Device of Port Shore Power of Envelope Voltage of Wireless Seamless Connection

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Abstract: This paper introduces the composition and working principle of the envelope voltage wireless seamless shore power device. Ship power and shore power use LoRa technology to communicate with each other, so that they can connect with shore power quickly and correctly after the ship touches the shore, and the work efficiency is improved. The wireless device realizes the transmission of voltage, frequency and phase data of ship power and shore power. It realizes the connection of ship power and shore power without impact current, improves the safety and reliability of ship shore power connection, and realizes ship energy saving and port environmental protection.

1. Introduction

Seamless power supply is an important part of port power supply intelligent center, and the use of wireless transmission is an important development trend. It can provide quick, convenient and convenient shore connection for ships. In order to solve the shortcomings and deficiencies of the existing technology, this paper proposes a wireless seamless connection device for ship power connection. Before the ship is landed, the power supply and demand of the ship are evaluated to determine whether the ship can connect to shore power. The equipment and operation required for the connection between the ship and the electric power station can be prepared in advance, so as to transmit and cooperate through the signal transmission between the ship's wireless module and the wireless module on the shore. After the ship is berthing, it can connect shore power quickly and conveniently.

The wireless communication technology in this paper is based on a new type of ultra-long-range low-power data transmission technology (LoRa) chip which is under 1GHz. Its receiving sensitivity is up to -148dbm, and its power consumption is low. Because the product uses a special spread spectrum technology, the terminals of different spread spectrum sequences will not interfere with each other even if they use the same frequency at the same time. The concentrator/gateway developed on this basis can receive and process data from multiple nodes in parallel, greatly expanding the system capacity. With LoRa technology, designers can maximize communication and lower power consumption for longer distances and save additional repeater costs.

2. Intelligent wireless device for port ship power supply

2.1. Communication network between shore power controller and port monitoring center
The use of LoRa technology makes the connection of ship power and shore power more practical and saves the signal line of the grid connected cable. In order to make the wireless transmission distance more stable and the transmission distance longer, the PA or LNA is used at the front end of the analog signal. The transmission power of PA can be adjusted from 0.1 to 7 watts, and the LNA can improve the signal reception sensitivity to -210 dBm.

Figure 1 Ship and shore power Grid-connected intelligent wireless device is mainly composed of shore wireless transmitting and receiving device, ship bridge wireless transmitting and receiving device and engine room touch screen. When the ship is connected to the shore, the cabin wheel machine can send the information of the ship's power grid to the cab through the seamless electric touch screen, and the driver can transmit the information to the bank controller through a wireless transmitter. At the same time, the electric power controller receives the information of the ship's electricity detection information, the specified information, the rated frequency, voltage and capacity of the shore power itself, and chooses whether it is seamless connected with the shore electricity and the program can be operated seamlessly. When the ship controller receives the instruction from the shore power controller, it can automatically adjust the frequency modulation of the generator, automatically adjust it to the condition of grid connected with the shore power, and automatically transfer the load and so on. Figure 2 is a system block diagram [1].

2.2. Wireless communication module
Figure 3 The wireless communication module of the ship controller includes communication module and touch screen. The communication module sends the received shore power information to the touch screen, and the touch screen displays the shore power information. The central processing module of shore power controller includes the central processor of wireless communication module. A communication method combining wireless LoRa communication and wired CAN communication network [2] is used to connect port shore power and ship supply equipment.

2.3. System control unit
The system control unit, as shown in Figure 4, is composed of the system control unit, the three-phase AC contactor, the hall voltage sensor, the hall current sensor, the industrial computer and so on.

Figure 4. System control unit and module
The system control module is composed of STM32F207, serial port level conversion circuit, CAN bus level conversion circuit, power supply module, executive components and so on. The composition block diagram is shown in Figure 4.
3. Connect shore power seamlessly with Envelope line

3.1. Principle and circuit (Figure 5)

![Electrical connection diagram of voltage difference envelope](image)

Figure 5. Electrical connection diagram of voltage difference envelope

3.2 Envelope voltage signal processing

After the voltage envelope waveform signal processing, Figure 6(a) is the absolute value conversion circuit, the detection circuit is shown in Figure 6(b), the capacitance C40 and C41 are used as the charging capacitor of the detector. As shown in Figure 7(a), ship electrical detection waveform, Figure 7(b) is a successful waveform.

3.3 Envelope line shore connection technology [3]

3.3.1 Power / frequency (P/f) control

P/f control is realized by rotor motion equation and prime mover governing equation, in which rotor motion equation:

\[
\begin{align*}
\dot{\omega} - \beta \omega &= \frac{P_m - P}{\alpha_s} - \beta (\omega - \omega) \\
\dot{\omega} &= \omega - \omega
\end{align*}
\]

In the formula, \(\omega_N\), \(\omega = 2\pi f\) are rated and actual rotor angular velocities, \(T_m\) and \(T\) are mechanical and electromagnetic torques, \(P_m\) and \(P\) are mechanical and electromagnetic powers respectively, \(\beta\) is the damping coefficient, \(J\) is rotary inertia, and \(\theta\) is power angle. Prime mover governing equation:

\[
P_a = P_r + K_s (\alpha_s - \omega)
\]

\(P_a\) is a given active power, \(K_s\) is a coefficient of adjustment. (1), (2) available (3):

\[
\frac{\alpha_s - \omega}{P_r - P} = \frac{1}{J\omega_s + \beta\alpha_s + K_s} = \frac{k_p}{\tau + 1}, \quad \text{therein} \quad \tau = \frac{J\omega_s}{\beta\alpha_s + K_s}, \quad k_p = \frac{1}{\beta\alpha_s + K_s}
\]

In the formula: \(P\) is the output active power; \(\tau\) and \(k_p\) are inertia time constant and active frequency droop coefficient [4].

3.3.2 Simulation and experiment

Detect the lowest point of the envelope of ship power and shore power voltage difference.
The shore voltage frequency is $f_1$, the ship voltage frequency is $f_2$, the frequency difference is $\Delta f$, and the envelope period is $T$. The left side is the simulation waveform and the right side is the experimental waveform.

Figure 8. $f_1=50\text{Hz}$ $f_2=49.60\text{Hz}$ $\Delta f=f_1-f_2=2.76s$

Figure 9. $f_1=50\text{Hz}$ $f_2=49.50-49.70\text{Hz}$ $T=2.7s$

Conclusion: The simulation and experimental results show that when the frequency of intelligent control ship generator is about 49.65Hz, wireless control ship and shore power seamlessly connect to shore power through envelope line, and ship load -10%~+30% is borne by ship generator. It is convenient for wireless intelligent control ship diesel generator to stop operation.

4. Wireless control of grid-connected of shore power and ship electricity

4.1. LoRa principle

The LoRa protocol is used for wireless communication over 4 kilometers (in a suburban environment), and the battery life can exceed 10 years. The transmission distance, speed and power consumption of several wireless communication modes are shown in Table 1.

| model     | Maximum transmission distance | Maximum transmission rate | Minimum receive power |
|-----------|-------------------------------|---------------------------|-----------------------|
| Bluetooth | 15m                           | 2M/S                      | 6mA                   |
| WiFi      | 100m                          | 54M/S                     | 105mA                 |
| ZigBee    | 75m                           | 250KB/S                   | 2mA                   |
| LoRa      | 4km                           | 600KB/S                   | 3mA                   |

The simple block diagram of LoRa is shown in Figure 10.

Lora signal receiving process, wireless signal after filtering demodulation and despread, and then make error correction, payload extraction, storage in Lora FIFO, provide to the SPI interface. The MCU can read data in FIFO through SPI interface. The emission process of Lora signal. The MCU writes the data to be sent to the Lora FIFO through the SPI interface. Then the data to the structure packet, to the decoder, modulation and spread spectrum transmission.

The Lora packet structure is shown in Figure 11:
4.2. The principle of the system is explained

4.2.1. Principle of shore power controller [5~7]
The principle of shore power controller is shown in Figure 12. The processing module of the shore power center collects the voltage and current signals on the bus, and obtains relevant information through phase sequence detection, phase line voltage detection, phase line phase detection, current detection and so on. Send and switch on to the ship electric controller or switch off instructions. Or send instructions to the ship electric controller to adjust the output power of the generator. It can also respond to user's various control commands through the touch-screen man-machine interface.

4.2.2. Principle of ship electric controller (Figure 13)
The ship electricity control module interacts with shore power controller through CAN bus. The ship power controller can perform the corresponding closing and closing actions after receiving the instructions from the shore power controller. It can also transmit state information to shore power controller. The shore power controller can monitor the working state of the generator in real time.

4.3 Wireless monitoring scheme (Figure 14)

The program flow chart of the system control module is as follows in Figure 15:
The program flow chart of marine power terminal controller is shown in Figure 16, and the program flow chart of shore power terminal including 50Hz shore power supply and 50Hz frequency conversion power controller is shown in Figure 17.
5. Conclusion
LoRa spread spectrum communication is adopted between shore power controller and ship electric controller. The SX1276/78 transceiver mainly adopts LoRa™ remote modem, for ultra long range spread spectrum communication, strong anti-interference. It can minimize current consumption. In a relatively open environment, LoRa's communication distance can reach more than 4 kilometers. Therefore, it is more suitable for use in port environment. A shore power controller is installed at each ship's berthing point. The shore power controller can not only communicate with the ship power controller, but also communicate with the port monitoring center through wireless communication. The statistics function of the electric quantity and the reference electric charge of the ship's shore power is added, and the total electric quantity and the reference electric charge can be displayed immediately after the ship's shore power is used. So that the ship can reduce unnecessary electricity charges to deal with the berthing time and improve the timeliness of shipping and departure. At the same time, it also provides idle shore power platforms faster for the waiting ships.

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