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Design of ABB Robot Teleoperation System Based on LoRa Technology

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Abstract

The traditional programming and control mode of industrial robot is affected by the distance of communication network cable, which is inconvenient for remote operation of industrial robot and poor control flexibility. Research on the industrial robot remote operation linkage system, design and develop an ABB robot remote operation linkage system based on LoRa technology. Firstly, PC is selected as the upper computer to design the human-computer interface, and the communication between the upper computer and LoRa module is established through RS232 and LoRa protocols; Then the LoRa module is built to communicate with the industrial robot, and the connection between the industrial robot and the remote workstation or data center is completed; Finally, remote control and management of industrial robots are realized. The experimental results show that the system can realize the remote control and status monitoring of ABB robot. The realization of this system can replace human beings to control and manage industrial robots in harsh environment, liberate human resources and improve production efficiency.

Keywords

Teleoperation; LoRa; Industrial robot; Remote control.

1. INTRODUCTION

The application of industrial robots can greatly improve production efficiency and reduce production and manufacturing costs, so industrial robots are widely used in automobile manufacturing, welding, spraying, stacking and other operations [1,2]. With the increasing demand for robots in space exploration, deep-sea exploration, nuclear industry and other fields, the robot teleoperation system can replace people to work in harsh environments, which is of great significance in improving work efficiency [3,4]. The traditional way to control the movement of industrial robots is through teaching devices, programmable logic controllers and other modes [5,6], but this mode is relatively cumbersome and time-consuming, and is easily limited by the distance of the communication network cable, which is inconvenient for remote control of robots [7]. Therefore, how to realize the remote control of robot using network has become a hot topic.

In 2010, Chen Wenjie and others at Shanghai Jiao Tong University have designed the Internet remote control system for the work unit of arc welding robot [8]; Literature [9] has designed an open-source MATLAB toolbox, which uses the Eth.RSIXML communication protocol to realize the remote operation of computers on KUKA robots, but this system is inconvenient to communicate with external hardware, so it cannot be promoted; In 2016, Li have established a

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remote control system based on WinSock to realize the control of SCARA [10]. However, only remote-control research was carried out for SCARA robots, and no relevant research was carried out for ABB robots; Design of wireless communication based on the “Bluetooth module” by Xiao, Sun and Tan from Beihang University, which solved the wireless communication problem of short-range robots [11], but the transmission distance of the "Bluetooth" module is relatively short, which cannot meet the long-distance data transmission and robot status monitoring.

In view of the above problems, this paper designs an ABB robot teleoperation linkage system based on LoRa technology. The system selects PC as the upper computer to design human-computer interaction interface and establishes the communication between the upper computer and LoRa module through RS232; Then the LoRa module is built to communicate with the industrial robot, and the connection between the industrial robot and the remote workstation or data center is completed; Finally, remote control and management of industrial robots are realized.

2. DEVELOPMENT OF EMBEDDED MODULE TELEOPERATION CONTROLLER

2.1. Overall structure design of embedded control system

The ABB robot teleoperation linkage system designed in this paper based on LoRa technology mainly includes ABB IRB120 industrial robot, LoRa module, IRC5 control cabinet, computer, etc., as shown in Fig. 1. In the VS (visual studio) environment, C# is used to write the remote control, management and monitoring interface of industrial robots. The computer is used as the upper computer of industrial robots. The communication between master LoRa module and slave LoRa module is realized by LoRa network protocol. The communication between the computer and LoRa module is established through RS232 serial port communication. At the same time, the development module is embedded in the IRC5 control cabinet of industrial robot to realize the signal relay of multiple robots, complete the collection, transmission and management of industrial robot data information, so as to realize the multi-robot remote operation, state monitoring and management.

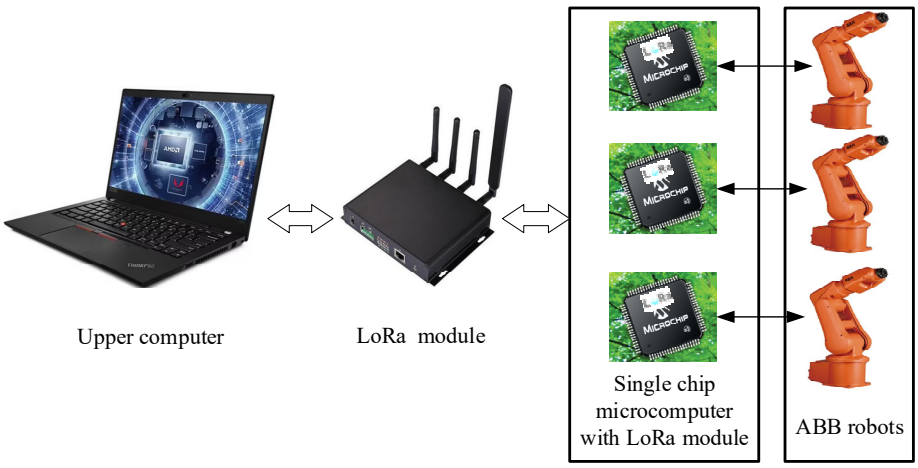

Figure 1. Structure of ABB robotic teleoperation system based on LoRa technology

2.2. Communication Design

In order to realize the remote operation linkage control of ABB industrial robots, compared with other wireless communication technologies, LoRa module has the advantages of long distance, low power consumption, low cost and large coverage capacity, so this design chooses LoRa module as the communication technology for remote control of robots.

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In the switching of working modes, we adopted the AT command mode. By setting the ID number of the device, the transmission address, the transmitting power, the air rate and the I/O port mode of the remote device, we realized the sending of AT commands to multiple LoRa slaves based on one LoRa host, which is convenient to control the work of multiple robots.

2.3. Hardware design of embedded module teleoperation controller

2.3.1 Design of LoRa circuit diagram

Module The power supply itself has a LDO module, which ensures stable input and output voltage through the compensation of two capacitors and the feedback of the inductor chip. The input voltage range is 3.3-5V.

The receiving circuit of LoRa is composed of C34, C4, L7, L1, and the Filter of the circuit needs to be selected by the communication frequency. U6 is the SAW Filter. Because various electronic devices are used around, the antenna will receive various frequencies in practical application, which interferes with LoRa and affects the transmission distance. The function of SAW filter is to filter signals outside the communication frequency. The circuit diagram is shown in Fig. 2.

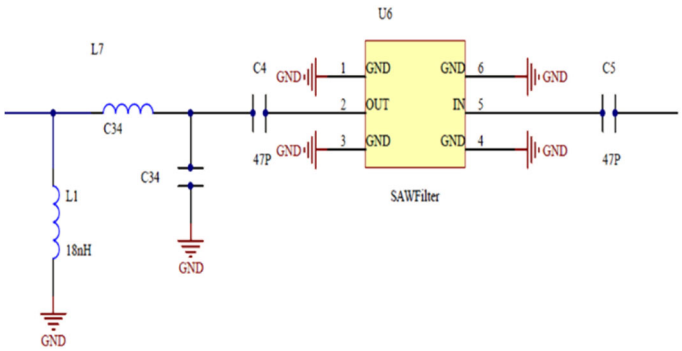

Figure 2. Receiving circuit of LoRa

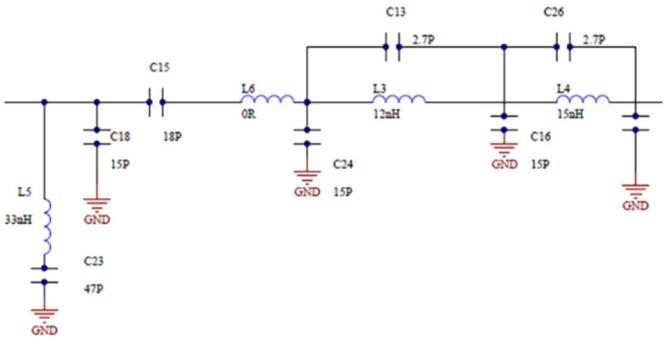

Figure 3. LoRa's transmitting circuit

Multiple filters are used in LoRa's transmitting circuit, in which C23 and LS form a series resonant circuit, while C26, L4, C13 and L3 are parallel resonant circuits. We select appropriate parameters according to different frequencies to achieve appropriate transmitting circuits, as shown in Fig. 3.

The module has two channels of digital input and output and three channels of analog, which can realize ADC acquisition. The 104 capacitor is a compensating capacitor. CT5 has a charge and discharge process to buffer the circuit when the input is disconnected. When the input increases gradually and the capacitor keeps charging, the current on R55 also increases gradually. When the input voltage gradually decreases, the capacitor is discharged to ensure the

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voltage stability on R55 and realize the AD conversion, while R54 plays the role of partial voltage protection.

3. SOFTWARE DESIGN OF ROBOT TELEOPERATION CONTROL SYSTEM

3.1. Software interface design of upper computer

The robot linkage system based on LoRa technology uses PC as the main control computer to control the robot to complete the actions set by the user through the upper computer, and monitors the robot's action state in real time. The functions and main interface of the system software mainly include: 1) remote robot control software; 2) LoRa module destination address I/O port monitoring window; 3) Clear the current monitoring information module; 4) Working timing switch function; 5) Monitoring timing switch function; 6) Monitor the working status window of LoRa module; 7) Function of reading working status; 7). Main menu commands.

3.2. Functions of upper computer software sub-module

The function of communication software sub-module determines the system performance, and the specific sub-module functions include: 1) Serial port setting of communication module. 2) Timing module setting including working timing and monitoring timing functions, to realize the start of multiple manipulators and monitoring of I/O status. 3) Data transmission module setting including the sending and receiving of motion instructions, as well as the query and application of motion status.

4) Single read function: realize accurate status monitoring of single I/O serial port of a single device. This function can be used in conjunction with the monitoring window function.

4. EXPERIMENTAL RESULTS AND ANALYSIS

In the relevant control of the input of ABB machine, the 3.3V low-level triggered relay module is selected to connect the embedded module to the I/O board, so as to solve the voltage mismatch between the robot and module. By adjusting the low-level input of GPIO module, the high level switching of relay is set, and the upper computer is used to issue AT+NS1=502,4,1 command. ABB robot communication based on LoRa technology is successful, as shown in Fig.4.

Figure 4. Robot control experiment diagram

5. CONCLUSION

The linkage system of ABB robot was established based on LoRa technology, and the LoRa module communicated with the robot's I/O serial port. The upper computer software was used to give instructions and control the ABB robot accurately. Finally, the low-power LAN protocol LoRa sent the data back to the upper computer. In addition, ABB robot movement state can be monitored and managed online by the upper computer. The realization of this system can

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replace the human to realize the control and management of industrial robots in the harsh environment, liberate the manpower and improve the production efficiency.

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