Design of the Power System and Remote Control System for the Unmanned Ship

Hao Zhang*, Zeyu Zhang
Wuhan Institute of Marine Electric Propulsion, Wuhan, China.
*Corresponding author's e-mail: 18995619539@163.com

Abstract. In lakes and reservoirs with high environmental protection requirements, it is necessary to adopt pure electric intelligent water quality monitoring ships, adopt pure electric power systems and intelligent remote control systems. This article specifically completed the design of the power system and remote control system of the smart ship, and elaborated the design method in detail. The system has the characteristics of high reliability, miniaturization, and modularization. The successful development of the system has greatly improved the intelligence of water quality monitoring ships, and has a positive effect on small intelligent ships in lakes and reservoirs.

1. Introduction
With the continuous improvement of emission requirements in inland rivers, lakes, ports and other fields, some environmental protection water areas have unmanned boats with electric boats for water quality monitoring and cleaning operations. As a new type of power ship with silent, environmental protection and zero emission, electric boats are gradually receiving industry attention. The use of electric boats has better quietness, environmental protection, is more environmentally friendly, and has a more comfortable experience.

The power system of the unmanned ship includes both the propulsion system and the remote control system. The power system is composed of the power supply system, the propulsion system, the remote control system, and the auxiliary system. The remote control system includes the propulsion control system of the ship and the remote control equipment on the mother ship. The propulsion control box distributes power to the load, and receives instructions from the mother ship to control the normal operation of the propulsion system and feed back the status of the propulsion system and power distribution system to the mother ship.

2. The Design Of Power System
In normal navigation conditions, the power supply system consists of two sets of 576V lithium battery packs (including BMS) and two power boxes. The lithium battery pack has a capacity of 100AH and a rated voltage of 576V. The lithium battery pack is centrally monitored and protected by BMS. The two power boxes take power from lithium batteries respectively, and provide power and protection for the ship through switches, DC/DC switching power supplies, fuses, etc., to meet the power supply of the branch control system. In shore power working conditions, the power supply system is provided by the mother ship with two power sources. At this time, the shore power is only used by the heater. During charging conditions, the charging interface box connect to the charging power supply cabinet on the mother ship to charge the lithium battery pack, which will be fully charged within 4 hours. The propulsion system includes a frequency converter (including the inverter controller CU320), a
permanent magnet motor, and the propulsion system's power and control electricity are taken from the power box.

![Block diagram of intelligent controller system](image)

**Figure 1** Block diagram of intelligent controller system

2.1 The main functions of the power system

The main functions of the power system are described as follows:

a) Power supply function

The power of the whole ship is provided by the direct current provided by two sets of battery packs for the load of the whole ship. Part of the DC power supplies power to the two sets of power propulsion branches, and part of it is inverted into AC power through the power box to supply power to the ship's daily loads. The power supply of the two branches of the cooling water pump, the data transmission station and the control system are independent of each other, and the failure of one power supply branch does not affect the normal operation of the other power supply branch equipment.

b) Propulsion function

The output power of the propulsion motor is limited by the inverter to ensure that the propulsion motor is not overloaded. The propulsion system also monitors the battery current and automatically reduces the propulsion speed when the battery current exceeds the set upper limit. In the speed control mode of this system, the frequency converter can adjust the speed of the motor according to the speed setting signal given by the control system. When a set of propulsion branches fails, the remaining set of propulsion branches can operate normally. The propulsion also has protection functions such as short-circuit, over-current, DC bus under-voltage, and motor overheating to ensure its own safety and reliability.
2.2 Design of the Battery System
The power system consists of a lithium battery system (including a lithium battery pack and BMS) and a power box. The power of the whole ship is provided by the DC power provided by two battery packs for the loads of the whole ship. One part of the DC power supplies power to the two sets of electric propulsion branches, and the other part is inverted into AC power through the power box to power the daily loads of the whole ship. The power supply is independent of each other, and the failure of one power supply branch does not affect the normal operation of the equipment of the other power supply branch. As the power source of the whole ship, the lithium battery system is composed of lithium battery pack and BMS\cite{1}.

At present, the development of lithium batteries, lithium iron phosphate batteries and ternary lithium batteries are two more important development directions, in terms of cycle times, lithium iron phosphate batteries and ternary lithium batteries are significantly better than other types of lithium batteries. The type of lithium battery is classified according to the battery's cathode material. Ternary lithium battery refers to the type of lithium battery composed of nickel, cobalt, and manganese as the cathode material of the battery\cite{2}. Compared with lithium iron phosphate as the cathode material The battery has the advantages of higher energy density, higher battery cell nominal voltage, longer battery life, etc. The energy density of ternary lithium batteries is significantly better than that of lithium iron phosphate batteries. However, the thermal stability of the ternary lithium battery is quite different from that of the lithium iron phosphate battery, and the stability of the working environment is very high. After comprehensive comparison and consideration of the working environment of marine conditions, the lithium iron phosphate type lithium battery is selected, and the structure of the lithium iron phosphate battery has two different types, mainly cylindrical and square. The two installation types of lithium iron phosphate batteries form multiple boxes according to the requirements of the ship's capacity to meet the installation requirements.

3. Design of remote control system

3.1 Main functions of the remote control system
The left propulsion controller and the right propulsion controller are independent of each other, respectively monitoring the status of the two propulsion branches, and the main controller controls the power box switch status and radio communication.

The ship contains two digital transmission radio stations, which are independent of each other, and when one of them fails, the normal operation of the other one will not be affected. The mother ship contains a set of portable terminals and a set of radio stations and control stations. The operator of the mother ship can control the unmanned ship through the portable terminal or the control station. Operation location conversion: The location switch button on the control station can be used to switch between different operation locations. The priority of the control station is higher than that of the portable operation terminal. Multiple operation modes: support standby mode, joint operation mode, independent operation mode, etc. Different operation modes can be selected on the panel. Real-time monitoring information: The ship’s relevant information can be monitored in real time on the display screen during operation, including BMS-related information, motor speed, motor power, bus voltage, equipment temperature, alarm information, etc., with power-off storage function, mother ship control station Historical faults can be recalled at any time, and no less than 1000 faults can be stored. The control station panel contains control buttons and indication buttons, which can indicate the real-time status of the system. Communication failure protection: When a communication failure occurs, the propulsion system will automatically stop and wait for the corresponding mother station operation instruction, which will not cause an out of control state. Hierarchical fault function: The unmanned ship control system is divided into two fault handling modes according to different fault levels, namely first-level fault (serious) and second-level fault (general). Different faults adopt different fault handling methods. The first level fault (serious) reports the fault and stops directly, the second level fault (general) reports the fault and limits the propulsion power. Manual emergency stop function: Both the control
station and the portable operating terminal contain emergency stop buttons, allowing the operator to adopt the emergency stop mode.

3.2 Topology of the remote control system

The control system consists of a propulsion control box, a frequency hopping radio station, a mother ship control station and a portable operating terminal. The mother ship operating station transmits control information to the propulsion control box through the frequency hopping radio. The propulsion control box accepts control commands to control the start, stop, speed increase, and deceleration of the propulsion system. At the same time, the propulsion control box accepts BMS, frequency converter, motor, etc. The status information is communicated to the mother ship control station and the portable operation terminal through the radio. The portable operation terminal can be operated in the full deck area of the mother ship. The control station and the portable operation terminal support standby mode, joint operation mode, independent operation mode, etc., and different operation modes can be selected on the panel\(^3\). When a communication failure occurs, the propulsion system will automatically shut down and wait for the corresponding mother station operation instructions, without causing an out-of-control state. Both the control station and the portable operating terminal contain emergency stop buttons, allowing the operator to adopt the emergency stop mode.

3.3 Design of remote control system

3.3.1. Control station (mother ship)

The control station and the radio station realize data interaction through RS485 or RS422 communication, and have the control and monitoring functions of the unmanned ship, which specifically includes the following functions:

- **Operation location conversion:** The location switch button on the control station can be used to switch between different operating locations. The priority of the control station is higher than that of the portable operation terminal; Multiple operation modes: support standby mode, joint operation mode, independent operation mode, etc., different operation modes can be selected on the panel; **Real-time monitoring information:** The ship’s relevant information can be monitored in real time on the display screen during operation, including BMS-related information, motor speed, motor power, bus voltage, equipment temperature, alarm information, etc., with power-off storage function, which can be used at any time. **Recall historical faults:** and store no less than 1000 faults. The operation station panel contains control buttons and indication buttons, which can indicate the real-time status of the system.

**Communication failure protection:** When a communication failure occurs, the propulsion system will automatically shut down and wait for the corresponding mother station operation instruction, which will not cause an out of control state. **Hierarchical fault function:** The unmanned ship control system is divided into two fault handling modes according to different fault levels, namely first-level fault (severe) and second-level fault (general). Different faults adopt different fault handling methods. **Manual emergency stop function:** Both the control station and the portable operating terminal contain emergency stop buttons, allowing the operator to adopt the emergency stop mode.

3.3.2. Portable Terminal

The portable terminal can communicate with the radio by wireless communication, and can also exchange data with the radio in the form of RS485 or RS422 bus. It has the control and monitoring functions of the unmanned ship, which specifically includes the following functions:

**Operation location conversion:** After the operation authority of the control station is transferred to the portable terminal, the activation button on the portable terminal activates the operation authority of the portable terminal; **Multiple operation modes:** support standby mode, joint operation mode, independent operation mode, etc., different operation modes can be selected on the portable operation
terminal; Real-time monitoring information: The ship’s relevant information can be monitored in real time on the LCD screen during operation, including BMS-related information, motor speed, motor power, bus voltage, equipment temperature, alarm information, etc. It does not have the power-down storage function. Among them, the portable terminal is provided with key information indicators such as a fault alarm indicator, a running indicator, and a ready indicator[4]. Communication failure protection: When a communication failure occurs, the propulsion system will automatically stop and wait for the corresponding mother station operation instruction, which will not cause an out of control state. Hierarchical fault function: The unmanned ship control system is divided into two fault handling modes according to different fault levels, namely first-level fault (severe) and second-level fault (general), and different fault handling methods are adopted for different faults. The first level fault (serious) reports the fault and stops directly, the second level fault (general) reports the fault and limits the propulsion power; Manual emergency stop function: Both the portable operation terminal and the control station contain emergency stop buttons, allowing the operator to adopt the emergency stop mode.

4. Conclusion
This paper designs the power system and remote control system of the intelligent water quality monitoring ship in lakes and reservoirs. The power system has the characteristics of high integration, intelligence and simulation. The remote control system greatly improves the intelligent level of the power system. The design can be extended to other small cruise ships, official ships and other pure electric ships, which has a positive effect on the development of smart ships.

References
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