage insulation test. Inside wiring includes primary wiring and secondary wiring, which are respectively introduced as follows.

(1) Primary wiring

Primary wiring includes inside wiring as well as input and output cable wiring of the VFD.

- **High Voltage Power Supply Input and Output Cable:** High voltage input and output terminals are configured in bypass cabinet. High voltage input cable shall be connected to input copper bar in bypass cabinet while high voltage output cable (that is the cable for load motor) shall be directly connected to output copper bar in bypass cabinet, as shown in Figure 3-12. Users may choose to lead in and out cables from the top or bottom.

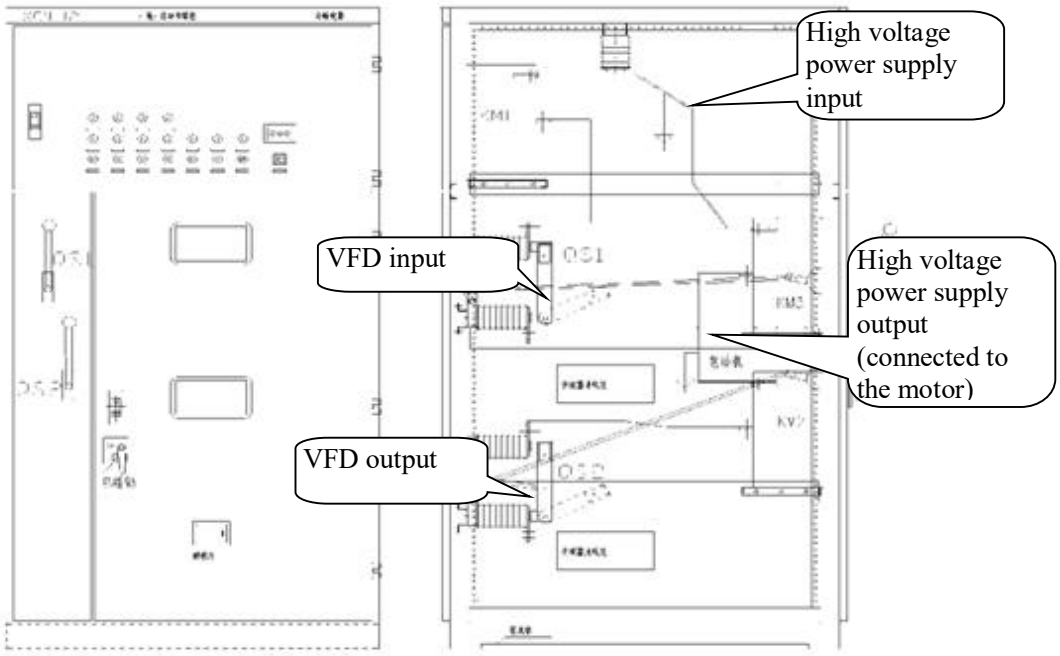

Figure 3-12 Primary Wiring Terminal Drawing of Bypass Cabinet

- **The cable from Bypass Cabinet to Phase-shifting Transformer:** Connect the lower end of QS1 to the primary side terminal of phase-shifting transformer with high voltage flexible cable. Wiring terminal of bypass cabinet is as shown in Figure 3-12 and primary side wiring terminal of the transformer is as shown in Figure 3-13:

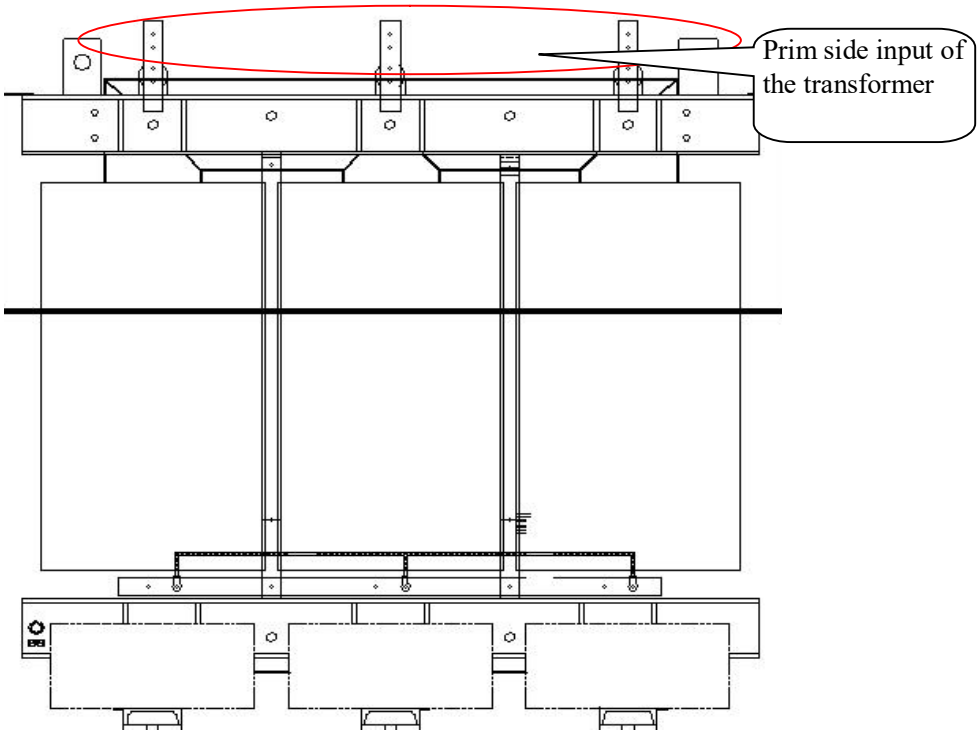

Figure 3-13 Input Terminals of the Transformer

- **The Cable from Secondary Side Terminal of Phase-shifting Transformer to Power Cell:** after VFD cabinet is in place and assembled, just connect two end of the cable with right cable number to secondary side terminal of phase-shifting transformer and input terminal of power cell. Secondary side terminal of the transformer is as shown in Figure 3-14 while input terminal of power cell is as shown in Figure 3-15:

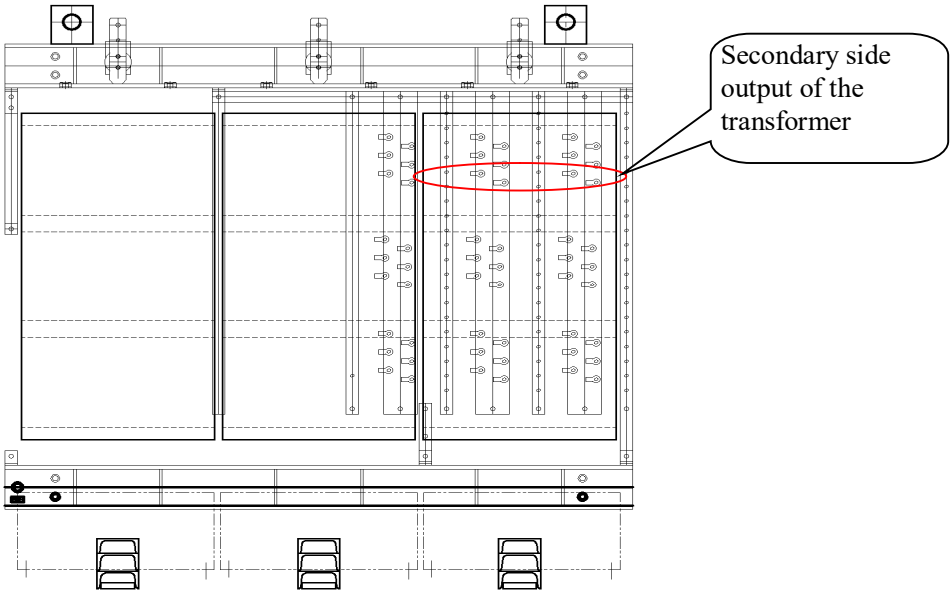

Figure 3-14 Interface Drawing of 5-level Transformer

- **Cascaded Cables of power cells/Wiring Cables of Neutral Point :**

Conduct wiring on cascaded cables(copper bar) of power cells and wiring cable of neutral point only after confirming the output waveform of power cell is normal in test. Its wiring schematic diagram is as shown in Figure 3-15.

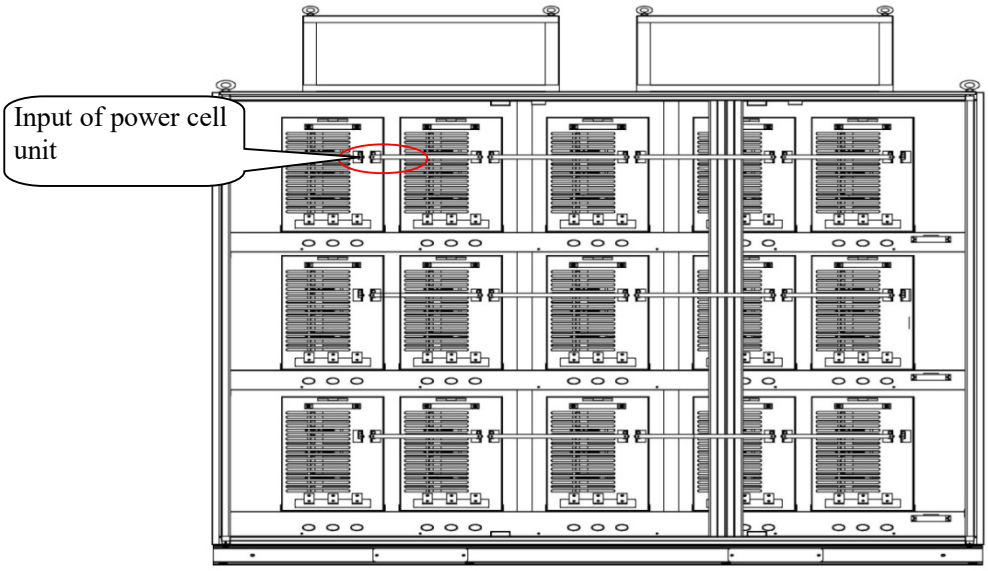

Figure 3-155-Level Tandem Connection Diagram

- **The Cable from the Output of Power cell to Bypass Cabinet:** After power cells are connected in tandem, connect the output rated voltage of the last level of power cell directly to the lower end of QS2, as shown in Figure 3-12.

(2) Secondary wiring of cables

- The wiring of power cell cabinets to transformer cabinet is mainly that of cooling system, temperature measurement signal and current measurement signal of the transformer. Wiring terminals are configured at the right side of transformer cabinet. Its standard wiring terminals are as shown in Figure 3-16.

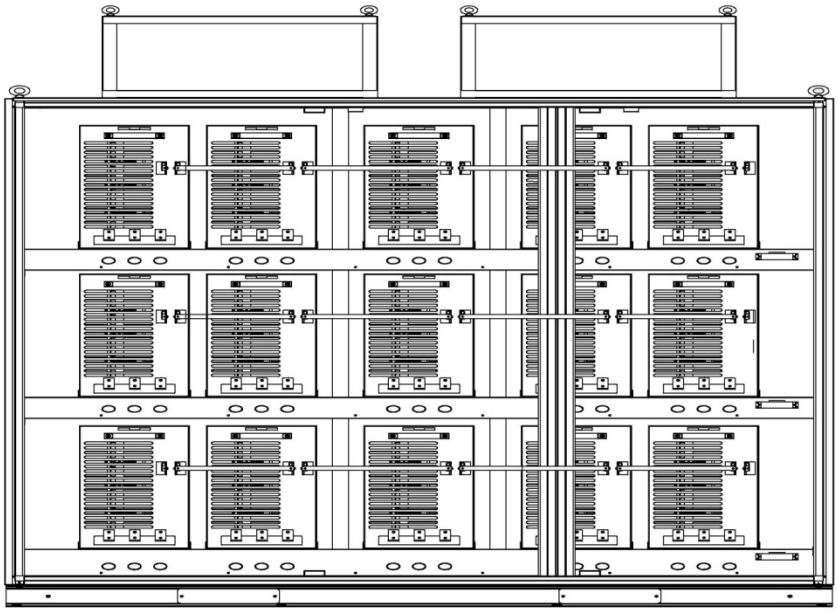

Figure 3-16 Diagram of Wiring Terminals inside Transformer Cabinet

- Wiring terminals of the transformer to bypass cabinet are configured at left side of transformer cabinet, and mainly for the wiring of power supply and status signal of high voltage isolator of bypass cabinet. Its standard wiring terminals are as shown in Figure 3-17.

Figure 3-17 Diagram of Wiring Terminals of the Transformer to Bypass Cabinet

- Signal interfaces between the VFD and users are configured in control cabinet, including various kinds of DI, DO, AI and AO signals and

control power supply, the standard wiring terminals are as shown in Figure 3-18:

Figure 3-18 Diagram of Signal Interfaces between the VFD and Users

- The secondary wiring terminal diagrams above are wiring diagrams for the VFD of standard configuration (only for reference). Different changes are made to the VFD terminal diagrams for different engineering projects. See their specific wiring diagrams in the electrical drawings prepared to corresponding projects!

3.4Inspection after Installation

After the VFD is completed with installation, overall inspection must be conducted upon cabinets and control circuit!!

Chapter IV Function Introduction

4.1 General

MV510 Series VFD converts fixed grid frequency of 50Hz or 60Hz to adjustable frequency of 0-50Hz or 60Hz. Its functions mainly include the following several types:

(1) Control functions related to motor drive

(2) Troubleshooting functions

(3) Signal input and output functions

(4) Supervision and display functions

(5) Communication functions

(6) Switch between power frequency grid and the VFD (optional)

In order to introduce you more details about our company's MV510 Series VFD, we explain some of its main functions one by one as follows.

4.2 Control Functions Related to Motor Drive

4.2.1 Control Modes

MV510 Series VFD adopts two control modes: "local control" and "remote control".

Under local control mode, the operation, shutdown, reset, frequency increase and decrease of the VFD are controlled by the operation on control cabinet of the VFD while DCS or other remote control stations won't work for control. Remote control is realized with DCS or other remote control stations.

During actual operation of the VFD, only one of the control modes can be chosen to work. You can turn the "Remote/Local" rotary knob on control cabinet door to choose one of both. If the knob points to "Local" position, it means the VFD

is under Local Control mode, and remote control is not working now. If the knob points to “Remote” position, it means the VFD is under Remote Control mode, and local control is not working now.

The choice of control mode won’t influence the VFD’s other functions. Whatever the VFD is under which control modes, the operating parameters and fault history of VFD can be displayed and searched on HMI.

4.2.2 Frequency Setting Methods

Currently MV510 Series VFD adopts two frequency setting methods:

(1) Digital quantity frequency setting.

(2) Analog quantity frequency setting.

Users may choose any one of the frequency setting methods in accordance with actual situation. When any one frequency setting method is chosen, the frequency value set by the other frequency setting method won’t work.

Frequency setting has self-hold function, which means when the VFD is switched from analog setting or terminal frequency setting method to manual frequency setting on control screen, set frequency will be automatically held on the setting value before the switch at first, and then gradually changes to current set frequency.

4.2.3 Setting of Frequency Hopping

In some drive systems, there is mechanical resonance point. If the motor runs at the frequencies close to such resonance point lasting for a long time, mechanical system will tend to bear intense resonance, and bigger fluctuated motor current. The system can’t function well and even the VFD trips for over current protection. Such resonance is very harmful and shall be avoided during the VFD operation. MV510 has the function of setting frequency hopping at 3 resonance points so the set frequency will automatically hops over such hopping frequency section and meanwhile, the system quickly passes through resonance points during its operation so that the motor can smoothly transits.

If the set frequency value is within the range of resonance frequencies, set frequency will adopt the upper limit value of resonance frequencies, resonance point quantity of mechanical system shall be determined in actual tests by users according to actual load situation. If users don't need this function, they can switch off frequency hopping function.

4.2.4 Torque Boost

In order to compensate the weak torque when the motor is running at low speed, torque boost voltage can be used as required to change "Voltage-Frequency" curve of VFD output so as to realize the output torque boost of the motor.

In order to realize reasonable operation of the motor, when the frequency is 0, output voltage is Ub, which is torque boost value, as shown in Figure 4-1. In actual operation, torque boost shall be appropriately set according to load nature. Too high torque boost voltage will cause over-current on the motor when the VFD starts. Moreover, the system efficiency will also be reduced. Usually suggested torque boost voltage is not over 5%.

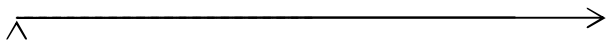

Figure 4-1 The VFD's Torque Boost Curve

4.2.5 Self-adaption of Output Voltage

Self-adaption function of output voltage means when grid voltage fluctuates, the system will automatically adjust the duty ratio of output PWM signal according to the fluctuation of bus voltage so as to guarantee that the output voltage won't be

influenced by grid voltage and load changes.

4.2.6 System Over-current Limitation

Both load sudden change and short-time over-current during speed rising are unavoidable. As a result, over-current handling principle is to avoid stopping. Therefore, the VFD has over-current self-handling function, and quick stop will only happen when the peak value of surge current is too high.

When over-current occurs during the operation, in order to avoid system alarm or stop, users can set current limitation level according to actual situation of the motor's rated current and load. When the current is over set limit value, the system will properly reduce output frequency. Until the current is lower than set limit value, working frequency will not be gradually recovered.

4.2.7BusOvervoltageLimitation

For the VFD with two quadrants, when the system is controlled to reduce its speed, it is very apt to bear voltage pumping-up on bus bar, which often triggers bus overvoltage fault, more seriously causes explosion of power cells.

Equipped with overvoltage limitation function with good dynamic features, our system can guarantee to protect from serious bus-bar voltage pumping-up on power cells during quick speed reduction to stop.

4.2.8 Self-start after Instantaneous Power Failure

Because industrial site is complicated, sometimes instantaneous power failure or instantaneous under-voltage will happen. As a result, not only speed regulating system shall meet the performance requirements during normal operation, but also it is required that the VFD has sufficient handling ability upon abnormal operation status.

MV510 has the most advanced self-start ability after instantaneous power failure. If the power failure time is extremely short, revolving speed tracking can be done according to residue voltage of the motor to quickly finish self-start function,

and recover to previous working condition in about 200ms. The ability can meet power-losing ride-through and unit cold bypass technology. If the power failure time is relatively long, residue voltage of the motor will quickly decay. In this case, the amplitude of residue voltage can be judged. If it is hard to realize residue voltage tracking, voltage drive method can be used. The motor's restart function can be realized by estimated active current and previous working condition can be recovered in about 3s.

4.2.9Flying Start

Flying start, also called as rotating start, can improve the system's continuous production ability and eliminate the restart impact of rotating motor upon grid side and the VFD itself, completion of flying start by estimating active current with active drive method can guarantee 100% of restart success in the whole frequency range within fundamental frequency. It is applicable to direct start of the motor when it is under initial and non-static status.

4.2.10 High Voltage Sampling

MV510 applies 2 high voltage non-inductive resistors (both have withstanding voltage of 40kV.) of 5MΩ in cascade for sharing voltage to guarantee the grounding current of cabinet enclosure within 0.8mA.Use isolating operational amplifier with isolating voltage of 15kV (we are the only company that uses it in this industry) to safely lead sampling simple into master control box, and also guarantee that the amplitude and phase distortion of sampling signal are as low as within 0.5%.

4.2.11 Modulation System

Modulated wave adopts sine wave superposed with 3rd harmonic wave, which can increase output voltage by 1.15 times.MV510 using single modulation wave double triangular carrier frequency modulation method, IGBT switching frequency is 640Hz.Rated output voltage harmonic wave of the system above 5^{th} harmonic wave is within 1%.Compared with single polar modulation, for equivalent harmonic

wave content, switching frequency is reduced by half so switching loss of IGBT is dramatically reduced and its service life is much extended. Meanwhile, it guarantees the power balance between different IGBTs during the dynamic process.

4.2.12 Restore Factory Settings

Factory setting is initial status of all the VFD's parameters. By restoring factory setting values, users can restore all the parameter values to initial status at any time and revoke all the parameter changes after the VFD is put into use. Factory setting values are stored in permanent memory unit together with control software. If the VFD cannot function well because of improper parameter changes, users can restore the VFD to default setting by modifying certain function number.

The VFD's factory default parameter values are separately adjusted and set by the manufacturer subject to different application circumstances. Users can modify them only if they are familiar with parameter meanings to guarantee the parameter modification won't cause severe consequence and get the approval from both parties.

4.3 Input and Output Signal Functions

The input and output signals of MV510 Series VFD mainly include digital input, digital output, analog input and analog output.

4.3.1 Digital Input

MV510 Series VFD provides 6 basic digital input channels. The definition of the channel is as follows:

Table 4-1 DI Input Interface

S/N	Name	Logic Requirements	Interface Type	Usage
1	DCS emergency stop	Pulse signal	Uncharged dry contact	Directly trip off user switch when the VFD is normally running.
2	DCS reset	Pulse signal	Uncharged dry contact	Reset fault history of the VFD.

3	DCS start	Pulse signal	Uncharged dry contact	Start the VFD and increase to set frequency in accordance with setting curve.
4	DSC stop	Pulse signal	Uncharged dry contact	Stop the VFD and decrease the frequency to 0Hz in accordance with setting curve
5	Spare	Pulse/level signal	Uncharged dry contact	
6	Spare	Pulse/level signal	Uncharged dry contact	

Besides, digitalinput channels of VFD system can be expanded as requested by users if necessary. Specific requirements shall be put forward in purchase order and technical protocol.

4.3.2 Digital Output

MV510 Series VFD provides 6 basic digital output channels, and all the channels are relay junction output.

Table 4-2 DO Output Interface

S/N	Name	Logic Requirements	Interface Type	Usage
1	Remote control	**Close:** The VFD is under DCS control. **Open:** The VFD is under local control	Uncharged dry contact: NO	Identify the VFD's control mode.
2	System ready	**Close:** Allow to close user switch. **Open:** Not allowed to close user switch	Uncharged dry contact: NO	Allow to close user switch (connect in cascade to closing circuit of user switch)
3	System standby	**Close:** Allow to start the VFD. **Open:** Not allowed to start the VFD	Uncharged dry contact: NO	Identify the running status of VFD.
4	VFD running	**Close:** The motor's running. **Open:** The motor's not running.	Uncharged dry contact: NO	Identify the running status of VFD.
5	Alarm signal	**Close:** The VFD shows alarm signal. **Open:** The VFD doesn't show alarm signal.	Uncharged dry contact: NO	Identify the VFD's alarming signal
6	Fault signal	**Close:** The VFD shows fault signal.	Uncharged dry	Identify the VFD's fault signal.

		Open: The VFD doesn't show fault signal.	contact:NO	
7	Open user breaker	Pulse signal	Uncharged dry contact: NO	Open user switch (connect in parallel to user switch)

Besides, digital output channels of VFD system can be expanded as requested by users if necessary. Specific requirements shall be put forward in purchase order and technical protocol.

4.3.3 Analog Input

MV510 Series VFD can monitor three-phase voltage and current at input side and output side of the system. In addition to monitor voltage and current, it also provides 2 external analog input channels, which can be 4~20mA current signal or 0~10V voltage signal. The definition of analog input of MV510 Series VFD is provided in Table 4-3.

Table 4-3 Analog Input Interface

S/N	Name	Logic Requirement	Interface Type	Usage
1	Set frequency	4～20mA/0～10V (Range: 0～50Hz)	Analog signal	Analog input of set frequency of the VFD
2	Spare	4～20mA/0～10V	Analog signal	Spare

Besides, analog input channels of VFD system can be expanded as requested by users if necessary. Specific requirements shall be put forward in purchase order and technical protocol.

4.3.4 Analog Output

There are 2 analog output channels on user terminals of MV510 Series VFD. Analog output signal can be 0~10V voltage signal or 4~20mA current signal.

Table 4-4 Analog Output Setting

S/N	Name	Logic Requirement	Interface Type	Usage
1	Output frequency	4～20mA/0～10V (Range: 0~1.2 times of rated frequency)	Analog signal	Analog output of operating frequency of the VFD
2	Output current	4～20mA/0～10V (Range: 0~1.5In)	Analog signal	Analog output of output current of the VFD

Besides, analog output channels of VFD system can be expanded as requested by users if necessary. Specific requirements shall be put forward in purchase order and technical protocol.

4.4 Supervision and Display Functions

MV510 Series High Voltage VFD has a set of human-machine interface that is very concise and easy to operate, and applies the touch screen produced by Beijing Kunluntongtai Company. It provides many choices to users and has both monitoring and operating functions, displaying many groups of analog and digital information of the system in real time, like input voltage, input current, output voltage, output current, setting frequency, output frequency, bus voltage, power cells' temperature and system operating status. Meanwhile, it has parameter setting and fault history functions.

4.5 Communication Function

MV510 Series VFD has not only powerful control functions itself, but also communicating function with other equipment. It has extensible communication protocol interfaces like Profibus-DP, MODIBUS and TCP/IP. Therefore, it can conveniently communicate with distributed control system (DCS) or other control systems.

4.6 Switch between Power Grid and VFD (Optional)

In order to avoid interrupting the production, MV510 Series High Voltage VFD is configured with bypassing MV510.If the VFD needs to be repaired or maintained, or bears any fault, the motor can be switched to line to operate so that the system can keep working.

Automatic bypass cabinet can be configured as optional parts. When switching from the VFD to line, no manual action is needed and fully automatic switch can be realized. When the equipment bears any fault and the system detects it, the switch of operation mode will be conducted automatically to ensure the operation of the VFD. With this function, system operating reliability is dramatically improved, which can satisfy the users who requires high reliability so that their system equipment or process won't be influenced by VFD fault. After bypass is running, users may decide to stop the VFD at a suitable time and repair the fault.

After switching to line, in order to meet working requirements, throttling VFD (ventilation door or valve) must be regualted again to make sure that the operating conditions meet process requirements.

Chapter V Operating Principles

5.1 Brief Introduction

MV510 Series VFD manufactured by TECO Technology (Wuxi) Co., Ltd. is specially designed for the application of induction motor with three-phase AC high voltage. With the features of being sturdy and durable, simple structure, strong adaption and competitive price, asynchronous motors are widely applied in the industrial production field. If power supply is direction line, the motor's revolving speed is fixed, and the motor control relies on changing other mechanical factors. As a result, the motor works with low efficiency for long time, which is a serious waste of energy. Besides, during the motor operation, users suffer terrible automatic adjustment performance as well as high maintenance and repair cost. What's more, direct start gives high current impact to both the motor and the grid, which brings potential risks to safety operation of machine set.

MV510 Series VFD is "High-High" type of high voltage VFD that applies new type high voltage and high power electrical and electronic VFDs. Through variable voltage and variable frequency (VVVF) control method of directly changing the frequency and amplitude of supplied AC power supply, the VFD with high efficiency conducts speed adjustment in a very wide revolving speed range so as to improve the system performance, enhance the production process, realize highly automatic control, improve product quality and reduce energy consumption.

5.2 Main Circuit

MV510 Series VFD is composed of multiple power cells in cascade, and high voltage output is achieved by superposing the outputs of multiple low voltage power cells. Figure 5-1 is typical circuit topological graph of 6kV series high voltage VFD.

Power grid provides three-phase 6KV/50Hz AC voltage, through phase-shifting transformer, to 15 power cells. Rated output voltage of each power cells is 690V, the outputs of adjacent power cells are connected. 5 power cells are superposed in each phase, which makes rated output phase voltage of high voltage VFD is 3450V. 15 power cells in three phases form Y-shape connection structure and achieve the line voltage of 6000V, which is directly supplied to induction motor.

Each power cells bears the total output current but only provides 1/5 of phase voltage and 1/15 of output power. Because this structure adopts the cascade of complete power cells but not that of power components, there is no voltage-sharing issue going with component cascade.

For different output voltage level, the quantity of power cells in cascade is different but the fundamental is same.

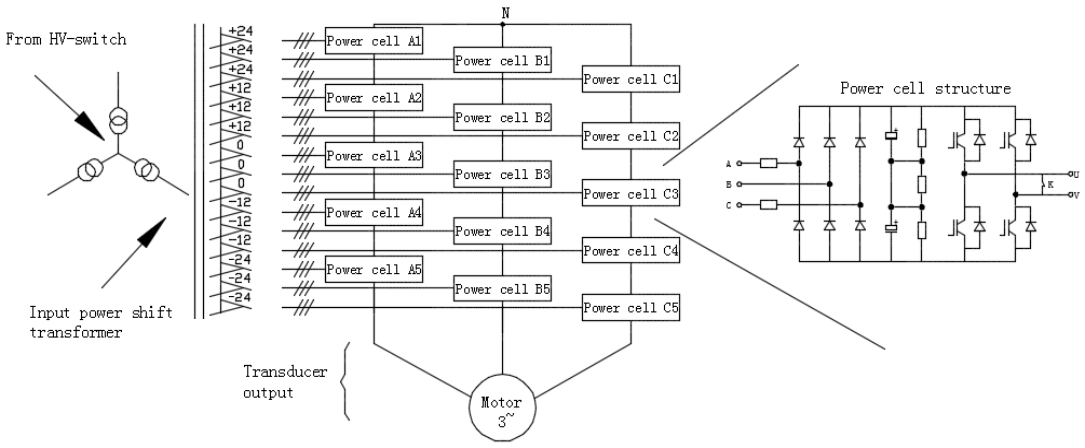

Figure 5-1 Typical Circuit Topological Graph of MV510 Series VFD

5.2.1 Phase-shifting Transformer

Secondary coils of integrated phase-shifting transformer supply power to each power cell separately. Each secondary coil of isolation transformer supplies power to only one power cell. In order to reduce harmonic current, phase-shifting transformer adopts multilevel design. Taking 6kV VFD as example, there are totally 15 sets of secondary coils that are connected in epitaxial delta. Each phase has 5 different phase groups with 12 electrical degrees between each other so they have phase-shifting degrees of 0 º,±12ºand ±24º. This phase-shifting connection can effectively eliminate below 29 times of harmonic waves, causes no harmonic interference of over national standard to power grid, and totally accords with the most strict requirement on voltage distortion and current distortion specified Standard IEEE 519~1992. Line voltage waveform at input side is as shown in Figure 5-2. Input voltage of MV510 Series High Voltage VFD is similar to sine wave and causes little harmonic pollution to power grid. Its total harmonic distortion is lower than 4%. Meanwhile, high power factor on input side requires no power factor compensation VFD.

Figure 5-2 Actually Measured Line Voltage Waveform at Input Side

5.2.2 Power Cells

See the structure diagram of power cells in Figure 5-3. The structure of each power cell is same and interchangeable. Each power cell contains input fuse, rectifier bridge, filter capacitor and IGBT VFD bridge. As well as the control boards that realize the control functions like driving, protection, monitoring and communication.

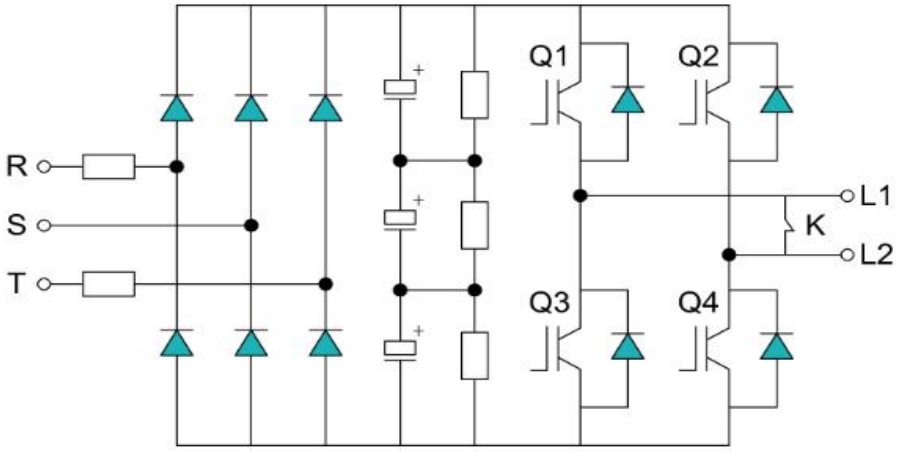

Figure 5-3 Power Cell Structure Diagram

Each power cell receives the modulation information sent by master controller through optical communication to generate the voltage and frequency that the motor requires, and each power cell's status information (including normal working condition and fault information) is also sent to master control system through optical fiber.

The input of power cell is three-phase AC voltage. After the rectification of three-phase rectifier, it becomes DC bus voltage through filter capacitor. Then it goes through H-shape single-phase VFD bridge that is composed of 4 IGBTs to realize SPWM control. At the output end, it becomes single-phase AC voltage with rated frequency of 50Hz/60Hz.(This frequency can be adjusted according to the motor's rated frequency.) Actually measured output waveform of power cell is as shown in Figure 5-4.

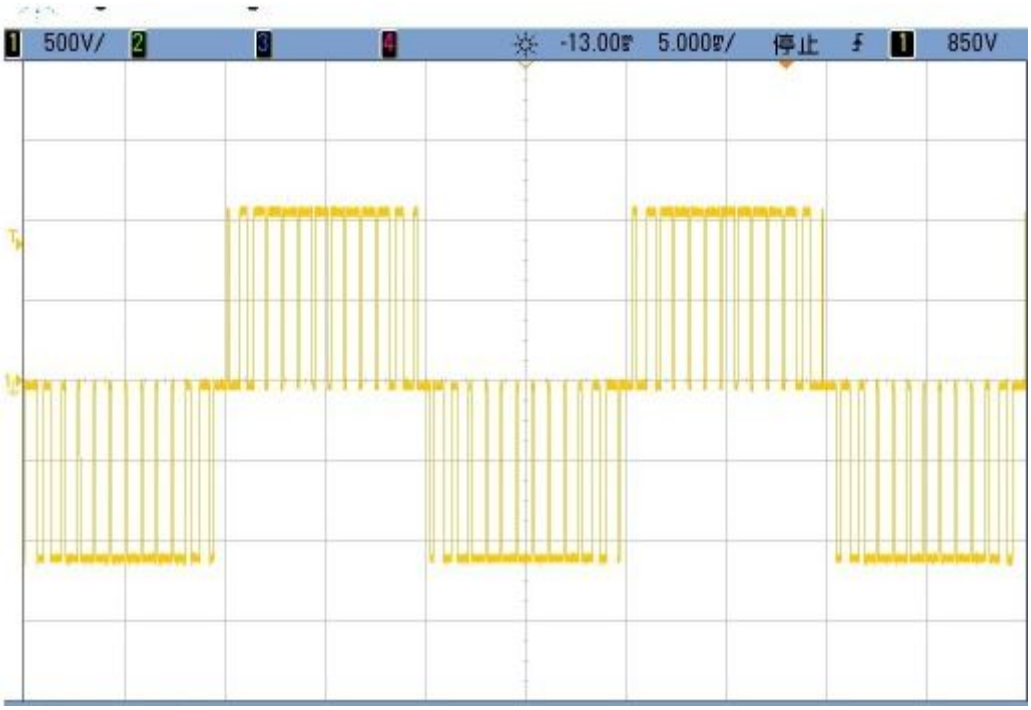

Figure 5-4 Actually Measured Output Waveform of Power Cell

Each cell outputs 3 different voltages that are +U, O and –U. For each phase, 5 power cells are superposed in cascade togenerate multilevel phase voltage waveforms, with 11 electrical levels that are O, ±U, ±2U, ±3U, ±4U and ±5U.Corresponding line voltage has 21 electrical levels. Actually measured line voltage waveform at output side is as shown in Figure 5-4.

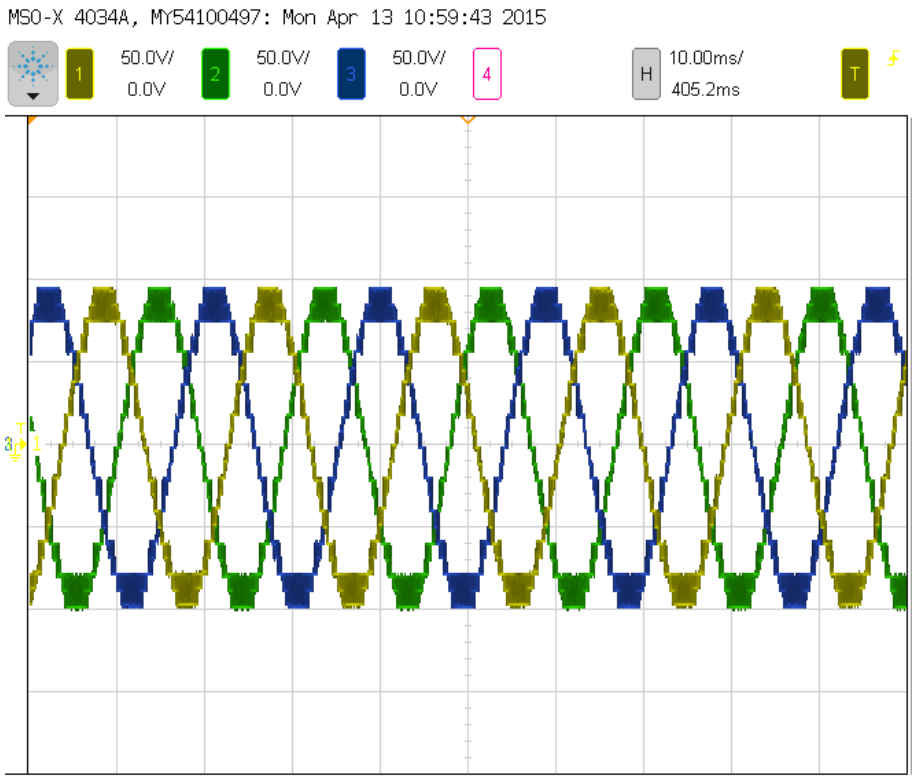

Figure 5-5 Actually Measured Line Voltage Waveform at Output Side

Compared with other competitors' products, the power cells configured with MV510 Series have the following advantages:

(1) Real-time sampling of temperature

Owing to the heat sink of power cell with NTC resistor, pulses are generated through PWM comparison circuit, then decoded by FPGA and uploaded to DSP. After being fitted by DSP, the display accuracy of temperature is 0.9°C. Temperature monitoring in real-time significantly improves product reliability.

(2) Bus design of power cells and real-time sampling of bus voltage

Power bus design is much adopted inside power cell, which effectively restrains switching spikes from occurring and meanwhile enhance the reliability so that power cells like IGBT work in a safe environment and meanwhile electromagnetic radiation from switching power component is reduced. Besides, bus voltage is conducted with AD collection in the accuracy of 12 digits, and conveyed to CPLD through SPI communication,

which is different from the case that other manufacturers just apply the comparator of hardware configuration as fault protection inside power cell. Our design provides very high guarantee on the improvement of software performance.

(3) Design of independent air duct

Each of power parts and control parts inside power cell adopts overall design scheme with bulk shielding and independent chamber shielding, which makes sure various heating components inside power cell have even heat dissipation. The whole power cell has a firm structure and good shielding effect, and EMC and EMI performance of power cells obviously outstanding.

1) Forced airflow is provided at electrolytic capacitor bank area to improve the heat dissipation of electrolytic capacitors and extent their service life.
2) Special air duct is installed for control board chamber of power cell to guarantee the control board of power cell has better heat dissipation and also considers EMC design.
3) Air ducts are configured on the surface of power components, and in the chambers of equalizing resistors and absorption circuit to reduce the temperature inside of power cell.

(4) Design of absorption circuit in power cells

Absorption circuit of power cell is designed according to accurate calculation and actual test. It reduces the switching loss of IGBT, decreases the temperature rise when power cell is running, and extend the service life of power components.

(5) Bypass function of power cells (optional)

MV510 adopts asymmetric mechanical bypass technology with NC contact. When any fault happens to power cell, its automatic bypass works.

Per actual condition, the system determines to operate with full or de-rating capacity. Compared with other control method, it has the following advantages.

1) The bypass of power cell can be realized even for power failure.

2) The bypass of power cell can be realized even for control board fault of power cell, or CPLG without working.

3) It is compatible to non-bypass system programs and structure. It's convenient to modify non-bypass system to bypass system with it.

(6) Power cell aging and test

1) Each power cell must go through 100% of rated current aging. Meanwhile, bypass function of each power cell is tested at 100% of rated current to guarantee the product reliability during usage.

2)All the control boards used in power cells must go through two times of test and aging. Moreover, aging conditions are much stricter, compared with temperature and humidity of industrial aging standard, so as to ensure the reliability of control board.

5.3 Control System

Control system includes master control system and electrical control system. Structure schematic diagram of control system in MV510 Series VFD is as shown in Figure 5-6.

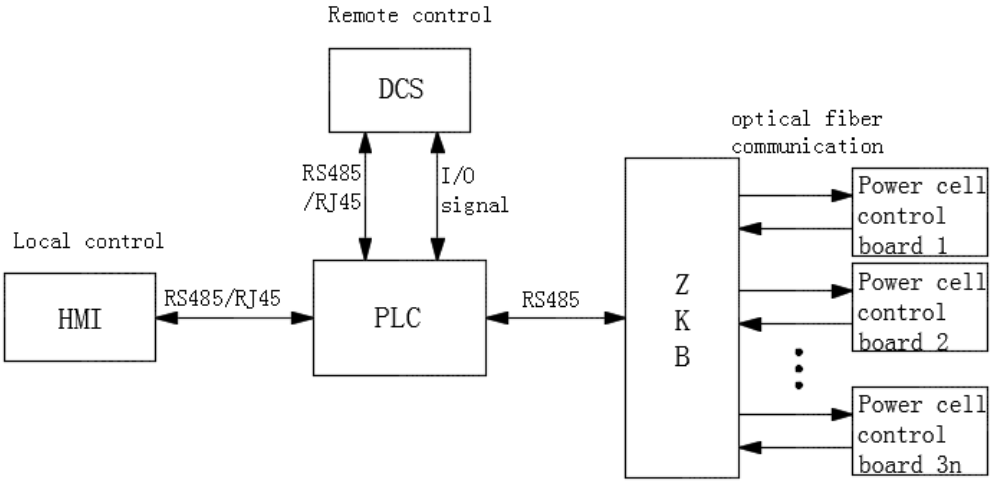

Figure 5-6 Structure Schematic Diagram of Control System

5.3.1 Master Control System

Master control system includes master control board, optical communication board, sampling board and interface board. Master control board adopts integrated design to avoid lots of connecting and plugging components. Master control system is installed the enclosure with overall shielding to improve the immunity against system's interference.

Master control system is the core part of the drive. It conducts quick protection, quick diagnosis of faults, control of operating status, and output of computation data. Optical fiber communication is applied between master control system and power cells. Data transmission is realized through hardware socket between master control board and optical fiber communication board. Optical fiber communication board conducts communication and control on control boards in power cells through optical fiber. It gives SPWM signal to each power cell and receives status information of each power cell. Such optical fiber is the only connection between power cells and master control system so main circuit of MV510 Series High Voltage VFD is electrically separated from control system totally.

5.3.2 Electrical Control System

Electrical control system includes power supply part, logic control system (including PLC and electrical control components) and HMI (human-machine interface). PLC adopts S7-1200/AP-200 with high reliability to conduct the control on input and output signals of the VFD. In addition, PLC also conducts the control, protection, and linkage and fault detection on peripheral electrical VFDs, the communication with master control system as well as the control on HMI.

HMI applies Beijing Kunluntongtai touch screen. By connecting to PLC, it mainly conducts command issuing, functional parameter setting, as well as display and recording of system status, operating status and faults.

RS-485 serial communication is applied between PLC and master control system. DCS upper control system issues control commands through user I/O terminals, like controlling the VFD's start, stop and reset. Meanwhile, DCS receives the VFD's feedback information and working parameters, like operating status, fault information and operating frequency.

Chapter VI Site Commissioning Instructions

6.1 Range

This chapter specifies the VFD's site commissioning instructions, including the VFD's test items, site test requirements and steps. Users can take it as reference to formulate site commissioning schemes, and our company's service personnel can also use it for site commissioning.

6.2 Terms

- **Site Commissioning**: After the VFD arrives at user site, and its installation passes acceptance check, conduct tests on the VFD according to specified test items.
- **Inspection on Power Supply in Control Cabinet**: After control power of AC380V is supplied, inspect the VFD without primary power according to the content specified in this manual.
- **Simulation Test:** After users turn the VFD's power switch to test position, and low voltage control power of AC380V is delivered, conduct the simulation of site actual operation of the VFD according to technical protocol and design documents.
- **Power Cells in Off Working State**: All the LEDs on front panels of power cells are off.
- **Individual Test of Power Cell**: With the VFD connected to main power, and output ends of power cells of the VFD are not connected in cascade, conduct the commissioning in accordance with specified content and steps.
- **Cascade Test of Power Cells:** After the VFD's power cells pass individual test, connect the output ends of power cells of the VFD in star, and test power cells in

accordance with specified content and steps.

- **No-load Test with Motor:** After cascade test of power cells of the VFD is passed, connect the motor without load, and conduct a test in accordance with specified content and steps.
- **Load Test with Motor:** After the VFD passes no-load test with the motor, connect the VFD to the motor with load (like a fan or water pump), and conduct a test in accordance with specified content and steps.
- **Run Test with load connected:** After the VFD passes load test with the motor, put it into the user's production system to operate.

6.3 Commissioning Instructions

6.3.1 Test Items

The VFD's site test items include: inspection with power supply on control cabinet, simulation test, individual test on power cell, cascade test on power cells, no-load test with the motor, load test with the motor, and Test Run with load connected test.

6.3.2 Inspection on Power Supply in Control Cabinet

Safety Precautions:

1. This step is limited to the connection of low voltage power supply of AC380V.
2. Before power on AC380V, be sure that the VFD's primary power switch is at test position.

(1) Inspection Process before power on

Inspect and confirm the installation and wiring in accordance with drawing→ Turn on AC380V→Status check→ Turn off AC380V

(2) Inspection of Installation and Wiring

- Does control power supply accord with design specifications.
- Check if the connection between signal cables and user interface is correct

and reliable according to design documents.

- Check if wiring connection is correct, unloosening, and reliable inside control cabinet according to design documents.
- Check various grounding wires are correct and reliable in accordance with design documents including electrical grounding wire of control cabinet, transformer grounding wire, cabinet grounding wire ,and grounding wire of cabinet door. If electrical grounding and high voltage grounding are separated.
- Check if power cell is correctly and reliably connected by plugging to upward and downward optical fibers of master control box.
- Check if the screws to fix inlet wires on power cells are firm and reliable.

(3) Status Check

- Check if status indications of various main actuators are correct according to design documents. Test if various low voltage control signals of the VFD and various buttons are effectively and correctly interlocked.
- Check the status of PLC input and output points according to design documents.
- Test remote control signals to make sure relevant interfaces are correct.
- Check various status indications of touch screen according to design documents.

6.3.3 Simulation Test

Safety Precautions:

1. Conduct simulation test only after the inspection on power supply in control cabinet is qualified.
2. Before simulation test, be sure that the VFD's primary power switch is at test position.

(1) Process of Simulation Test

Check and confirmation→ Turn on control power of AC380V→ Conduct Simulation Test→ Turn off control power of AC380V.

(2)Items of Simulation Test

- Check if the following various main actuators work well.
  1) Isolating switches
  2) Contactors
  3) Breakers
  4) Cooling fan system
  5) Door trips function
  6) Electromagnetic locks
  7) The lights in cabinet
- Upon major faults or emergency disjunction, the VFD immediately trips its primary breaker at customer side.
- For the simulation operation between VFD and direct on line in bypass, before the VFD gives enabling signal of closing high voltage switch, its primary breaker can't be closed manually or automatically.
- Fault alarms are reliable and status indications are correct.
- Under local control mode or remote control mode, it functions well to start, stop and reset the VFD.

  Calibrate the operating frequencies set by local and remote mode on touch screen.

6.3.4 Individual Test

Safety Precautions:

1. Conduct individual test of power cell of the VFD only after simulation test is qualified.
2. After the VFD's primary power is turned on, it's prohibited to operate isolating switch.
3. Before the VFD's primary power is turned on at the first time, be sure to close all the cabinet doors of the VFD, and meanwhile, don't stand in front of the VFD cabinet within the range of 2meters.
4. Conduct the test beyond 5 minutes after the VFD's primary power is turned onat the first time.
5. During all the test items, testing personnel on site must wear safety helmet, insulating gloves and insulating boots.
6. During all the test items, testing personnel on site must dress cleanly. It's not allowed to wear short sleeves and short pants, or bring keys, cell phones, watches, ornaments and other metalwork.

(1) Test Process of Individual Power Cell

Check and confirmation→ Turn on control power of AC380V→TheVFD is ready→ Turn on primary power of VFD→ Operating→ Test of individual power cell→ Stop→ Turn off primary power of VFD→ Turn off control power of AC380V.

(2) Individual Test and Record

- Measure effective values of line voltage at input side of each power cell with digital multimeter, and record voltage value.
- Choose local control mode for the VFD, and let it operate to 50Hz.Measure PWM waveform of output voltage on each power cell by using an oscilloscope, and record one complete normal voltage PWM waveform and

all the abnormal voltage PWM waveforms.

- If output waveforms of all the power cells are normal, read the effective values of output voltage on each power cells by using an oscilloscope, and record them.
- During the VFD's operation, measure and record the temperature at air intake of power cell cabinet.

6.3.5 Cascade Test of Power Cells

Safety Precautions:

1. Conduct cascade test of power cells of the VFD only after their individual test is qualified.
2. After the VFD's primary power is turned on, it's prohibited to operate isolating switch.
3. During all the test items, testing personnel must wear safety helmet, insulating gloves and insulating boots.
4. During all the test items, testing personnel must be dressed clean and tidy. It's not allowed to wear short sleeves and short pants, or take keys, cell phones, watches, ornaments and other metalwork.
5. After individual test of power cell is qualified and before connecting output copper bars of power cells in cascade, make sure the VFD's primary power switch is at test position and each power cell is under off working state.

(1) Process for Cascade Test of Power Cells

Install the copper bars for cascade→ Connect neutral points→ Connect measuring instruments→ Check and confirm→ Turn on control power of AC380V→The VFD is ready. →Turn on the VFD's primary power switch→ Operate the VFD→ Check line voltage waveform→ Stop→ Turn off the VFD's primary power→ Turn off control power of AC380V

(2) Test Items for Cascade Test of Power Cells

- Choose local control mode for the VFD, measure and record the output line

voltage waveform of the VFD at 10Hz, 20Hz, 30Hz, 40Hz and 50Hz by using an oscilloscope and high voltage probe, and record the results. The oscilloscope shall display effective voltage values.

- During the VFD's operation, measure and record the temperature at air intake of power cell cabinet.

6.3.6 No-load Test with Motor

Safety Precautions:

1. Conduct no-load test with motor on the VFD only after the cascade test of power cells are qualified.
2. After the VFD's primary power is turned on, it's prohibited to close isolating switch.
3. During all the test items, testing personnel must wear safety helmet, insulating gloves and insulating boots.
4. During all the test items, testing personnel must be dressed clean and tidy. It's not allowed to wear short sleeves and short pants, or take keys, cell phones, watches, ornaments and other metalwork.
5. After cascade test of power cells are qualified and before connecting the VFD's output to the motor's cable, be sure the VFD's primary power switch is at test position.
6. If finding the motor rotates reversely during the test, before correcting the motor's phase sequence, make sure the VFD's primary power switch is at test position and each cell is under off working state.

(1) Process of No-load Test with Motor

Connect the motor→ Connect measuring instruments→ Check and confirm→ Turn on control power of AC380V→The VFD is ready. → Turn on the VFD's primary power switch. → Operate 5Hz→ Check the motor's rotating direction→ If it is reverse, stop the equipment. →Turn off the VFD's

primary power switch.→ Wait power cells to run out of power→ Correct the motor wiring→ Check and confirm→ Turn on the VFD's primary power switch.→ After the motor's rotating direction is correct, increase the frequency.→ Check the waveforms of output voltage and current→ Stop →Turn off the VFD's primary power switch →Turn off control power of AC380V.

(2) Test Items of No-load Test with Motor

- Before the VFD's no-load test with motor, according to working conditions and customer demands, request the user to arrange staff to measure and record the motor's vibration parameters in axial, horizontal and vertical directions under no load and maximum load during the operation with power frequency.
- Before the VFD operates with motor, firstly confirm the cooling type of the motor driven by the VFD. If it is forced air cooling, confirm the minimum rotating speed under which the motor is allowed to run for a long time so as to prevent motor superheat.
- Check the setting of the VFD's various parameters, eliminate fault history, and set the motor's acceleration and deceleration time to be 3 minutes or longer. Choose local control mode to start the VFD to drive the motor with no load from 5Hz, and search and record the motor's mechanical resonance point during its acceleration. If finding any mechanical resonance point, stop the operation and set frequency hopping parameter. Repeat the acceleration process from 5Hz and observe if the setting of frequency hopping point is effective. Test is repeatedly until mechanical resonance points are totally restrained and make detailed record.
- With an oscilloscope and current probe, observe and record. The current waveforms at the VFD's output side and the transformer's input side at 10Hz, 20Hz, 30Hz, 40Hz and 50Hz.The oscilloscope shall display effective

current values.

- When the motor is running under the minimum allowed rotating speed, request the user to arrange staff to pay attention on the motor's temperature rise all the time.
- Measure the motor's axle temperature.
- During the VFD's operation, measure and record the temperature at air intake of unit cabinets.
- The VFD shall operate to continuously drive the motor with no load for one hour.

6.3.7 Load Test with Motor

Safety Precautions:

1. Conduct load test with motor on the VFD only after its no-load test with motor is qualified.
2. After the VFD's primary power is connected, it's prohibited to close isolating switch.
3. During all the test items, site testing personnel must wear safety helmet, insulating gloves and insulating boots.
4. During all the test items, site testing personnel must be dressed clean and tidy. It's not allowed to wear short sleeves and short pants, or take keys, cell phones, watches, ornaments and other metalwork.
5. When connecting the motor to its load and connecting measuring instruments, be sure to guarantee the VFD's primary power switch is at off position and various units are under off working state.

(1) Process of Load Test with Motor

Connect the motor→ Connect the motor to its load→ Connect measuring instruments→ Check and confirmation→ Turn on control power of AC380V→ The VFD is ready→ Turn on t the VFD's primary power→ The

VFD operates→ Check voltage and current waveforms→ Stop→ Turn off the VFD's primary power switch→ Turn off control power of AC380V.

(2) Test Items of Load Test with Motor

- Choose local control mode for the VFD operation. With an oscilloscope and current probe, observe and record: The current waveforms at the VFD's output side and the transformer's input side at 10Hz, 20Hz, 30Hz, 40Hz and 50Hz, as well as the motor's vibration values in 3 directions.
- When the motor is running under the minimum allowed rotating speed, request the user to arrange staff to pay attention on the motor's temperature rise all the time.
- When the motor is running under the minimum allowed rotating speed, request the user to arrange staff to pay attention on the motor's temperature rise all the time.
- The motor's vibration in three phases.
- Monitor the motor's axle temperature.
- During the VFD's operation, measure and record the temperature at air intake of unit cabinets.
- The VFD shall operate to continuously drive the motor with load for 2 hours.

6.3.8 Run Test with Load Connected

Safety Precautions:

1. Conduct Run Test with load connected on the VFD only after its load test with motor is qualified.
2. After the VFD's primary power is connected, it's prohibited to close isolating switch.
3. During all the test items, site testing personnel must wear safety helmet, insulating gloves and insulating boots.
4. During all the test items, site testing personnel must be dressed clean and tidy. It's not allowed to wear short sleeves and short pants, or take keys, cell phones, watches, ornaments and other metalwork.

(1) Test process of run test with load connected

Operate according to user operating instructions

(2) Test items of test run with load connected

- The motor's vibration in three phases.
- Monitor the motor's axle temperature.
- Operating frequency and current.
- Environment temperature
- Transformer temperature
- The temperature at air outlet of cabinets
- The VFD shall continuously operate in the user's production system for 72 hours.

Chapter VII Troubleshooting and System Maintenance

7.1 Fault Classification

MV510 Series VFD has complete fault monitoring and protection functions, and its faults can be classified into major faults and minor faults (alarms). When faults happen, the VFD firstly conducts corresponding reactions in accordance with fault types. Meanwhile, issues fault signals to touch screen and DCS remote control systems, and displays exact happening time and description of faults on touch screen. See the VFD's fault classification and corresponding reaction in the table below.

MV510 Series VFD has complete fault diagnosis, locating and reacting functions. It can classify the faults that happen to the system, conduct different reactions according to major and minor faults, meanwhile output fault types, fault description and fault happening time in real time, and save fault history. Fault classification and reactions are as shown in the table below.

Table 7-1 Classification and handling of faults

Type	System Reaction
Alarm	**(1)** Alarm light on the panel of control cabinet is normally on **(2)** The VFD continues to operate or operates on bypass with de-rating capacity **(3)** Display happening time and description of the alarm on touch screen
Fault	**(1)** Alarm light on the panel of control cabinet is normally on **(2)** Block the VFD's output **(3)** The motor freely stops **(4)** Display happening time and description of major fault on touch screen
Serious Fault	**(1)** Alarm light on the panel of control cabinet is normally on **(2)** Block the VFD's output **(3)** The VFD issues high voltage disconnection signal

	(4) The motor freely stops **(5)** Display happening time and description of major fault on touch screen

Common system faults, reasons and corresponding measures are respectively introduced as follows. When operators find any system fault, they shall arrange to eliminate the fault as soon as possible to guarantee the system works well and timely notify our company. We will try our best to help your honored company to find the fault reason and make the VFD return to normal operation.

Table 7-2 Alarm of VFD

S/N	Fault name	Phenomenon	Causes and measures
1	Control power loss	HMI displays “Control power loss”, and the VFD is still running.	**Causes:** Loss or failure of main control power **Remedies:** Check the incoming line of main control power
2	Cooling fan failure	HMI displays “Cooling fan failure”, and the VFD is still running.	**Causes:** Power switch of the fan is accidentally disconnected or hardware of the fan fails **Remedies:** **1)** Check the cooling fan state and its power switch position. **2)** Check whether the fan line is short-circuited, or fan hardware is damaged.
3	Transformer overheating alarm	HMI displays “Transformer OH alarm”, and the VFD is still running.	**Cause:** Over temperature in the transformer cabinet **Remedies:** **1)** Check whether the transformer cooling fan and indoor air conditioner are

			normal. **2)** Check if ambient temperature of VFD room is up to standard, and input current is normal.
4	Cell alarm	HMI displays " XX cell has XXXX alarm", and the VFD is still running.	**Causes:** Find out the causes according to fault description on HMI. **1)** " Bus under voltage" means cell bus voltage is below the protection value. **2)** " Cell over temperature" means the cell temperature is higher than the protection value for over three minutes. **Remedies:** Check the fault type, and find out the causes of fault. Arrange for replacement of the faulty cell as soon as possible.
5	Communication error between PLC and MCB	HMI displays "Comm. error between PLC and MCB", and the VFD is still running, but the content on the touch screen is no longer refreshed.	**Cause:** Communication abnormality between main control box and PLC. **Remedies:** Check whether the telecommunication cable between main control box and PLC is damaged.
6	Communication error between HMI and PLC	HMI displays "Comm. error between HMI and PLC", and the VFD is still running, but content on the touch screen is no longer refreshed.	**Cause:** Communication abnormality between touch screen and PLC **Remedies:** **1)** Check whether the telecommunication cable between touch screen and HMI

			is normal. **2)** Check whether interface hardware is damaged.
7	Analog signal loss	HMI displays " Analog signal loss", and the VFD is still running.	**Cause:** Frequency value set by DCS is not detected by the VFD. **Remedies:** Check whether the frequency setting signal line of DCS is normal

Table 7-3 Fault of VFD

S/N	Fault Name	Phenomenon	Causes and remedies
1	Hardware over current fault	HMI displays "Hardware OC fault", and block output of the VFD.	**Cause:** Output blocked immediately when output current is 2.5 times higher than the rated level. **Remedies:** **1)** Check whether the Hall sensor and output current sampling board are damaged. **2)** Check operating condition of motor, or any sudden change of load.
2	Serious output over current fault	HMI displays "Serious output OC fault", and block output of the VFD.	**Cause:** Output is immediately blocked when output current is 1.8 times higher than the rated current of motor. **Remedies:** **1)** Check whether the "over current 1 threshold" and "over current 1 time constant" parameters are correct. **2)** Check whether Hall sensor and output current sampling board are damaged.

			3) Check operating condition of motor, or any sudden change of load.
3	Output over current fault	HMI displays “Output OC fault”, and block output of the VFD.	**Cause:** Output blocked after 3s time delay when output current is 1.5 times higher than the rated current of motor. **Remedies:** **1)** Check whether the “over current 2 threshold” and “over current 2 times constant” parameters are correct. **2)** Check whether Hall sensor and output current sampling board are damaged. **3)** Check operating condition of motor, or any sudden change of load.
4	System overload fault	HMI displays “System OL fault”, and block output of the VFD.	**Cause:** 1min time limit protection when the current of motor is 1.2 times higher than its rated level **Remedies:** **1)** Check whether the “overload threshold” and “overload time constant” parameters are correct. **2)** Check whether Hall sensor and output current sampling board are damaged. **3)** Check whether the system is overloaded for a long time.
5	System overheating fault	HMI displays “System OH fault” and block	**Cause:** 10min inverse time limit

		output of the VFD.	protection when the current of motor is 1.1 times higher than its rated level. **Remedies:** **1)** Check whether the "over temperature threshold" and "over temperature time constant" parameters are correct. **2)** Check whether Hall sensor and output current sampling board are damaged. **3)** Check whether the system is overloaded for a long time.
6	Input over voltage fault	HMI displays "Input OV fault", and block output of the VFD.	**Cause:** Effective value of input voltage is 1.1 times higher than the rated voltage. **Remedies:** **1)** Check whether the input neutral point connection position of phasing transformer is correct. **2)** "-5%" position: The cell input voltage increases by 5%. **3)** "0" position: The cell input voltage is the standard value. **4)** "+5%" position: The cell input voltage decreases by 5%. **Note:** This alarm may be caused by transient condition that may not exist at the time of measurement.
7	Input under voltage fault	HMI displays "Input UV fault", and block output of the VFD.	**Cause:** The effective value of input voltage is 0.8 times lower than the

			rated voltage. **Remedies:** Refer to “input over voltage”.
8	Cell fault	HMI displays “XX cell XXXX fault”, and block output of the VFD.	**Causes:** Find out the causes according to fault description on HMI. **1)** “ Bus over voltage” means cell bus voltage exceeds the protection value. **2)** “ VFD fault” means IGBT failure. “ Input phase loss” means three-phase input power failure of the cell. **3)** “ Upward (Downward) communication fault ” means interruption of communication between the faulty cell and master control system **Remedies:** Check the fault type, find out the causes of fault, and arrange for replacement of the faulty cell as soon as possible.
9	Power cell overheating fault to stop running	HMI displays “Power cell OH fault to stop running”, and block output of the VFD.	**Cause:** “Power Cell OH fault” means the cell temperature is higher than the protection value for over three minutes. **Remedies:** Check the fault type, find out the causes of fault, and arrange for replacement of the faulty cell ASAP.

Table 7-4 Serious Fault of VFD

S/N	Fault Name	Phenomenon	Causes and remedies

1	High voltage loss during operation fault	HMI displays " High voltage loss during operation fault ", and block output of the VFD.	**Cause:** Abnormal loss of high voltage is detected by the VFD. **Remedies:** Find out the reasons of high voltage loss. **1)** Check whether the high-voltage breaker and vacuum contactor of VFD are normal. **2)** Check whether the "power-off voltage" parameter is correct. **3)** Check whether input voltage sampling board is damaged.
2	Cabinet door open fault	HMI displays "Cabinet door open fault". Block output of the VFD, and cut off high-voltage power.	**Cause:** Cabinet door travel switch and the door are not closed. **Remedies:** Check whether the cabinet door is opened or electrical function of the travel switch is normal
3	Transformer overheating fault	HMI displays "Transformer OH fault". Block output of the VFD, and cut off high-voltage power.	**Cause:** Internal temperature of transformer higher than trip value of protection temperature **Remedies:** **1)** Check if the transformer's cooling fan and indoor air conditioner function well. **2)** Check if environment temperature in VFD room meets requirements. **3)** Check if the VFD is

			under overload state for a long time.

7.2 System Maintenance

The influence of service environment factors like temperature, humidity, pH value, dust and vibration of service environment as well as many other reasons like aging and wear of inside parts of the VFD will cause potential fault risks to the VFD. As a result, be sure to conduct daily inspection on the whole VFD system and regulation maintenance.

7.2.1 Safety Information

(1) Maintenance staff must receive trainings, be familiar with the equipment structure, and understand practical operation knowledge.

(2) Only the staff who received the training above is allowed to operate and repair the VFD.

(3) Touch the parts inside VFD cabinet only when you can guarantee the VFD's input high voltage vacuum switch is off, and no high temperature exists.

(4) Be sure to follow high voltage operating instructions during maintenance, like wearing insulating gloves, insulating shoes and safety glasses, be sure to have other staff at site for protection during work.

(5) Be sure to install safety protection fence (with the warning board of high voltage danger). Don't move it away during the VFD operation.

(6) It is prohibited to place inflammable materials beside the VFD.

(7) Be very careful when handling or measuring the parts inside the VFD, and pay attention not to make short circuit between instrument wires or touch other terminals.

(8) In order to ensure personal safety, it's prohibited to operate the VFD with cabinet doors open.

(9) Pay attention to handle the VFD's power cells with care when transporting them.

(10) Power cells must be stored on racks in ware house. In special circumstance, they can be put on ground for a short time but the ground must be dry and flat.

(11) Component replacement is the best method for eliminating faults but users must make sure new components and broken ones have the same model sand specifications.

(12) Be sure to replace the VFD's power cells beyond 5 minutes after the VFD's high voltage power is turned off.

(13) The maintenance on the VFD's power cells require special instruments. There is no part inside power cell for users to maintain so it's prohibited to open it. For further repair, corresponding power cellsshall be handed over to our company's Engineering Department.

(14) If any fault happens to the VFD's power cells, please immediately notify our company's Engineering Technology Department.

7.2.2 Maintenance Instructions

7.2.2.1Earlier Stage of VFD in Operation

(1) Thoroughly clean inside and outside of VFD cabinet with the dust collector with plastic suction nozzle and guarantee there is no excess dust around the equipment.

(2) Keep good ventilation and illumination in the VFD room and guarantee ventilating VFD functions well.

(3)Make sure the VFD's inside cables are correctly and reliably connected.

(4) Make sure all the grounding wires in the VFD cabinet are reliable, and grounding points bear no rust.

(5) Make sure the isolating switch in bypass cabinet of the VFD works well, and can correctly close and open.

(6) After the VFD passes acceptance check through 72 hours of pilot run, various connection nuts for the VFD's inside cables shall be tightened again.

(7) Various connection nuts for the VFD's inside cables shall be tightened again within half year.

(8) Various connection nuts for the VFD's inside cables shall be tightened for every 6 months after half year.

7.2.2.2VFD in Operation

During the VFD's normal operation, maintenance shall be well done to guarantee good operating environment. Through daily maintenance and inspection, various abnormal conditions can be timely found. Their reasons can be timely learned,and potential faults can be timely prevented so as to guarantee normal operation of the equipment and extend the VFD's service life.

(1) Carefully monitor and record various display parameters on the VFD's touch screen and immediately report it if finding any abnormal condition.

(2) Carefully monitor and record the environment temperature in the VFD room, which can't be over 40℃.

(3) The filter screen on VFD cabinet door shall be cleaned every week. If there is too much dust in working environment, the cleaning interval shall be shortened according to actual situation.

(4) During the VFD operation, a piece of notebook paper with standard thickness shall be able to be adsorbed on the filter screen at air intake on cabinet door.

(5) VFD room must be kept clean and shall be regularly cleaned according to actual site situation.

(6) VFD room must have good ventilation and illumination and ventilating VFD shall function well.

(7) The temperature at air outlet of power cell cabinet in the VFD can't be over 50℃.

(8) Check the operation of cooling fan of VFD system. Once finding the fan of the VFD or input transformer stops running, please notify professional staff to repair it.

(9) Check the temperature rise of rectifier transformer. Once finding its temperature is over 120℃, please notify professional staff to repair it.

(10) Check if the overall equipment has any abnormal vibration, noise and odor.

Appendix: Overview List of VFD Inspection Items

Inspection Point	Inspection Item
Ambient environment	● Check environment temperature, humidity and vibration. ● Check if there is any dust, gas, oil mist and water drop in air. ● Check if any foreign matter or hazardous article is placed nearby.
Voltage	● Check if the voltage of main circuit and control circuit is normal.
Touch screen	● Check if the display of touch screen is clear, and any character is missing. ● Check if there is any abnormal noise or vibration, loosen bolt, deformation damage, color change caused by over temperature and attached dust or contamination.
Overall	● Check if there is any bolt becoming loosened or falling off, deformation, crack, breakage or aging and color change caused by over temperature on the equipment and insulators as well as attached dust and contamination.
Main circuit	● Check if any conductor exists color change caused by over temperature or leans aside. ● Check if wire jacket is broken, discolored or damaged.
Phase-shifting transformer	● Check if there is abnormal noise or odor.
Control circuit	● Check if any screw or plug connector becomes loosen. ● Check if there is any abnormal odor, color change, crack, breakage, deformation or obvious rust.

Cooling system	● Check if there is any abnormal audio noise or vibration, loosen bolt and color change caused by over temperature. ● Check if the clearances at air intake and outlet of heat sink are blocked or attached with foreign matter.

Appendix :Abbreviation Table

Abbreviation Name	Full Name	Abbreviation Name	Full Name
Acc.	Acceleration	MCB	Main Control Box
Alarm_his	Alarm history	min.	Minimum
AI	Analog input	NC	Normal Close
AO	Analog output	NO	Normal Open
CCW	Counter Clockwise	OC	Overcurrent
coeff.	coefficient	OH	Overheating
comm.	communication	OL	Overload
corr.	correction	OV	Overvoltage
CPLD	Complex Programmable Logic Device	P.	Pump
CPU	Central Processing Unit	par.	parameter
CT	Current Transducer	PLC	Programmable Logic Controller
CW	Clockwise	R.T.	Real Time
DC	Direct Current	REF	Reference
Dec.	Deceleration	RTD	Resistance Temperature Detector
DSP	Digital Signal Processor	SMPS	Switching Mode Power Supply
EM	Emergency	SPD	Surge Protection Device

En.	Enable	sync.	synchronous
Esti.	Estimated	T.C.	Time Constant
FPGA	Field Programmable Gate Array	temp.	temperature
FREQ	Frequency	UPS	Uninterruptible Power Supply
HMI	Human Machine Interface	UV	Undervoltage
HV	High Voltage	VFD	Variable Frequency Drive
JF	Jump Frequency	Xx	A1, A2,.. B1, B2,.. C1,C2,..
M.	Motor		
max.	Maximum		
MV	Medium Voltage		