Design of Optimal Scheme for Industrial Network Monitoring of Ocean Energy Power Generation System

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Abstract. In recent years, with the development of ocean energy power generation technology, the monitoring technology of ocean energy distributed micro-grid power generation system is also advancing with the times. This paper proposes an optimization solution for the industrial network monitoring of the ocean energy power generation system composed of HMI, PLCs, distributed I/O, etc., in order to better adapt to the complex and changeable harsh environment of ocean energy power plant, provide real-time and accurate data for subsequent fault diagnosis of the power generation system. It mainly realizes the functions of microgrid system status detection, fault alarm, and real-time display of electrical parameters of the system during power generation. The test simulation results show that the design realizes the intelligent monitoring of real-time parameters of the power generation process.

1. Introduction

Under the background of my country's energy utilization structure adjustment, the development and utilization of ocean energy, especially ocean energy power generation, has begun to take shape. Due to the volatility of the ocean energy field, power generation equipment cannot convert ocean energy into continuous and stable electrical energy in real time according to changes in the energy field, but can only change with changes in ocean energy input power; my country’s ocean energy flow density is low, in terms of conversion efficiency, ocean energy power generation devices are still at a relatively low level [1]. In addition, the power control of ocean energy power generation system has many problems that need to be solved urgently in terms of monitoring technology: the power generation of ocean energy is affected by various factors, and it will show fluctuations, how to improve the stability of the power output of the power generation unit; how to receive the operating data of the power generation system more accurately and in real time, so that the control system can make timely feedback actions, etc. [2].

Aiming at the deficiencies of the above-mentioned monitoring technology applied to the marine energy power supply system, this paper proposes an optimized design of the industrial network monitoring technology for the marine energy power supply system. Real-time data monitoring of the power generation process has improved the reliability of fault diagnosis and analysis. It is of great significance for ensuring the stability and real-time performance of data transmission in the complex and changeable marine environment, and comprehensively promoting the development and utilization of marine energy.
2. Ocean Energy Industry Network Monitoring Optimization Scheme

2.1. Current Status of Monitoring Technology for Ocean Power Generation System

After years of development, ocean energy development and utilization technologies have become more mature. In sharp contrast with the current situation of rapid development of ocean energy power generation devices, the current research and utilization of real-time monitoring systems for ocean energy power generation devices are obviously insufficient. By summarizing the development process of the data acquisition and transmission system, combined with the actual environment of ocean energy power generation, it can be seen that the power generation unit monitoring system has many limitations: (1) The power supply and wiring of the monitoring system are inconvenient and cannot be adapted to the civilian power supply; (2) The maintenance cost of the monitoring system is high, and high system reliability is required; (3) The monitoring parameter range is large, and the coupling between the parameters is strong; (4) The data collection is not representative, the display mode is single, and the intelligent effect is lacking. Conducive to the operator's observation and analysis [4]. In addition, the system performance and structure also need to be continuously improved: for example, the micro-grid monitoring system using the traditional centralized structure requires a central controller with strong computing power to deal with diverse distributed energy sources. Once the central unit fails, the entire system may fall into a paralyzed state and the entire system may be paralyzed and the distributed power supply cannot provide real-time power supply, it is difficult to expand other applications. [5].

In summary, this article uses Portal (TIA) software to design the overall monitoring technology of the marine energy power supply system based on the industrial network. Combined with the distributed I/O equipment, the corresponding distributed monitoring structure and effective communication topology are designed respectively. At the same time, the configuration design of the touch screen are introduced, and the simulation test results of the corresponding modules are given.

2.2. Overall design

Compared with the ordinary on-site environment, the ocean power generation site has high dust content, variable temperature, humidity, high EMC interference, high risk of mechanical damage, and harsh environment. Ordinary networks cannot be directly used in industrial environments and require industries with strong environmental adaptability. Network for on-site communication [6].

The main advantages of the industrial network monitoring system designed in this paper are: (1) The devices on the field level can communicate freely, and the tasks of the control system are easier to complete; (2) The interoperability of information transmission and communication between devices and systems can be realized; (3) Comply with the openness of the unified standard system; (4) Adapt to different field environments; (5) Real-time communication [6]. It improves the real-time performance and stability of data collection and transmission, and optimizes the communication connection between field devices. The overall structure diagram of the system is shown in Figure 1.

![](image)

Figure 1 Schematic diagram of the overall system structure

2.3. Design of distributed automation monitoring structure

This article uses ET200SP to build a distributed automation structure to collect signals from a variety of on-site equipment in a distributed manner. Realize the connection with the central control system through a bus system, and realize the data transmission from the field device to the controller in a
stable and safe industrial communication mode; The industrial Ethernet PROFINET communication protocol specially used in the fields of I/O device communication, alarm, data recording, etc. is used for the communication between the device and the controller. Compared with other communication protocols such as RS485 and RS232, it has a fast transmission rate and strong stability, large amount of data transmission, strong compatibility and other advantages [8]. At the same time, with the help of the gateway IE/PB Link to integrate the existing PROFIBUS slave stations, the communication protocol between the devices is planned uniformly, eliminating the tedious protocol conversion between some devices. The device network view is shown in Figure 2.

![Figure 2 Device network view](image)

This paper uses the Siemens TIA Portal development tool to design the industrial network monitoring and management interface of the wave energy and tidal energy integrated power supply system based on touch screen, PLC and distributed I/O equipment. Using Siemens PLC S7-1500 as the control element, equipped with a 7-inch smart panel touch screen display element, and using distributed I/O equipment ET200SP and ET200S as the intermediate components for signal acquisition and fault diagnosis. The specific control structure diagram is shown in Figure 1. The HMI sets the relay status of the power generation unit, and uses the digital input module and analog input module of ET200SP to communicate the data of the bottom information collection equipment such as sensors with the upper equipment through DI and AI channels. The display shows the electrical parameters of the power generation process in real time. At the same time, it uses ET200S realize the real-time fault diagnosis function of PLC.

![Figure 3 Structure diagram of the monitoring system](image)
2.4. Monitoring system module design

The monitoring technology of the ocean energy integrated power supply system proposed in this paper is mainly aimed at the signal acquisition and communication of system switching, equipment operating status and analog quantities.

(1) Switch quantity and equipment status monitoring: The digital input module of ET200SP is used to monitor the switching value of the power generation system in real time, and the operating status of each device is displayed at the same time. The monitoring process is shown in Figure 4.

![Figure 4 Flow chart of switching value and equipment status monitoring](image)

(2) Analog quantity monitoring (voltage, current): With the aid of the analog input module of the distributed I/O ET200SP, the data collected by the sensor, such as DC bus voltage and current, are communicated with the PLC in real time, and finally displayed on the corresponding screen of the touch screen. The monitoring process is shown in Figure 5.

![Figure 5 Flow chart of analog monitoring](image)

The traditional temperature data acquisition uses a temperature sensor to first convert the temperature analog quantity into a mA/mV level small signal and then perform the analog quantity conversion. There is a certain delay and energy loss, and the measurement error is large [8]. The temperature signal acquisition unit of this system uses the ET200SP dedicated temperature measurement AI channel to measure the value corresponding to the thermistor or thermocouple of the temperature sensor in real time, and then directly convert it into the engineering quantity displayed on the touch screen. The measurement range becomes larger and the real-time performance is enhanced, the measurement error is reduced, and the channel parameter settings are shown in Figure 6.

![Figure 6 Temperature measurement AI channel parameter setting](image)
2.5. HMI configuration design

The monitoring system designed this time mainly includes four parts: equipment status display, switch and analog information display, system real-time power generation record, and fault alarm prompt. In addition, a preliminary configuration simulation for system fault diagnosis is made. The screen display structure is shown in Figure 7.

![Initial screen structure](image)

**Figure 7 Initial screen structure**

The main screen design is as follows:

1. **Analog quantity monitoring screen**
   - Select the main monitoring screen in the initial face change, and then click the analog monitoring main screen button to enter the real-time display of battery pack and supercapacitor temperature, DC bus and load electrical parameters; click the button at the bottom of the interface to view the changing trend of each data View, the simulation result is shown in Figure 8.

   ![Partial simulation results of analog monitoring](image)

   **Figure 8 Partial simulation results of analog monitoring**

2. **Power generation statistics screen**
   - From the monitoring main screen, press the button to enter the power generation statistics interface, and configure the real-time power generation, daily power generation, monthly power generation, and system total power generation display functions of wave energy and tidal current energy units, as shown in Figure 10.

   ![Real-time display screen of power generation](image)

   **Figure 9 Real-time display screen of power generation**

3. **System alarm screen**
   - Use the HMI alarm function in the TIA Portal tool to set the system alarm category, and configure two types of alarm: discrete alarm and analog alarm, as shown in Table 1 and Table 2.

   **Table 1 Discrete alarm**

   | Alarm text       | Alarm category | Trigger variable     | Trigger address |
   |------------------|----------------|----------------------|-----------------|
   | Unit overspeed   | Errors         | Accident information | %M19.0          |
   | Unit overcurrent | Errors         | Accident information | %M19.1          |
When a corresponding failure occurs in the power supply system, the corresponding sensor transmits the data information to the PLC, and the touch screen system alarm screen displays the alarm information in real time, as shown in Figure 11. At the same time, the alarm status (arrival, departure, confirmation) will also be updated and displayed synchronously for the operator to check and repair.

2.6. Fault diagnosis analysis

Perform fault diagnosis and analysis through the various parameters and equipment status obtained by the monitoring system, establish and update the fault diagnosis library in real time, quickly query the cause of the fault and eliminate the fault alarm, provide the follow-up monitoring system with self-learning ability and enhance the accuracy of fault diagnosis and efficiency of control. So as to quickly solve the problems of various equipment failures in the integrated power supply system, so that the system can maintain a stable operating state. Part of the fault diagnosis analysis is shown in Table 3.

| Parameters and device status | Fault diagnosis analysis | Troubleshooting method |
|-----------------------------|-------------------------|-----------------------|
| Overvoltage after wave energy stabilization | 1. Wave energy generator power is too high. 2. The output voltage of the charge and discharge controller is too high. 3. Load decreases instantly. | 1. Decrease the opening of the water turbine guide vane and reduce the speed. 2. Add a transformer regulator and check the control loop. 3. Control the load. |
| Overcurrent after wave energy stabilization | 1. Pre-stage generating power is too high. 2. The power curve setting is inappropriate. 3. Short circuit inside the rectifier | 1. Adjust the voltage regulator on the excitation controller and replace the motor winding. 2. Correct the power curve. 3. Replace the diode. |
| Undervoltage after trend energy rectification | Tidal current generator speed is too low | 1. Check the discharge capacity of the energy storage unit, the connection of the stator winding, and the rotor winding circuit. 2. Correct the power curve. |
3. Conclusions

This article uses wave energy and tidal energy integrated power supply system as the carrier, uses Siemens TIA Portal software, combined with man-machine interface, S7-1500, distributed I/O equipment (ET200SP/ET200S) and gateway IE/PB Link to complete industrial network monitoring Technical design and research. Finally, related simulation experiments were carried out to realize the functions of real-time display of the operating parameters and equipment status of the integrated power supply system, and system failure alarms, and optimized the unstable data communication, slow transmission rate, and poor real-time performance in the harsh environment of ocean power generation. At the same time, the distributed automatic monitoring structure in this design makes up for the inconvenience of scattered industrial field equipment and inconvenient data acquisition; the temperature acquisition unit enhances the real-time transmission of temperature signals, reduces measurement errors. It has certain reference significance for the subsequent research and design of power control of ocean energy power generation system.

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