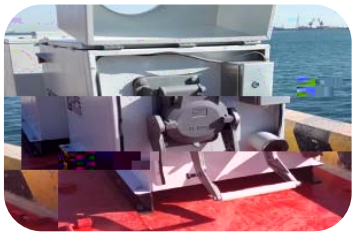
DF5010 Catalogue

Onshore Power Supply System

For Reliable, Secure and Economical Energy System Operation

Dongfang Electronics International Engineering Co., Ltd.
Dongfang Electronics Co., Ltd.

1 Onshore Power Supply System

With the development of shipbuilding technology and the needs of shipping, the number of large-tonnage ships has increased rapidly, and the use of onshore power supply instead of ship generators during the port call can effectively reduce the large-scale air and noise pollution caused by the combustion of fuel oil and achieve zero emission. At the same time, the use of onshore power supply is also a trend according to the current and future energy trends.

1.1 Composition of Onshore Power Supply System

The onshore power supply system is composed of three parts: the onshore variable frequency power supply system, the ship-to-shore connection system, and the shipboard power receiving system, as shown in Figure 1, The Architecture of High-voltage Onshore Power Supply System.

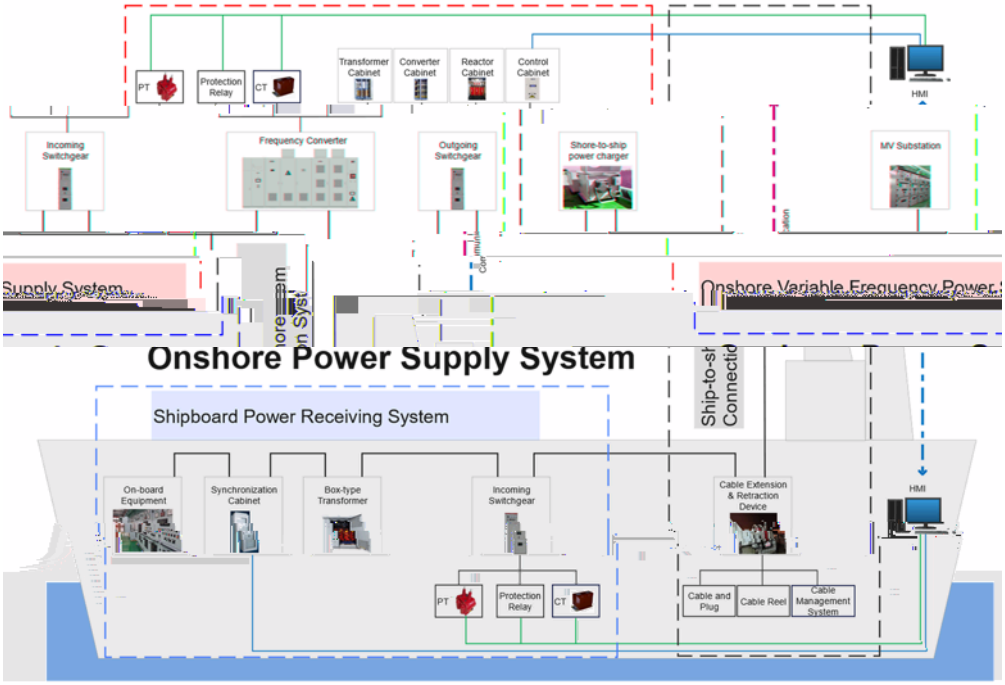


Figure 1 Architecture of High-voltage Onshore Power Supply System

Onshore variable frequency power supply system: It is mainly composed of high-voltage variable frequency power supply and shore-to-ship power charger and connecting cables.
Ship-to-shore connection system: It is composed of cable reel, plug and connecting cable, etc.
Shipboard power receiving system: It is composed of shipboard transformer, shipboard power receiving cabinet, shipboard power distribution cabinet and connecting cable, etc.

1.2 Main Functions

The onshore power supply system integrates monitoring, control, protection, metering, billing, and equipment management, and meets the requirements of high-voltage onshore power connection through flexible configuration and combination.

1) **Power conversion:** Convert the voltage / frequency of port land side power grid to the voltage / frequency required by ship.

Voltage (V)	Frequency (Hz)
6,600	60
6,000	50
440	60
400	50

Table 1: Voltage & frequency of output of onshore variable frequency power supply system

Regarding the cruise ship, the voltage / frequency required by ship is normally 11kV 50Hz / 60Hz.

2) **Ship Connection Method**

High-voltage ship connection: The number of cables is small, the connection is simple, and it is suitable for large capacity.

Low-voltage ship connection: The number of cables is large, the connection is complex, and it is suitable for small capacity.

Onshore power supply system can supply power to ship by high voltage or low voltage, usually the below rules should be followed:

When power capacity required is less than 630kVA, low voltage power supply could be used.

When power capacity required is between 630kVA and 1600kVA, high voltage power supply is suggested.

When power capacity required is greater than 1600kVA, high voltage power supply should be used.

When the low-voltage power supply method is adopted, the number of ship-to-shore connection cables is large, and the volume of the cable reel is large, which will occupy a lot of space. For the ship of small tonnage, it is recommended to provide the cable and cable reel by land side.

When the high-voltage power supply method is adopted, the cable and cable reel will be usually supplied by ship side according to the international practice. And land side will establish the power supply point in the dock front.

3) **Shore-to-ship Power Supply Method:** Connection without ship's power running, and Connection with ship's power running.

Connection without ship's power running: When the ship enters the port, firstly turn off

all the electrical equipment on the ship and stop the ship's generator, then connect to the onshore power supply, and finally turn on the ship's electrical equipment. It realizes the switching from the ship's generator to the onshore power supply. When the ship leaves port, it should be operated in reverse sequences.

Connection with ship's power running: It is also called synchronization connection mode, in which the ship electrical equipment's normal operation is not affected, and it has significant benefits for the important electrical equipment on the ship.

Connection with ship's power running mode is the trend of the onshore power system, and it provides the quick protection to fulfill the safe operation of onshore power system.

4) **Metering and Billing:** It meets the requirements of high-precision metering and billing of the port electric energy.
5) **Real-time Monitoring:** It will monitor all the real-time data of onshore power supply system. All the real-time data and fault information can be monitored by HMI.
6) **Integrated Control:** All the functions of the system are controlled through the dedicated control system, and through the triple control network structure combined by optical fiber, RS485 and industrial Ethernet being configured on variable frequency power supply equipment.

2 Product Overview

2.1 Onshore Variable Frequency Power Supply System

Based on its own mature and reliable high-voltage variable frequency technology, Dongfang Electronics Co., Ltd. has independently developed and manufactured the high-voltage onshore variable frequency power supply system required for the onshore power supply system and has established an onshore power supply product line.

The onshore variable frequency power supply system converts the

2) Component Function

Phase-shifting Cabinet: A dry-type phase-shifting rectifier transformer is a device that provides multiphase rectifier power supply for variable frequency driver. The total harmonic distortion (THD) of the input current of the onshore power supply system is much less than the standard of 5%, and the input power factor can be kept close to 1 due to the certain phase difference between the secondary windings of the transformer that provides power to the converter unit, thus eliminating most of the harmonic currents caused by a single converter unit.

Converter Cabinet: The converter cabinet is composed of multiple converter units, and the converter units are cascaded to achieve high-voltage output, which is the most important component of energy conversion. The control signal is sent by the optical fiber transceiver controller to control the IGBT to turn on and turn off according to a certain law to output corresponding waveform.

Impedance Cabinet: It is composed of reactors and power resistors to reduce the instantaneous impacts caused by voltage and current fluctuations during synchronization.

Isolation Transformer Cabinet: It makes the primary and secondary sides be completely electrically insulated and the circuit be also isolated. Energy-saving dry-type copper-core winding transformer is adopted.

Control Cabinet: It is the core control component of variable frequency power supply, which acquires the signals of each component, and ensures the normal operation of variable frequency unit by certain algorithm and logic control.

2.3 Main Parameters

Rated Output	Rated output voltage		6kV 50Hz / 6.6kV 60Hz / 11kV 50Hz or 60Hz
	Rated overload current		120% / 1 minute configurable
Input	Main circuit		Three-phase 10kV, 50Hz
	Control circuit		Three-phase four-wire, 380V, 50Hz
	Allowable power fluctuations	Voltage	±5%
		Frequency	±5%
	Input power factor		Above 20% rated load, 0.95
Harmonic Distortion			IEEE Std 519-1992, GB/T 14549-93
Efficiency (Transformer included)			>96%
Control Function	Control mode		V/F control, PQ droop control
	Output frequency		50 / 60Hz
	Output frequency resolution		0.01Hz
	Ancillary features		Energy-saving statistics, operation information records query, fault recording
Run / Stop Operation			Touch screen, communication

Communication	RS485, Ethernet
Protection Functions	Automatic current limiting, overcurrent cut-off, motor overload, overvoltage, undervoltage, instantaneous power failure, input and output phase loss, cooling fan failure, converter unit fault bypass protection, transformer failure, output grounding, input transformer secondary short circuit
Alarm Functions	Input and output overload, converter unit overheating, unit phase loss, output single-phase grounding, input / output voltage and current unbalance, input / output PT disconnection, door switch, transformer overheating, cooling fan failure, etc
Display & Operation Method	Touch screen, door buttons, power indication
Cooling Method	Forced air cooling / Liquid cooling
IP Protection Level	IP30

2.4 Technical Features

Control system of onshore variable frequency power supply adopts DF1725 embedded centralized control product independently developed by Dongfang Electronics Co., Ltd. and it is integrated in the control cabinet of variable frequency power supply.

The controller adopts 32-bit MCU+DSP+FPGA hardware platform, and the software is real-time multitasking operating system.

The communication protocol follows international standards using Ethernet, Modbus, and other communication methods, which is convenient for connection with various ship control systems. The communication method adopts optical fiber.

It has various peripheral interfaces such as RS485 and Ethernet, which is convenient for expansion of multiple field bus communication to support centralized control and monitoring of upper control system on variable frequency power supply, high-voltage incoming / outgoing cabinet, transformer, fans, high voltage shore-to-ship charger, etc.

By collecting the operation signals of each equipment, the system is protected and controlled, and the protection functions are: 50Hz / 60Hz operational power line interlock protection, system operation condition protection, power-on program control protection, power cut-off program control protection, system fault protection, personnel maloperation protection, and hardwired interlock protection.

Through DF1725 communicating with the control unit, the status monitoring, metering and billing, parameter modification, real-time control, and fault recording & diagnosis

can be realized.

Display function: It can display the frequency, voltage, current, three-phase unbalance, active power, reactive power, power factor and other parameters of the output power supply, and display statistics and measurement for active power energy and reactive power energy.

Phase sequence detection and adjustment: The power output phase sequence has automatic and manual adjustment modes.

Hardwired interface: Commands of start, stop, reset and emergency stop.

Operational status signals: power ready, running, stopped, alarm, fault (shutdown).

The power supply quality complies with relevant standards.

It has protection functions such as instantaneous overcurrent, short circuit, overload, output undervoltage, input undervoltage, overvoltage, overheating, input frequency range, overcurrent, phase loss protection, unit converter abnormal protection, output voltage unbalance protection, IGBT component overcurrent protection, IGBT component overtemperature protection, converter input current protection, AC bus grounding protection and other protection functions.

Output voltage closed-loop control technology: When the onshore power supply equipment is running, its output adopts voltage closed-loop control, and the PID method is used to ensure the stability and accuracy of the output voltage by detecting the output voltage's feedback. With the automatic switching function of opening and closing, when there is a problem detected, it will not cause large voltage fluctuations, so that the electrical equipment on shipboard will not be affected by voltage fluctuations.

The variable frequency power supply has the ability of three-phase voltage unbalance self-adaptation, allowing three-phase unbalanced operation. The unbalance of the variable frequency power supply meets the relevant standards of onshore power supply, and the output can still be stable when the three-phase load unbalance is greater than 20%.

Reverse power protection: Double protection is adopted. One protection is system detects the voltage (voltage amplitude and phase angle) and frequency of the ship power grid in real time and adjusts the voltage and frequency of the system power supply output in real time to achieve the synchronization, so as to realize the seamless power supply connection function of the onshore variable frequency power supply system. The second protection is to add discharge resistances inside the onshore power supply equipment, and the reverse power can be directly consumed in case of reverse power supply, and at the same time, the system output power supply is detected and adjusted in real time, so as to realize the short period synchronization between onshore power supply and ship power supply, completing the load transfer and realizing the smooth switching of the load.

3 Onshore Power Supply Solutions

3.1 Solution Categories

1) Variable Frequency Solution

High voltage variable frequency solution: It is suitable for ships with large capacity.

Low voltage variable frequency solution: It is suitable for ships with small capacity.

2) Grid Frequency Solution

High voltage grid frequency solution: It is suitable for ships with large capacity.

Low voltage grid frequency solution: It is suitable for ships with small capacity.

3.2 Ship Connection Method

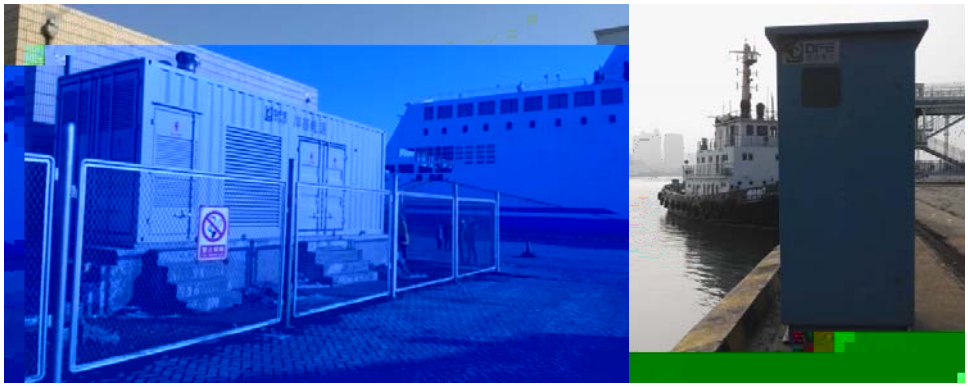
High-voltage ship connection: There is a step-down transformer on ship, and needs few cables, the connection between the onshore power charger and the ship is simple. This solution is suitable for the ship with large capacity.

Low-voltage ship connection: There is no step-down transformer on ship. and needs more cables, the connection between the onshore power charger and the ship is complex. This solution is suitable for the ship with small capacity.

3.3 Basic Solutions

1) High Voltage Ship Connection and High-voltage Variable Frequency Power Supply Solution

It is suitable for the ship with large capacity and there is a step-down transformer on ship.



2) High Voltage Ship Connection and Grid Frequency Power Supply Solution

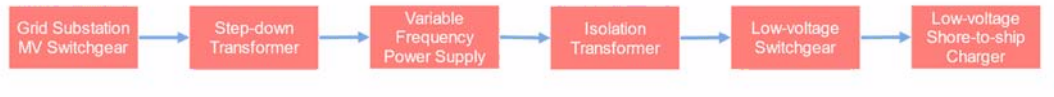
It is suitable for the ship with large capacity and there is a step-down transformer on ship.

3) Low Voltage Ship Connection and High-voltage Variable Frequency Power Supply Solution

It is suitable for the ship with large capacity and there is no step-down transformer on ship.

4) Low Voltage Ship Connection and Low-voltage Variable Frequency Power Supply Solution

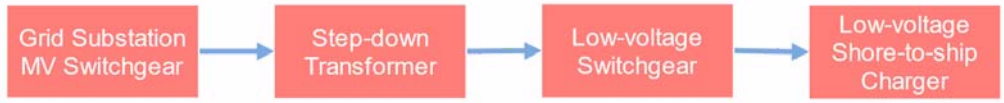
It is suitable for the ship with small capacity, the input of the onshore power supply comes from the substation MV side, and there is no step-down transformer on ship.



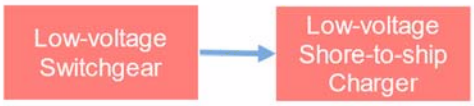
It is suitable for the ship with small capacity, the input of the onshore power supply comes from the substation LV side, and there is no step-down transformer on ship.

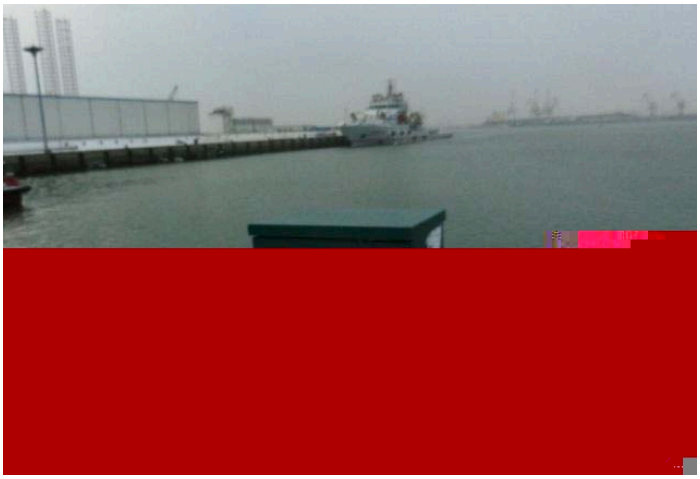
5) Low Voltage Ship Connection and Low-voltage Grid Frequency Power Supply Solution

It is suitable for the ship with small capacity, the input of the onshore power supply comes from the substation MV side, and there is no step-down transformer on ship.



It is suitable for the ship with small capacity, the input of the onshore power supply comes from the substation LV side, and there is no step-down transformer on ship.





4 References

4.1 Onshore Power References

Project	Power Conversion Method	Solution Category	Capacity	Quantity
Yantai West Port Wanhua Terminal	GMV-SDTF-VFPS-SUTF-HVSC	VF	1.6MVA	1 (1 OSPS with 2 SC)
Penglai Port	GMV-VFPS-ISTF-HVSC	VF	2MVA	1 (1 OSPS with 2 SC)
	GMV-VFPS-ISTF-HVSC	VF	2MVA	2 (1 OSPS with 2 SC)
Yantai Port Ro-Ro Passenger Terminal	GMV-TF-HVSC	GF	1.6MVA	2 (1 OSPS with 2 SC)
Longkou Port Phase 2	GMV-TF-LVSC	GF	630kVA	1 (1 OSPS with 2 SC)
Longkou Port Phase 1	GMV-TF-HVSC	GF	2MVA	1 (1 OSPS with 2 SC)
Weifang Port	GMV-TF-HVSC GMV-VFPS-SDTF-LVSC	GF / VF	2MVA	2 (1 OSPS with 4 SC / 1 OSPS with 8 SC)
Yantai Port Container Terminal	GMV-SDTF-VFPS-SUTF-HVSC GMV-SDTF-VFPS-ISTF-LVSC	VF	2MVA	1 (1 OSPS with 2 SC) Spare HVSC
Yantai Port International Container Terminal	GMV-VFPS-ISTF-HVSC	VF	2MVA	1 (1 OSPS with 2 SC)
Yantai Port Tongsan Terminal	GMV-VFPS-ISTF-HVSC	VF	2MVA	1 (1 OSPS with 2 SC)
Zhangzhou China Merchants Port	GMV-VFPS-ISTF-HVSC	VF	2MVA	1 (1 OSPS with 2 SC)
Ningbo Port Daxie Terminal	GMV-VFPS-ISTF-HVSC	VF	5MVA	2 (1 OSPS with 4 SC)
Huanghua Port	GMV-VFPS-ISTF-HVSC	VF	2MVA	5 (1 OSPS with 2 SC)
	GMV-SDTF-VFPS-ISTF-LVSC	VF	800kVA	9 (1 OSPS with 2 SC)
Yantai West Port Ore Terminal	GMV-SDTF-VFPS-SUTF-HVSC	VF	2MVA	1 (1 OSPS with 3 SC)
Weihai Port Ro-	GMV-TF-HVSC	GF	2MVA	1 (1 OSPS

Ro Passenger Terminal				with 2 SC)
Laizhou Port	GMV-TF-LVSC	GF	2MVA	1 (1 OSPS with 2 SC)
Note: GMV (Grid MV), TF (Transformer), SDTF (Step-down Transformer), ISTF (Isolation Transformer), SUTF (Step-up Transformer), OSPS (Onshore Power Supply), HVSC (High-voltage Shore-to-ship Charger), LVSC (Low-voltage Shore-to-ship Charger), SC (Shore-to-ship Charger), VF (Variable Frequency), GF (Grid Frequency).				

4.2 Shipboard Power Receiving System Reformation References

Project	**Power Receiving Method**	**Capacity**	**Quantity**	**Ship Name**
Bohai Ferry (Yantai)	High voltage	2MVA	6	Bohai Pearl, Bohai Green Pearl, Bohai Crystal Peral, Bohai Diamond Pearl, Bohai Agate Pearl, Shengsheng 2
Bohai Ferry (Weihai)	High voltage	2MVA	1	Bohai Hengsheng
Bohai Ferry (Longkou)	High voltage	2MVA	2	Bohai Hengda, Bohai Hengtong

Dongfang Electronics International Engineering Co., Ltd.

Dongfang Electronics Co., Ltd.

Address: No.2 Jichang Road, Yantai, Shandong Province, P.R. China, 264000

Tel: +86-535-5520949

Fax: +86-535-5520930

Email: idf@dongfang-china.com

Website: http://www.dongfang-china.com/en