High Reliability DF5000 Series MV VFD

DF5000 Series MV VFD: -

- use Power Units connected in series to sum up the waveform

- belongs to the type of voltage source "AC-DC-AC" direct high voltage(High-high)method.

- It is a high reliability, high efficiency, high energy saving, no pollution, high voltage high power variable frequency device.

- **Power factor > 0.95**
- **Efficiency > 96%**
- **Input & Output Harmonic satisfy IEEE 519-1992 Standard, no harmonic pollution to the source**
- **Good output voltage waveforms eliminate heating up of Motor, reduce mechanical stress of shaft and vanes, largely prolong the life time of the motors**
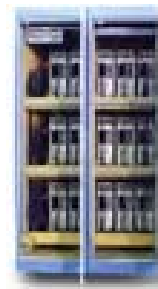

旁路柜 | 变压器柜 | 功率单元柜

DF5000 MV VFD

Cabinet Layout

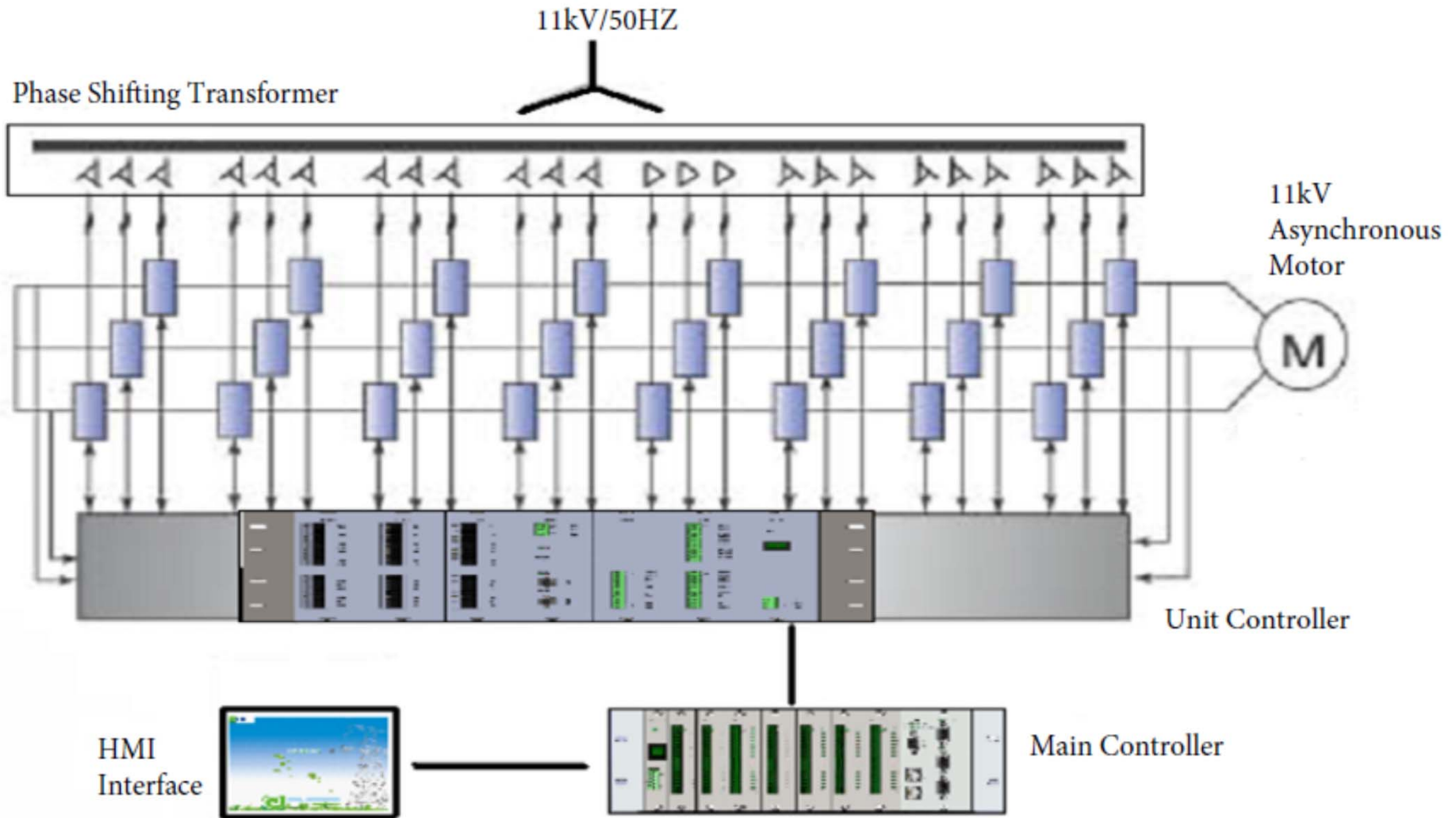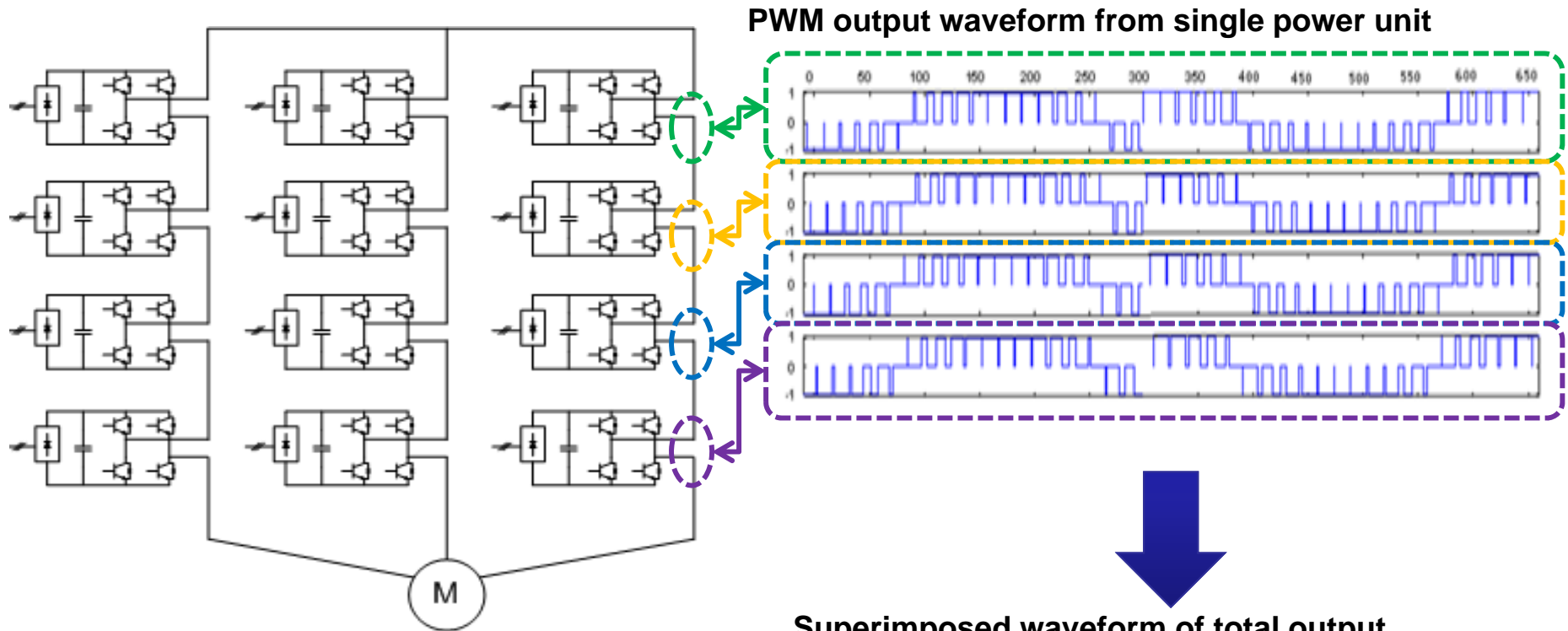Phase Shifting Transformer

Power Unit Cabinet

Control Cabinet

Bypass Cabinet

VFD System Circuit

11KV VFD System Topology Diagram

Technical Background
Superimposed of serially connected waveform

PWM output waveform from single power unit

Superimposed waveform of total output

Excellent Sine Wave
supply to motor
&
Frequency Varying
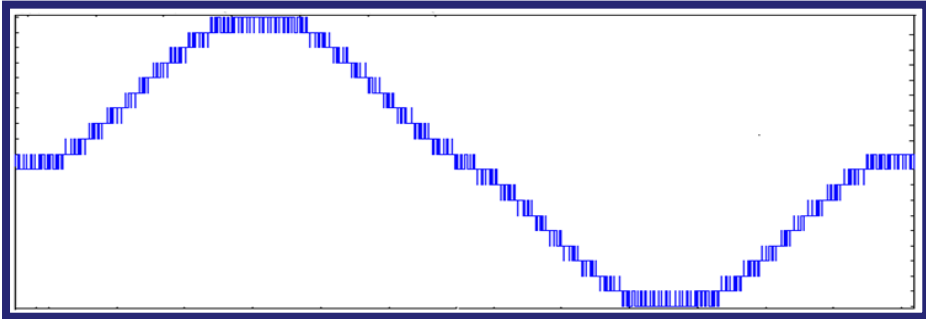
VFD output perfect sinewave to Motor

Multiple waveforms output, produces perfect Sinewave, no output filter required, suitable for old motor as well
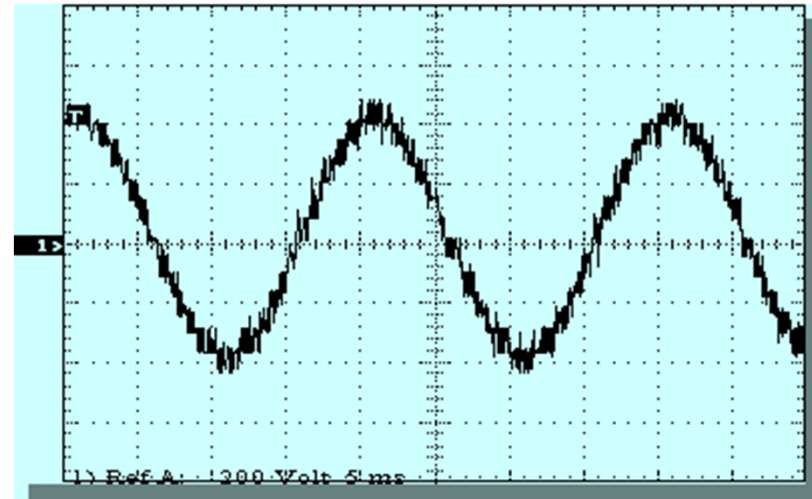
VFD Output Voltage Waveform
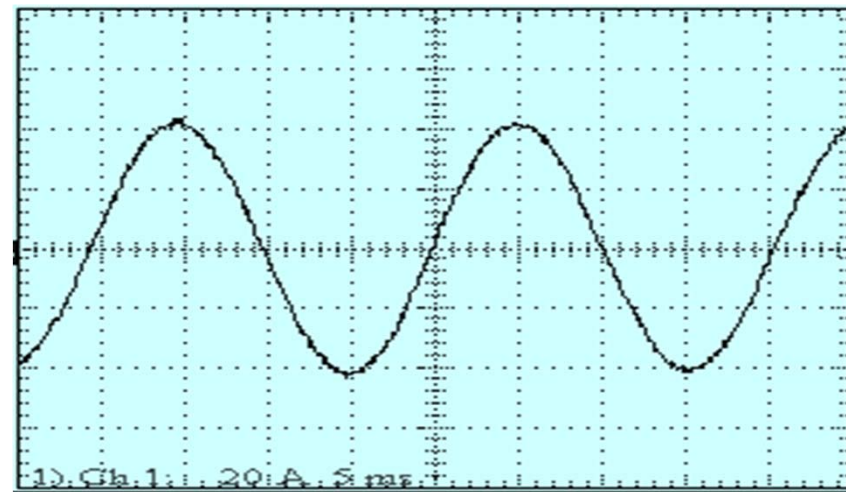
VFD Output Current Waveform
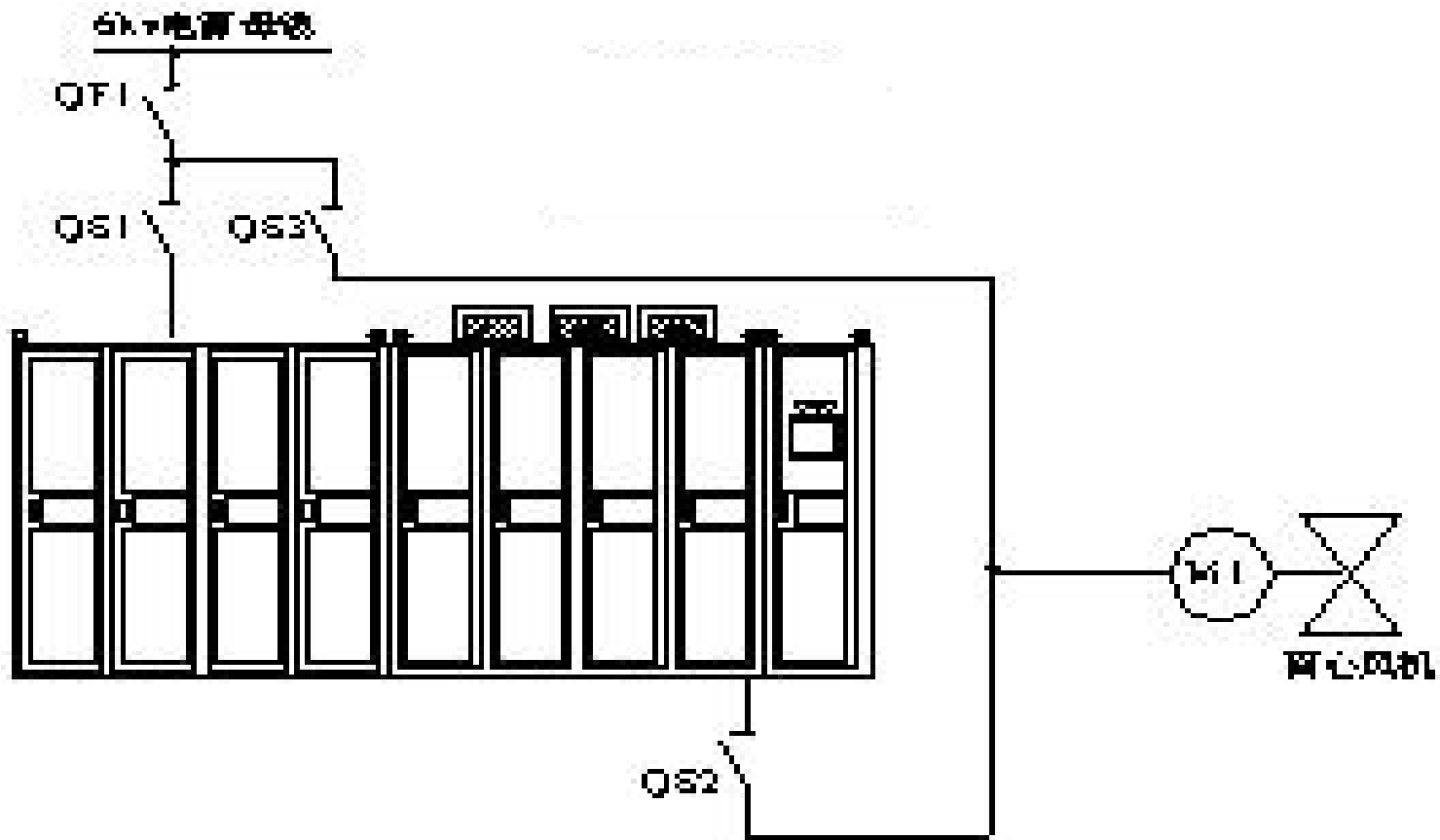
Typical application: One drive for one motor
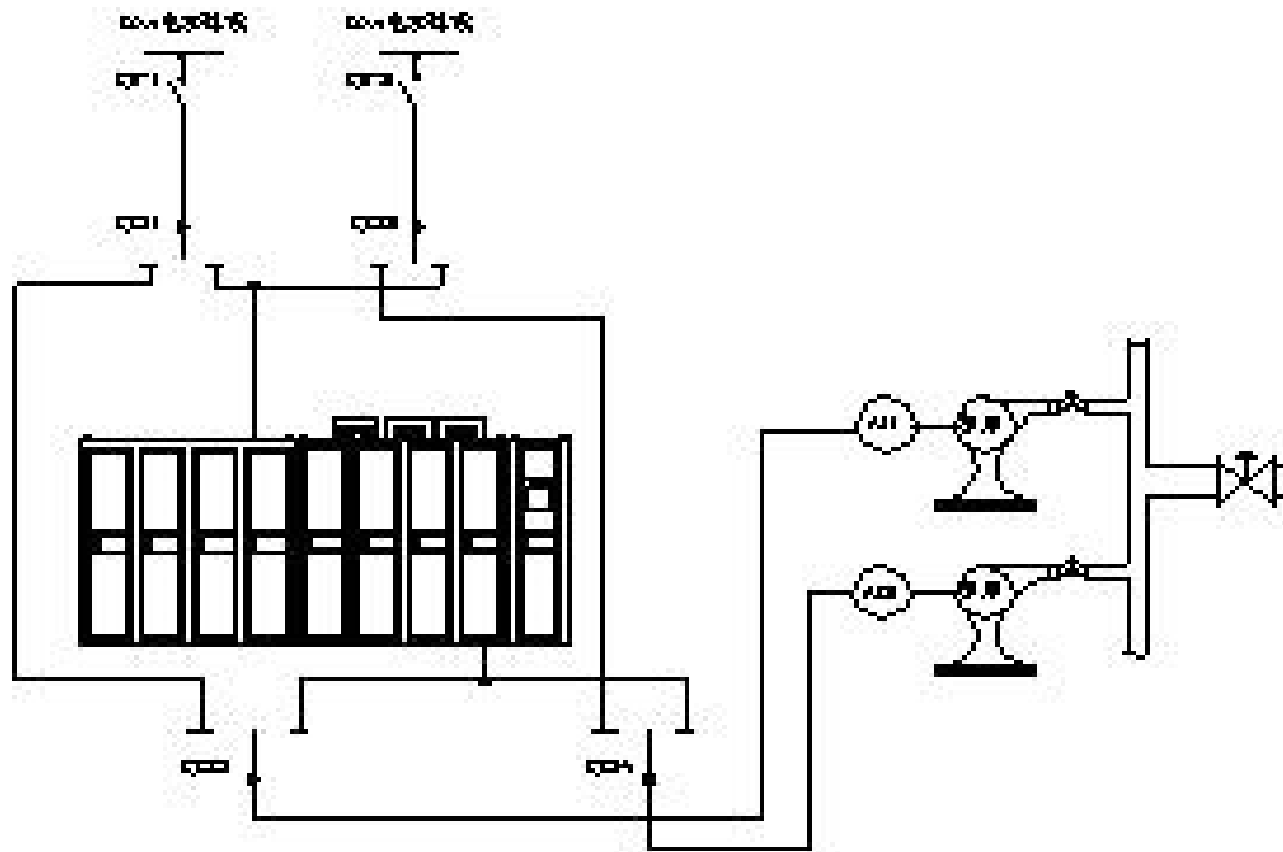
One drive for two motors

VFD Bypass Circuit

Existing
VCB Panel

By Pass
Panel

Phase Shift
Transformer
Panel

Power Cell
Panel

Power Cell
Panel

Main Control
Panel

VFD SYSTEM

LBS

LBS

LBS

New Variable Frequency Drive Panel

Existing
Motor

Regend: LBS = Load Break Switch
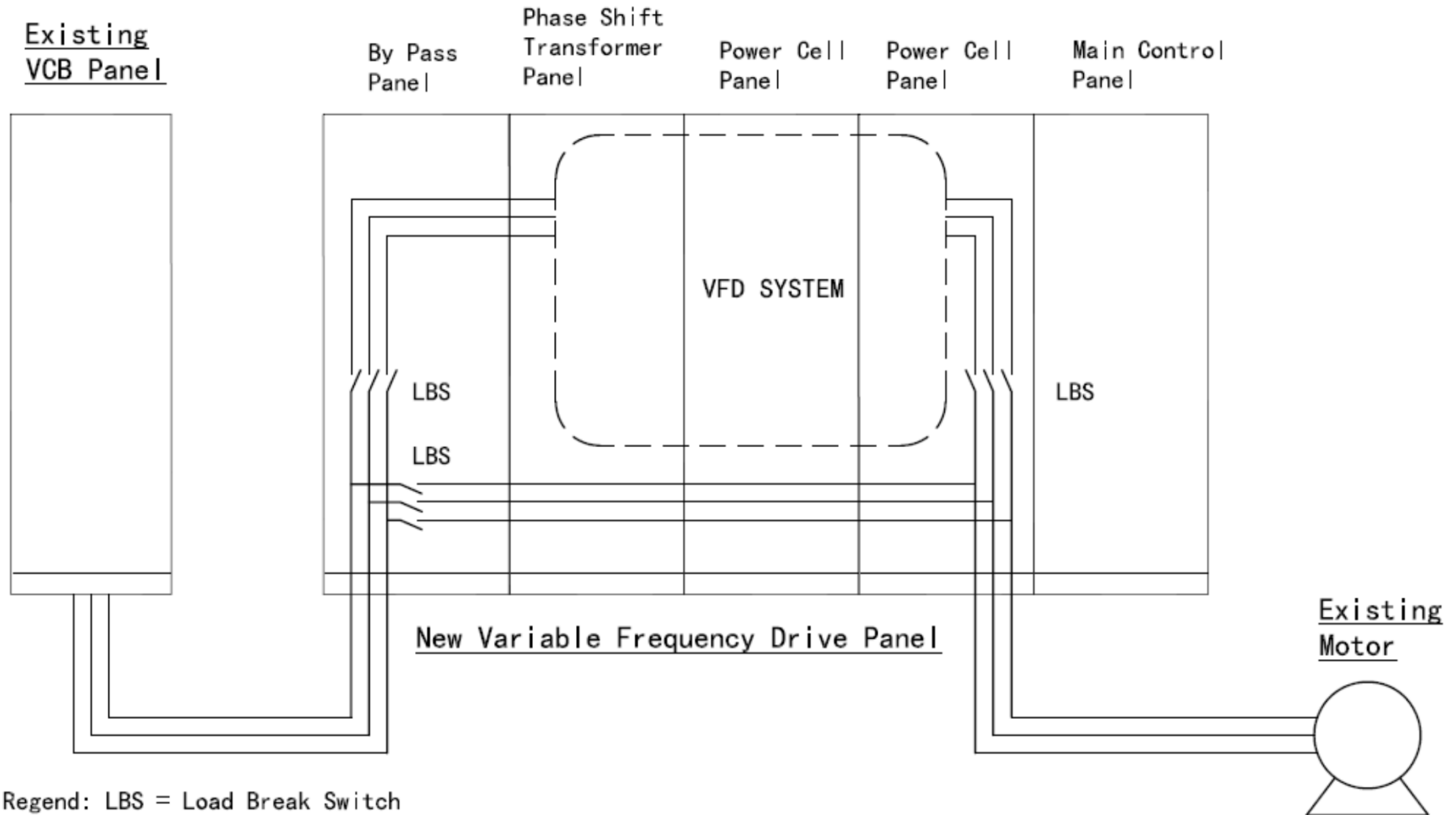
VFD Bypass Circuit Schematic Diagram

DF5000 VFD Technical Core Advantages

— **Vector Controlled Type MV VFD**

    * faster speed for dynamic response，big initial torque；

    * significant increase in speed control accuracy；

    * suitable for any load condition；

— **Multiple Power Supply, undisturbed switch over**

    * High Voltage Auxiliary Supply、Multiple Power Supply for Control System
    * Undisturbed switch over，ensure reliable working of control system

— **Patented Protection Technology**

    * Protection function of Control System fully comply
      to IEC618000 Standard
    * Multiple patented protection technology, ensure
      system running in stable and reliable condition

Main Controller Hardware Platform Innovation
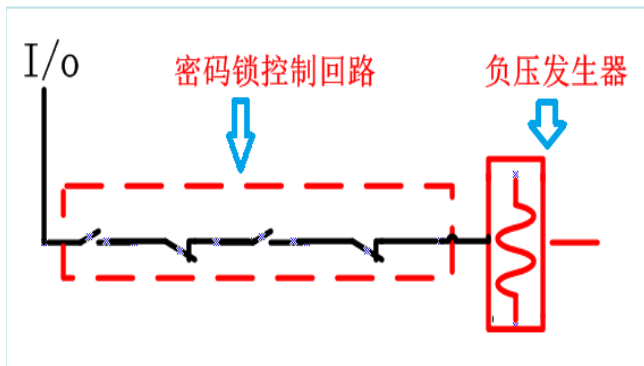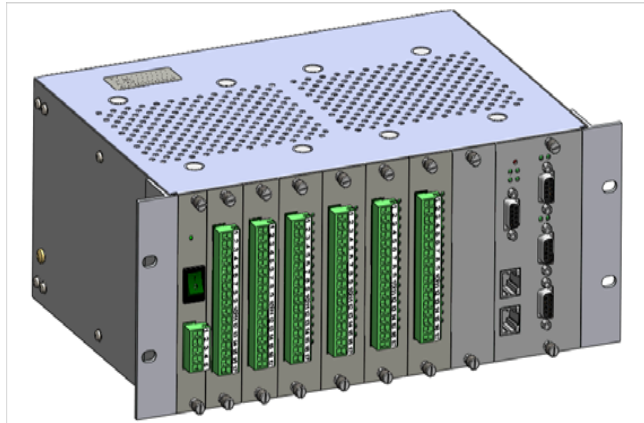
■Hardware Platform using self-developed，modular type of Main Controller(Real Time) to replace PLC system(Non-Real Time) normally used by other manufacturers

■Main Controller is equipped with Hot standby Redundant Power Supply Module

■ "MCU+FPGA Programmable" structure，core software using FPGA to program and design in Hardware，no opportunity for the Controller to "hang"，the reliability is increased more than 10 times

■ Modules is "Hot Swappable"

■ "code lock + node verification + -ve voltage" command control technique, increase the reliability of command control, achieve level IV of highest EMC level in Power System, exceed standard requirement.

Main Controller Software Platform Innovation

Information Of ECM- Version:

No.	Name	ST	No.	Name	ST
1	Received Error		17	IGBT4 Short Circuit	
2	Downlink Optical Fiber Fault		18	IGBT3 Short Circuit	
3	Temperature Alarm		19	IGBT2 Short Circuit	
4	Super Heat		20	IGBT1 Short Circuit	
5	Phase Loss		21	Fault	
6	DC Overvoltage		22	Alarm	
7	IGBT4 Open-circuit		23	Bypass	
8	IGBT3 Open-circuit		24	Reserve	
9	IGBT2 Open-circuit		25	Reserve	
10	IGBT1 Open-circuit		26	Reserve	
11	IGBT4 Overcurrent		27	Reserve	
12	IGBT3 Overcurrent		28	Reserve	
13	IGBT2 Overcurrent		29	Reserve	
14	IGBT1 Overcurrent		30	Reserve	
15	Unit Controller Received Error		31	Reserve	
16	Uplink Optical Fiber Fault		32	Reserve	

A1 B1 C1
A2 B2 C2
A3 B3 C3
A4 B4 C4
A5 B5 C5
A6 B6 C6
A7 B7 C7
A8 B8 C8
A9 B9 C9

Back

No. | ID | Tim

Clear First P

Unit Controller Information

No.	Name	Status	No.	Name	Status
1	Input Overvoltage		17	Motor Current Unbalance	
2	Input Undervoltage		18	Output Undervoltage	
3	Input Voltage Unbalance		19	Output Voltage Unbalance	
4	Input Instantaneous Trip		20	Input Current Unbalance	
5	Input Overcurrent		21	Input Phase Loss	
6	Motor Overvoltage		22	Output Phase Loss	
7	Motor Overcurrent		23	Bypass Stage Over Limit	
8	Motor Instantaneous Trip		24	Auto Current Limited	
9	Input Power-off		25	Output Single Phase Grounding	
10	Input Power-off Reclose		26	ECM Overvoltage	
11	Input Power-off Trip		27	ECM Overvoltage Alarm	
12	Input PT Open-Circuit		28	Scan Frequency Success	
13	Output PT Open-Circuit		29	Scan Frequency Failure	
14	Phase Order Incorrect		30	Normal Switch	
15	Input Over Voltage Trip		31	Forced Switch	
16	Version Difference between FPGA and DSP		32	Peak Current	

DSP Version
High Word
Low Word
FPGA Version
High Word
Low Word

on Menu

HVF Close
HVF Trip
Bypass Close
Bypass Trip
PF/VF Switch

Back

un Menu

Utilize big capacity storage device, achieve disturbance recording, Time Tag analysis and retrieve, realise problem "Analysis Expert" system

User Friendly HMI(Human Machine Interface)

Complete data record searching

Screen 1:

Main Controller	Unit Controller	ECM	Real-time Data Curve

Welcome to data inquiry system

Back

Screen 2:

History SOE	History Data	History Curve	Data Maintenance
Previous Day	← SOE of date →		Next Day

No.	ID	Time	ST	Name

| First Page | Last Page | Pageup | Pagedown | Back |

Screen 3:

Main Controller	Unit Controller	ECM	Real-time Data Curve

Real-time Data Curve

Output F
Output I
Output V
Output P
Input I
Input V
Input P

Real Value
Full Value

120 110 100 90 80 70 60 50 40 30 20 10 0%

0 1 2 3 4 5 6 7 8 Minutes

	Stop	Start	Coordinate Conversion	Back

Screen 4:

Unit Controller Realtime Data	Unit Controller Information	Reserve	Reserve

Name	Value	Unit	Name	Value	Unit
Input Urs		kV	Output Urs		kV
Input Ust		kV	Output Ust		kV
Input Utr		kV	Output Utr		kV
Input Irs		A	Output Irs		A
Input Ist		A	Output Ist		A
Input Itr		A	Output Itr		A
Input P		kW	Output P		kW
Input COS			Output COS		
Input F		Hz	Output F		Hz
Motor Speed		rpm	Reserve		

Back

Screen 5:

DI1	DI2	DCAI	AO	System

No.	Name	ST	No.	Name	ST
1	Remote Start		9	Remote Bypass Close	
2	Remote Stop		10	Remote Bypass Trip	
3	Remote Emergency Stop		11	Motor Emergency Stop Button	
4	Remote Revert		12	Speed Setpoint1	
5	Remote VF/PF Switch		13	Speed Setpoint 2	
6	Remote PF/VF Switch		14	Speed Setpoint 3	
7	Remote HVF Close		15	Speed Setpoint 4	
8	Remote HVF Trip		16	Speed Setpoint 5	

Back

Screen 6:

History SOE	History Data	History Curve	Data Maintenance

Delete History SOE in CF-Card
Delete History Data in CF-Card

Caution:
Data Maintenance is Critical,
operated by professional only!

Back

Power Unit Information

Unit Controller Information

No.	Name	Status	No.	Name	Status
1	Input Overvoltage		17	Motor Current Unbalance	
2	Input Undervoltage		18	Output Undervoltage	
3	Input Voltage Unbalance		19	Output Voltage Unbalance	
4	Input Instantaneous Trip		20	Input Current Unbalance	
5	Input Overcurrent		21	Input Phase Loss	
6	Motor Overvoltage		22	Output Phase Loss	
7	Motor Overcurrent		23	Bypass Stage Over Limit	
8	Motor Instantaneous Trip		24	Auto Current Limitted	
9	Input Power-off		25	Output Single Phase Grounding	
10	Input Power-off Reclose		26	ECM Overvoltage	
11	Input Power-off Trip		27	ECM Overvoltage Alarm	
12	Input PT Open-Circuit		28	Scan Frequency Success	
13	Output PT Open-Circuit		29	Scan Frequency Failure	
14	Phase Order Incorrect		30	Normal Switch	
15	Input OverVoltage Trip		31	Forced Switch	
16	Version Difference between FPGA and DSP		32	Peak Current	

DSP Version

High Word

Low Word

FPGA Version

High Word

Low Word

Back

ECM Status

R	Fault	Alarm	Bypass	S	Fault	Alarm	Bypass	T	Fault	Alarm	Bypass
A1				B1				C1			
A2				B2				C2			
A3				B3				C3			
A4				B4				C4			
A5				B5				C5			
A6				B6				C6			
A7				B7				C7			
A8				B8				C8			
A9				B9				C9			

ECM Status | ECM Voltage | ECM Temperature | ECM Information

Back

ECM Voltage

R	Value	Unit	S	Value	Unit	T	Value	Unit
A1		V	B1		V	C1		V
A2		V	B2		V	C2		V
A3		V	B3		V	C3		V
A4		V	B4		V	C4		V
A5		V	B5		V	C5		V
A6		V	B6		V	C6		V
A7		V	B7		V	C7		V
A8		V	B8		V	C8		V
A9		V	B9		V	C9		V

ECM Status | ECM Voltage | ECM Temperature | ECM Information

Back

ECM Temperature

R	Value	Unit	S	Value	Unit	T	Value	Unit
A1		℃	B1		℃	C1		℃
A2		℃	B2		℃	C2		℃
A3		℃	B3		℃	C3		℃
A4		℃	B4		℃	C4		℃
A5		℃	B5		℃	C5		℃
A6		℃	B6		℃	C6		℃
A7		℃	B7		℃	C7		℃
A8		℃	B8		℃	C8		℃
A9		℃	B9		℃	C9		℃

ECM Status | ECM Voltage | ECM Temperature | ECM Information

Back

Main Controller Software Platform Enovation

Dual Ethernet Port, **Internal integrated with** "MODBUS"、"PROFIBUS"、"DCS", etc. multiple interface

* Consist of 100 over standard protocol
* Can communicate with most of the Master Station or DCS

This technique we have one pratical new patent 《Modular Design Type of Main-Controller used in MV VFD》。

Patent No: ZL 2010 2 0153450.1

Low voltage reverse supply to high voltage pre-charging technique

Traditional Solution

■In case system is supplied with Medium Voltage without "Pre-charging", the high starting current will give a surge impact to switches and VFD components, which might sometime cause damage of device or mul-function of protection.

■During Testing & Commissioning, the Medium Voltage must be available else the testing and diagnose of device can not be carried out

Our New Solution

■ Using "low voltage reverse supply to high voltage pre-charging technique", reduce the surge impact to system and device, increase system reliability

■ In case Medium Voltage is not yet available, still can perform system testing, diagnosis, function verification, and actual signal waveform can be sent out, increase working efficiency

For this technique, Dongfang has one pratical new model patent:
《using low voltage technique to do medium voltage VFD Pre-charging Circuit》.
Patenet no: ZL 2010 2 0153457.3

Using low voltage technique to pre-charge MV VFD, solve the problem of surge impact to capacitors, other components and switches

MV Winding

690V Phase Shift Winding

LV 415V

Control Locking Logic

Pre-charging Resistor

LV Auxiliary Winding

Vector Balance Central Point to Bypass Power Unit

Utilize reliable electrical type bypass technique, to ensure when a particular Power Unit is spoilt, the VFD can still deliver normal output

创新解决方案

Traditional Method

■Multiple Power Unit in series, when a particular Power Unit Spoilt, two other Power Units need to be bypassed at the same time

■Using Electronic type of bypass method which can result in component spoilt under High Voltage

■Can not satisfy the condition of continuous running "stop not allowed" industry situation

■ Unit bypass using "Vector Balance Central Point" technique, can bypass only one particular spoilt unit

■ Unit Bypass using electrical type, avoid the situation of component spoilt under high voltage situation

■ Fully satisfy the condition of continuous running "stop not allowed" industry situation

When One Power Unit Spoilt can run with lower rating

11kV/50Hz

3 phase Asynchronous Motor

M

Unit Controller

HMI Interface

Main Controller

11KV VFD System
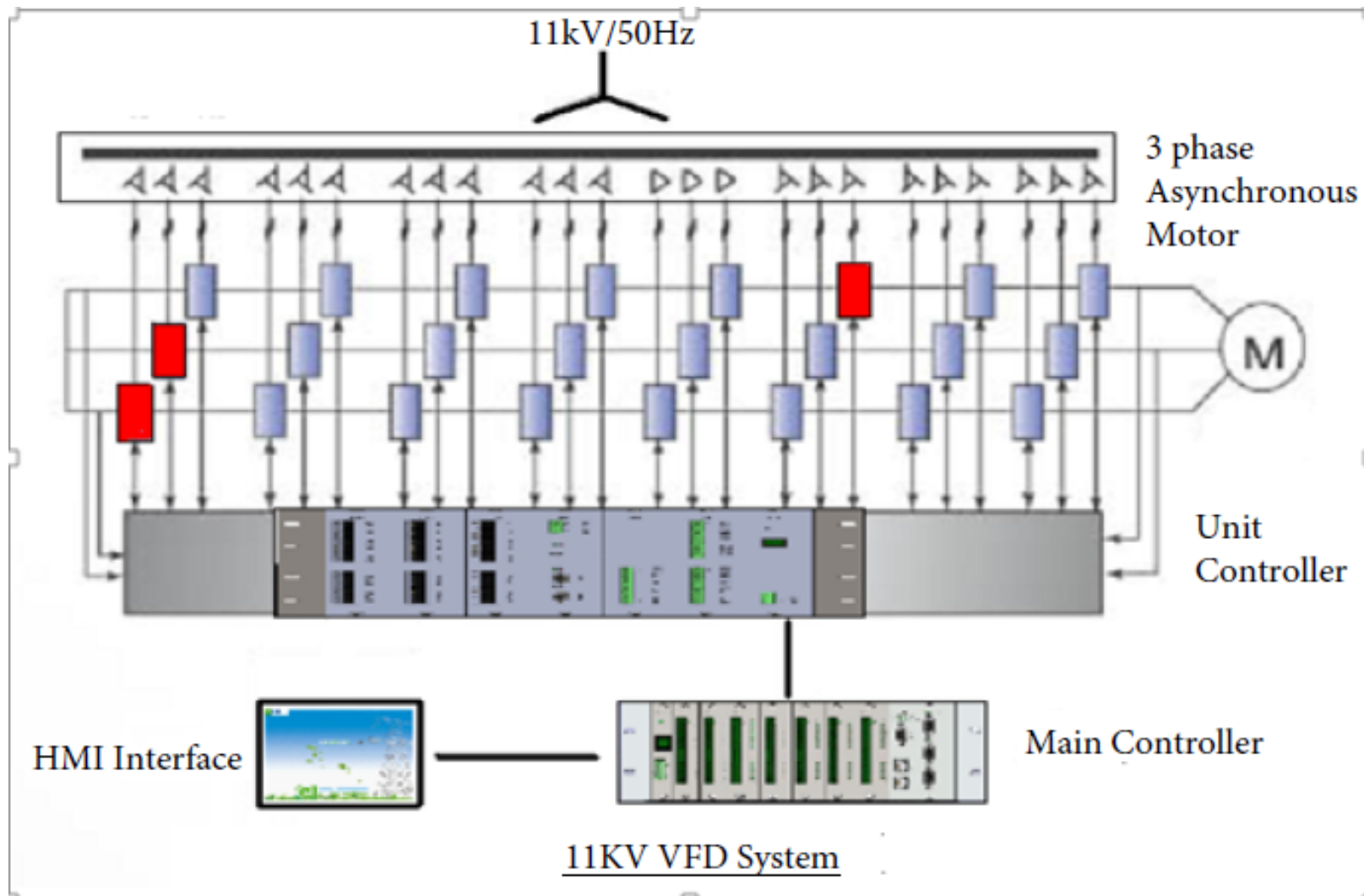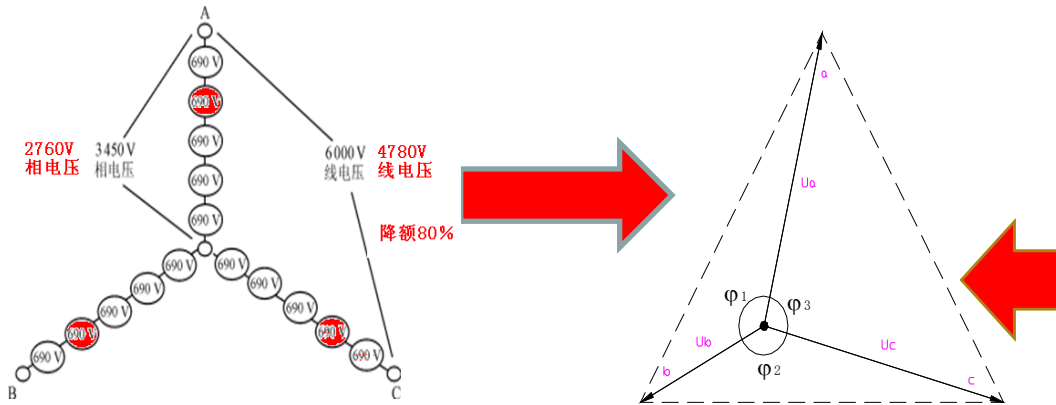
> ➤ **"Center Point shifting, Voltage Vector Balanced"**
> **It means when one Power Units spoilt, we bypass only the particular unit and do not need to bypass 3 units, this is realized by adjusting 3 phase output voltage to achieve line voltages balance**
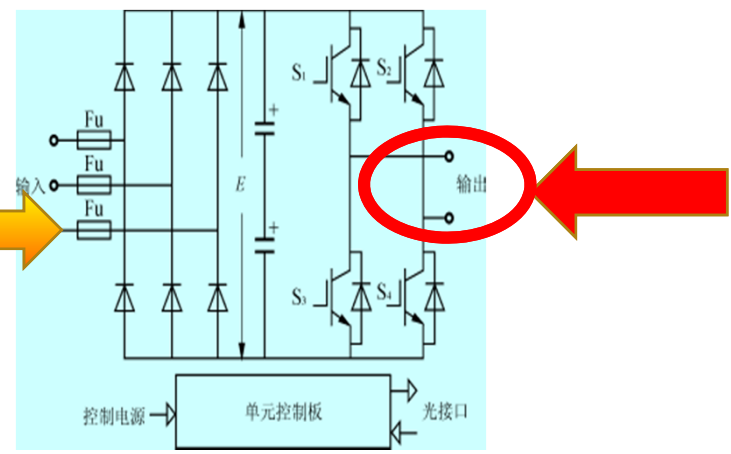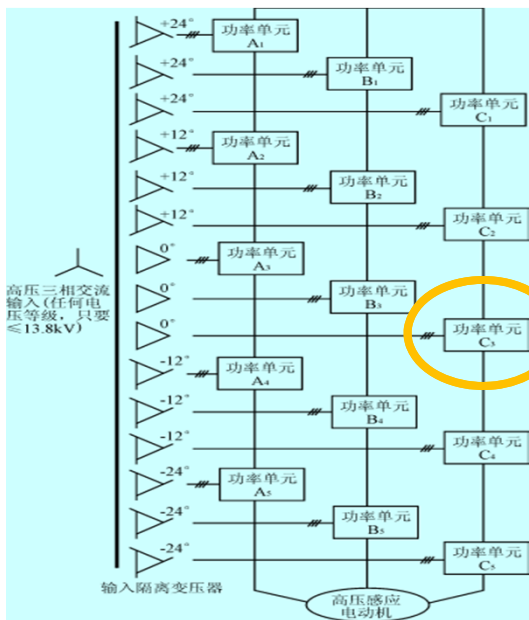
➤ **The bypass mechanism is by electrical type and not electronic type**

➤ **Bypass of unit is initiated by Main Controller so even Power Units is totally spoilt also can be bypassed**

ATMS(Auto Track Motor Speed) Technique，direct driving rotating load

"ATMS" technique，solve the problem of MV VFD direct driving rotating load

Traditional Method

■When Motor load is rotating, can not transfer from Power Frequency to variable frequency, need to stop the motor in order to let VFD output take over the Power Frequency output

■ under large power load, efficiency of system operation reduce significantly

New Method

■"ATMS"control technique，using frequency scanning and locking technique，can trace motor running condition without speed transducer，can ensure any rotation speed of the motor under adjustable frequency range, automatic identify motor condition and speed，no need to stop the motor and can change from Power frequency to variable frequency without any surge impact

■Using energy feedback technique, feedback the energy re-created by VFD to the source, re-using the energy, reduce heat produced by the device, increase the device life time.

■Under big power load and special system condition, reliability & efficiency of system operation is increased significantly

Rotating Load Direct Drived By VFD

➢ **VFD firstly send out 50Hz signal to motor stator**

➢ **Following voltage/frequency curve, scan the frequency of the frequency-reducing rotor, and monitor VFD output current at the same time**

➢ **When "Turning Point" appear in VFD output current, which means frequency scanning is successful, and lock the current frequency.**

➢ **VFD follow the motor rotor current frequency, bring the motor to the target frequency**
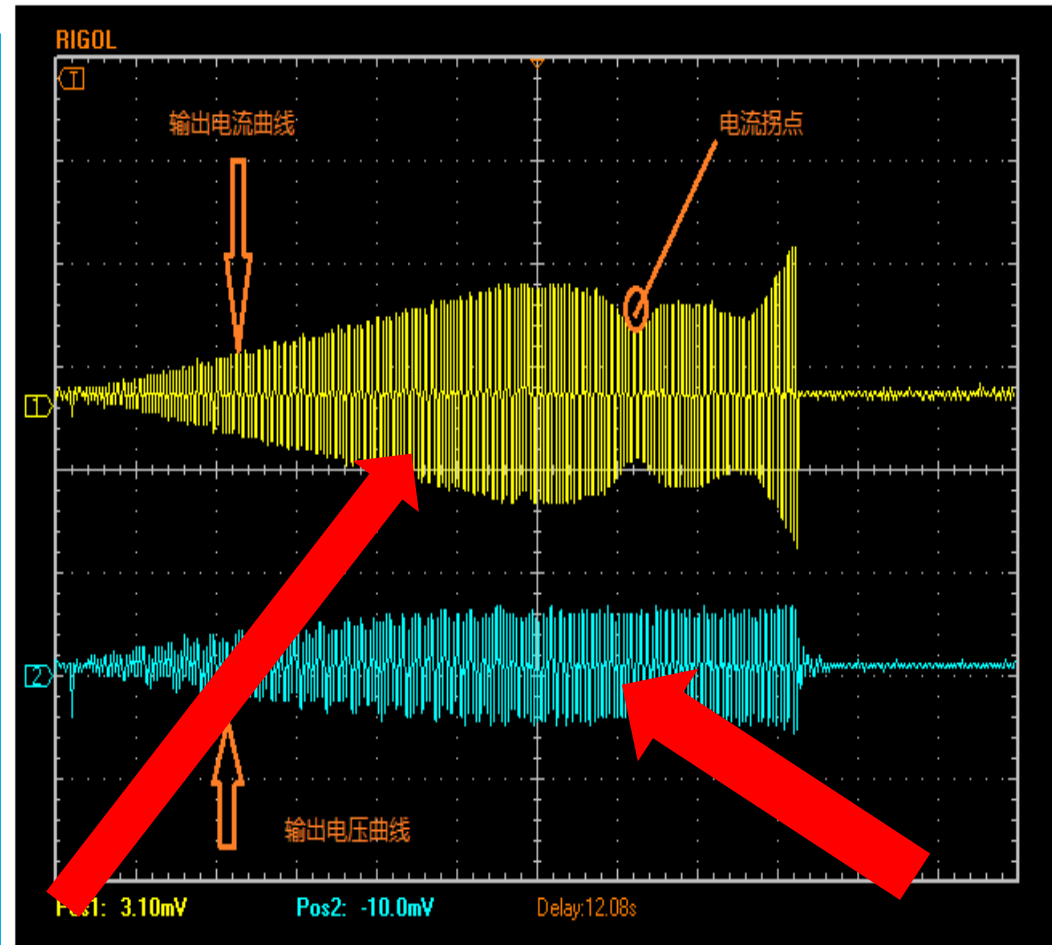
Current Waveform

Voltage Waveform

◆Inductionless bar，reduce di/dt
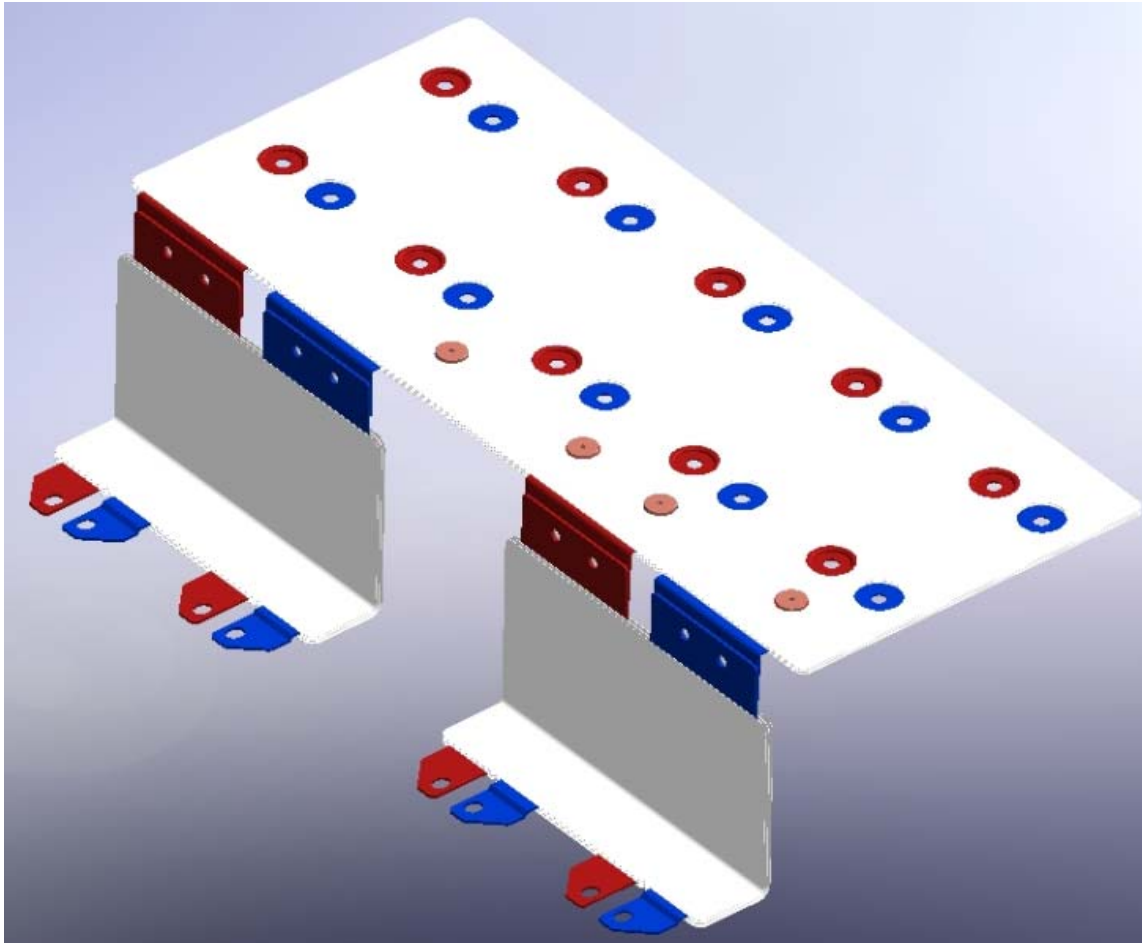
$$V=L*di/dt$$

Other Electrical Component Design

◆Inductance in IGBT circuit
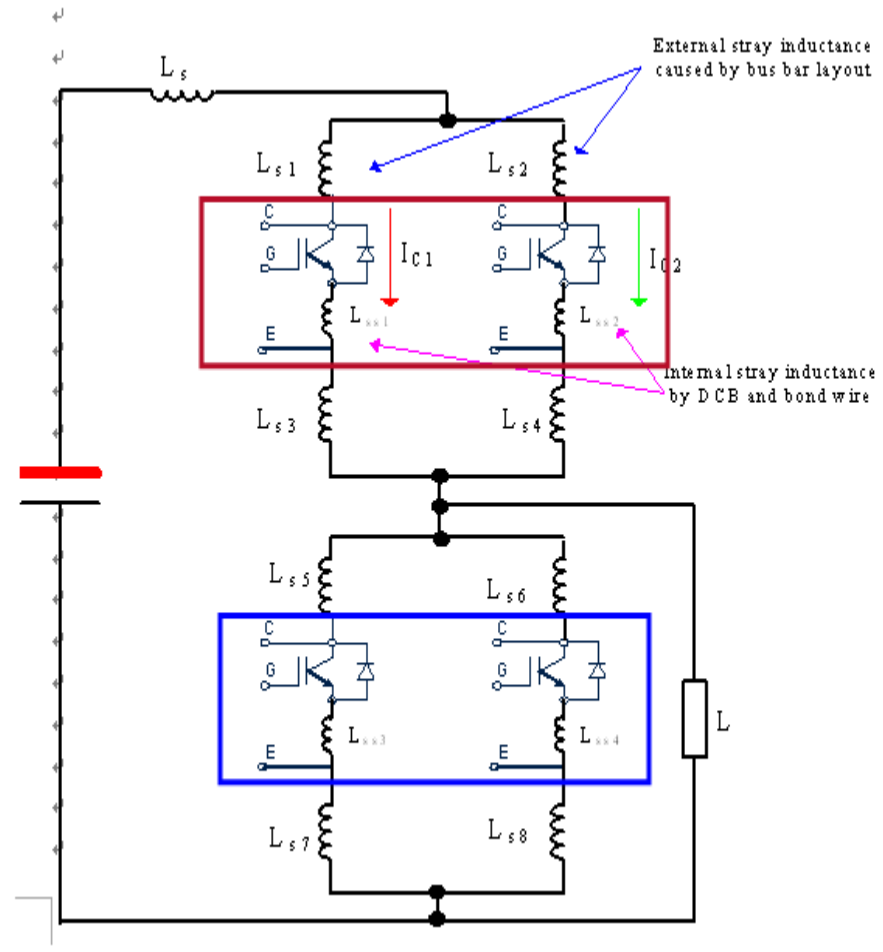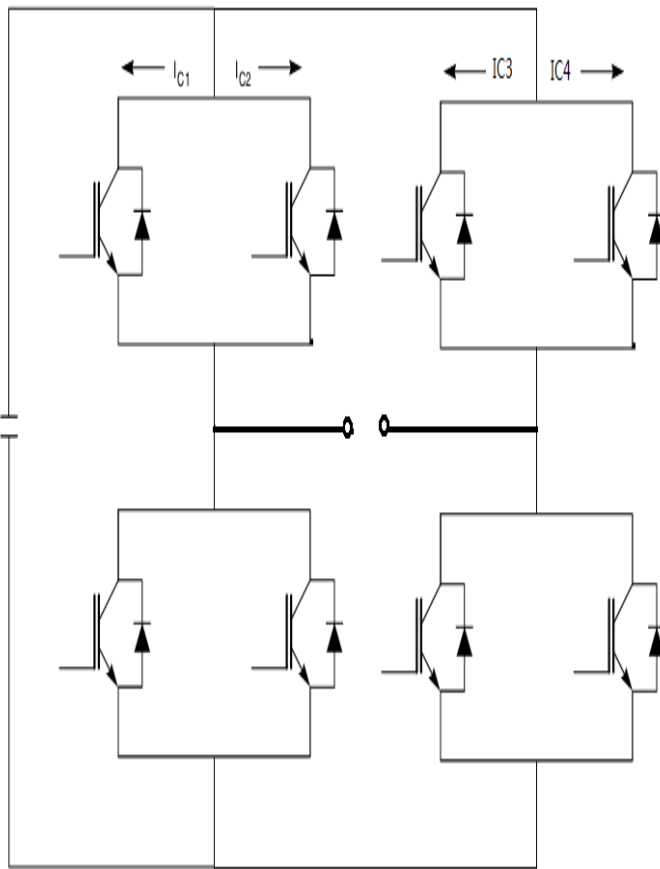
Other Electrical Component Design

◆Heat dissipation actual measurement

tally with design figures
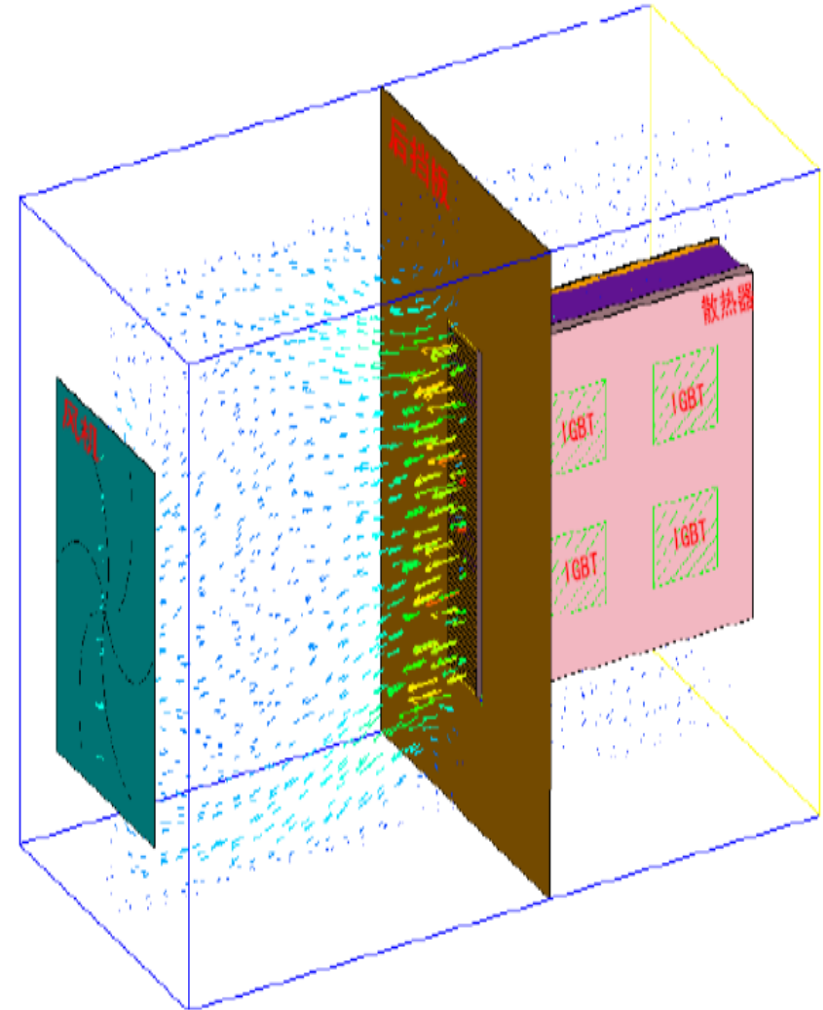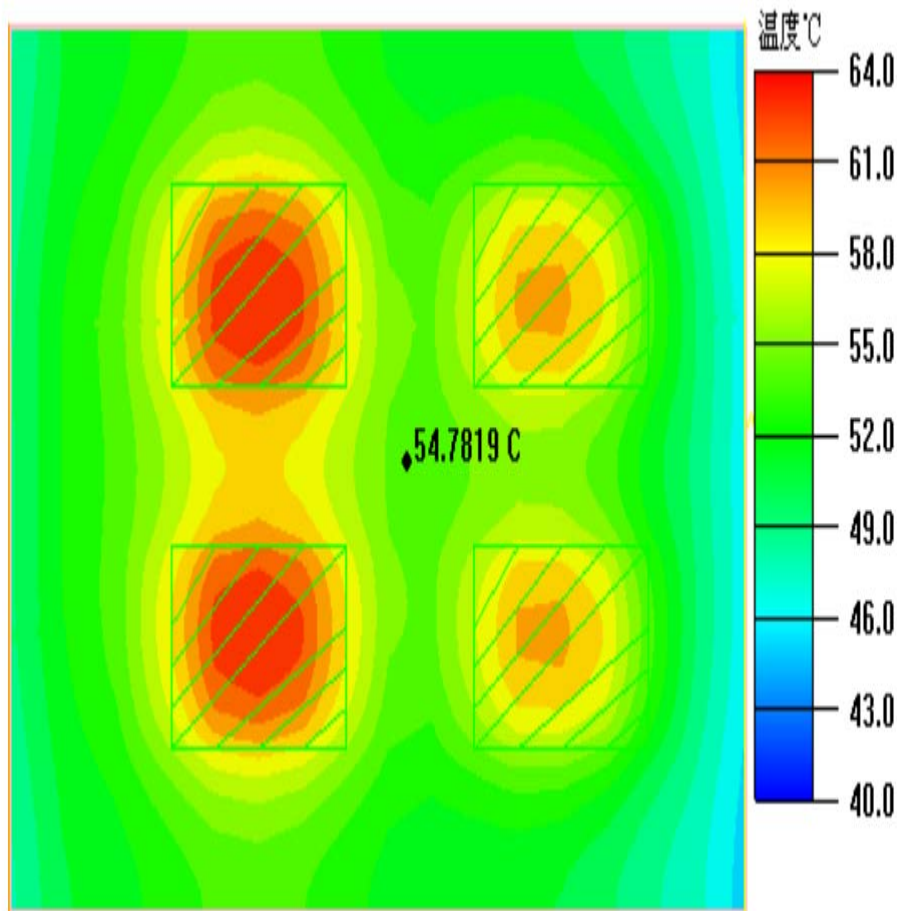
Functions Comparison

Function	DF5000 VFD	Other Manufacturers
Pre-charging Circuit	Yes	No
Power Unit Bypass Initiation	by Main-Controller	by Power Units
Power Unit Bypass Method	Electrical Type	Electronic Type, chances of IGBT spoilt by high voltage is higher
Main-Controller Operating System	Real Time Multi-Tasking using Own developed RTU	Non-Real Time Using Third Party PLC
Event Recording	Unlimited	Limited
Line Voltage Vector Balance technique	Yes	Only Some have
ATMS function	Yes	Only Some have

Function	DF5000 VFD	Other Manufacturers
Testing without Medium Voltage	Yes	No
EMC Testing	Most Severe Class IV	Mostly class III
Power Units Temperature Information	By Digital display	just showing status(by green colour, red colour, etc.)
Type Test Content	All Items	Mostly part of the Items

☐ **About Energy Situation & Demands**

☐ **About DF5000**

☐ **Application & Case**

精确创新 持续进步

Case 1#

Customer: Yantai Wanhua Huali Thermal Power Plant

Solution supplier: EPC project

Project Brief:
One set of DF5000 system using one drive two solution to reform 2 sets of fans (6kw/355kw×2) with remote control of DCS
Application Scope: electricity, chemical

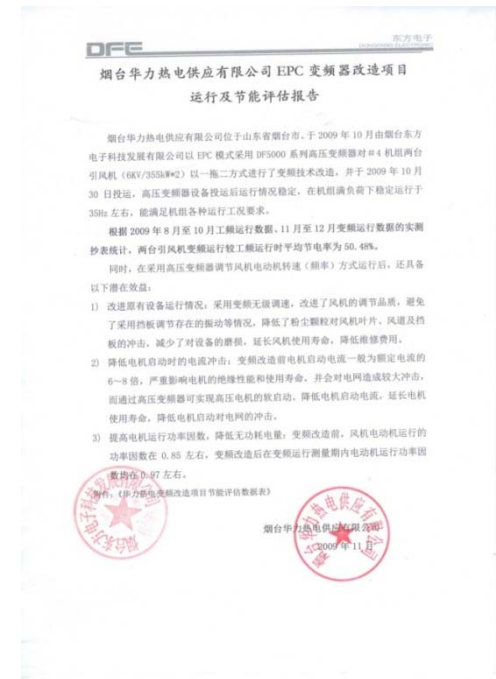**Application loads: Centrifugal fans**

Achievement:
The average energy-saving rate is 50.48%
Saving 1475 thousands kwh electricity power every year
Saving RMB 700 thousands(around RM455K)
cost for customer every year

续进步

Case 1#

精确创新　持续进步

Case 2#

Customer: YANTAI SPANDEX CO.,LTD

Equipment supplier for EPC project

Project Brief:
One set of high voltage converter and one set of low voltage converter. Using one drive two solution for compressor (10kV/500kW) and water pump (380V/110kW) with closed loop temperature control .

Application Scope: chemical, textile

Application loads: screw compressor, water pump

Achievement:
The energy-saving rate for compressor is 44.8%
The energy-saving rate for compressor is 44.6%
Saving 980 thousands kwh electricity power every year
Saving RMB 600 thousands(around RM390K) cost for customer every year

Case 2#

精确创新　持续进步

➢烟台万华华力热电厂

Case 3#

Customer: Ru shan Wall Cement Plant

Equipment supplier for EPC project

Project Brief:
One set of high voltage.
Using one drive one solution with local HMI control for Centrifugal fan
(10kV/400kW).

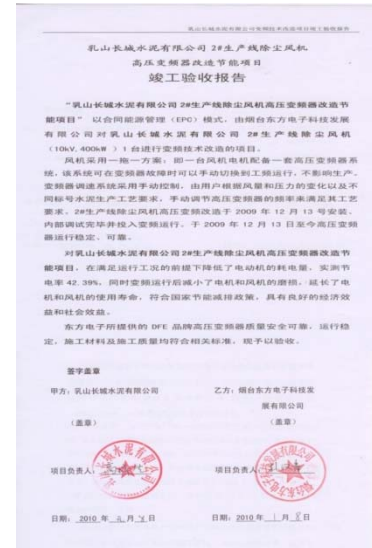Application Scope: cement

Application loads: Centrifugal fan

Achievement:
The energy-saving rate for Centrifugal fan is 35%
Saving 700 thousands kwh electricity power every year
Saving RMB 500 thousands(around RM325K) cost for
customer every year

Case 3#

Case 4#

Customer: Shanxi Baode Power Plant

Solution supplier: EPC project

Project Brief:
8 sets of high voltage converter.
Using one drive one with automatic bypass solution for 4 sets of fans(6kV/1600kW), 4 sets of Centrifugal fan (6kV/1400kW), with DCS system integrated

Application Scope: Power Plant
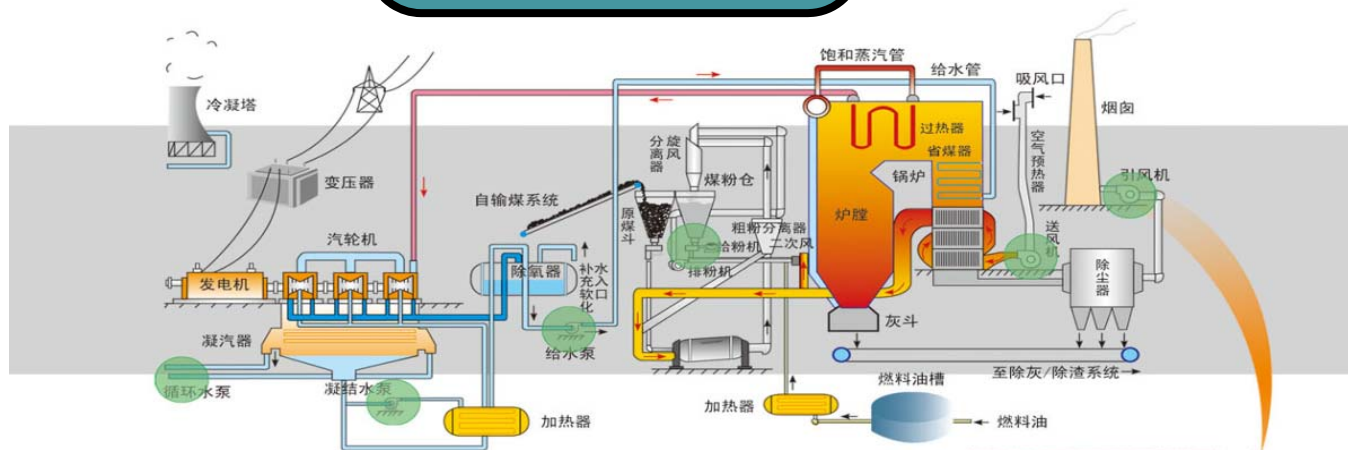
Application loads: fan and centrifugal fan

Achievement:
The energy-saving rate for fan and centrifugal (80% load) > 30%
Saving 20 millions kwh electricity power every year
Saving RMB 10 millions cost(around RM6.5M) for customer every year

Case 4#

保德电厂#2机组变频改造项目节能分析数据
（统计周期：2008年12月1日15点至2009年3月1日16点）

设备	变频运行耗电量(万kWh)	平均运行功率（kW)	结算节电率	节约标煤（吨）
引风机A 1400kW	78.49	413.75	54.69%	331.6
引风机B 1400kW	77.48	408.43	52.45%	299.1
一次风机A 1600kW	116.48	614.05	49.73%	403.3
一次风机B 1600kW	116.35	613.33	46.68%	356.5
结算周期内风机变频运行时间统计：	1897小时			
结算周期内4台风机节电量总计：	397.2931万kWh			
结算周期内4太风机节约标煤	1390.5吨			

引风机

引风机使用高压变频设备后节电率超过50%

高压变频设备

通过使用东方电子的高压变频节能方案，保德电厂4个月4台电机节省标煤达1390吨，减少了不可再生资源浪费的同时，提高了设备运行的稳定性，延长了设备的使用寿命。

续进步

Case 4#

精确创新 持续进步

Thank You

精确创新 持续进步