Design of Intelligent Sonar Array Placement System Based on MCU

J.Y. ZHANG.
Kunming Shipborne Equipment Research & Test Center, Kunming 650051, China
email: zhangjianyu@750.com

Abstract: Aiming at the problem that the existing sonar array placement methods are not intelligent and rely heavily on human resources, a remote Array Placement System Based on ATmega2560 microcontroller is designed to place the array remotely and accurately through the remote controller. This design can promote the Unmanned degree and accurate operation of Sonar array placement.

1. Introduction
At present, manually controlling the winch machine is generally used to lay the large sonar array in the project. The intelligence of this method is not high. It requires multiple people to operate multiple winches simultaneously and can not know the depth information of the array during the laying process. This paper can realize the intelligent array placement by installing the control system based on MCU in the winch. By installing a rotary encoder inside the winch[1-2], the array placement depth can be converted and fed back to the operator through the LCD screen. The operator can control the winch through a wireless communication module. Multiple hoists are connected through CAN bus, which can achieve better synchronous control, effectively ensure that the array is always in a horizontal state with the ground in the process of placement, and has a particular role in protecting the security of the array. At the same time, due to the bad working environment of the remote control device in the field of array placement, we have formulated some schemes to ensure the reliability and safety of the remote control operation.

2. The overall design of intelligent sonar array placement system
As shown in Fig. 1., the device consists of a wireless remote controller, receiver, and driving device[3-5]. The remote controller sends out and forms roll call and placement control commands sent to the receiving end through the wireless transmission module. The receiving end receives the control command sent by the control end and then encapsulates it into a CAN bus control signal. The driver drives the motor in the winch to pull the wire rope to achieve the function of lifting and laying the array. At the same time, the driving end needs to collect the number of motors turns in the driver in real-time and feedback to the remote control end to display the control effect in the LCD screen in real-time.
2.1 Design of the remote control terminal

The design block diagram of remote control terminal is illustrated in Fig. 2. The control mode of the remote controller consists of automatic and manual control modes\(^6\text{-}\text{7}\). In an automated way, you need to set the height of the array through the menu first. After selecting, click the enable button, and the main driver will start to rotate, thus pulling the array to move to the lake. At the same time, the slave driver follows the position of the master controller according to the reading of the encoder, so that we can realize the horizontal placement of the array. The control effect of the remote controller can be displayed on the LCD screen in real-time.

Two control levers are set on the top of the LCD screen. The two control levers can manually control the motor, adjusting the array placement attitude under particular circumstances. Before operating the joystick, you should first select their operation object, and the left and right joystick can act simultaneously after choosing the function. The upper end of the remote control panel also has a power supply and a communication indicator. When the switch of the remote control turns on, the power indicator is on. When the communication is regular, the communication indicator will flash.
2.2 Design of the driver terminal
The driver provides a wireless transceiver module, a rotary encoder module, and a motor gating module\[8\], as shown in Fig. 3. The current placement depth of the array can be calculated by counting the output pulses of the rotary encoder\[9-10\]. After starting the machine, the remote control will automatically send out a roll call command. When the motor is online, the communication board will return the online condition of the motor to the remote control, effectively avoiding the invalid operation of the offline motor by the operator. The motor gating module includes an address decoder module and relay module. Through the software programming of the CPU module, the motor can be enabled and disabled.

![Driver design block diagram](image)

3. The modular design of system hardware

3.1 Power module design
The schematic diagram of the power module is illustrated in Fig. 4. This design uses a 12V battery to supply power for the system. Tps430 voltage regulator chip can convert 12V power into 5V power to supply power to MCU. Through the processing of the above circuit, the microcomputer can obtain Low Ripple Voltage.

![Schematic diagram of the power supply circuit](image)

3.2 Circuit design of master control circuit
The circuit diagram of the main control chip is as shown in Fig. 5. This design uses ATmega2560 as the processor. The processor has 54 digital input/output ports, 16 of which can operate as PWM output, also has 16 analog inputs and 4 UART interfaces, which can fully meet the design requirements.
3.3 Motor drive circuit

After receiving the control command, the driver analyzes the order, enables the corresponding motor through the motor gating module, and controls the motor through the PWM technology [11-13]. The motor drives the steel rope to move and finally realizes the traction and placement of the array.

We provide the detail of the motor drive circuit in Fig.6. In the design, the driver board also uses a mega2560 controller. The processor uses the dir signal to control the rotation direction of the motor and uses the PWM signal to control the rotation amount of the motor. Considering the considerable power required by the drive motor, we use the drive circuit built by the in-line bridge driver chip IR2110 to provide voltage for the motor.
4. Design of wireless communication protocol
The remote controller communicates with the receiver through wireless communication\textsuperscript{[14-15]}. Here we design a wireless communication protocol for array placement devices.

4.1 Command type between the remote control terminal and receiving terminal
Command from remote control to receiver:

| Command type | Command code | Command meaning | parameter |
|--------------|--------------|-----------------|-----------|
| ROLL         | 0000         | Roll call command, Check the online status of the lower computer | none |
| SET          | 0001         | Parameter setting command, send operating parameters to the lower computer, such as PID parameters | Multibyte |
| ASK          | 0010         | Parameter query command, The motion parameters of the motor are inquired and displayed on the upper computer | none |
| GO           | 0011         | Movement execution command | Target location, Multibyte |
| ALARM        | 0100         | Alarm command | none |
| STOP         | 0101         | Stop command | none |
| INQUIRY      | 0110         | Query motion state command | none |

Fig. 7. Command from remote controller to receiver

The command types returned from the lower computer to the upper computer are as follows:

| Command type | Command code | Command meaning | parameter |
|--------------|--------------|-----------------|-----------|
| ansROLL      | 1000         | Response to the roll call | none |
| ansSET       | 1001         | Respond to the parameter setting command | OK |
| ansASK       | 1010         | Respond to the parameter query command | PID parameters |
| ansGO        | 1011         | Response to the movement execution command | OK |
| INQUIRY      | 0110         | Respond to the motion status query command | none |

Fig. 8. Command from receiver to remote controller

4.2 Frame format of communication protocol between remote controller and receiver
The communication format between the remote controller and the receiver is as follows:

| Byte number | 0 | 1 | 2 | n+2 | n+3 | n+4 |
|-------------|---|---|---|-----|-----|-----|
| content     | Frame start flag FFH | Drive number | Command number | Parameter length \(0-6\) | parameter | Frame check | End of frame |

Fig. 9. communication format between controller and receiver
5. Conclusion
In engineering, sonar array placement is usually done manually. In the process of array placement, it is often impossible to know the precise depth of array placement and control the attitude of the array. In this paper, single-chip microcomputer, CAN bus, wireless communication, rotary encoder, and other technical means are used to design an array placement system that can set and display the placement depth in real-time. It can promote the intelligence of the array; Through this device, the operator can remotely control multiple drivers, which improves the placement efficiency to a certain extent and improves the safety of personnel in the operation process.

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