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Circuit Design of Wall-climbing Robot based on STM32

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Abstract

The wall-climbing robot is a technology that integrates machinery, inspection, sensing, control and other technologies and is applied in the industrial field, especially equipment inspection in the petrochemical industry. However, limited by the material, shape, defect morphology and detection methods of the object to be inspected, relevant research at home and abroad is not much and it is not mature enough. Aiming at the difficulties in the circuit design of wall-climbing robots, through experiments and trial and error, the circuit and various functional units of wall-climbing robots were fully planned and designed.

Keywords

Wall climbing robot; STM32; circuit design.

1. Introduction

Wall-climbing robot, as a combination product of mechanical discipline and electronic technology discipline, makes up for the extreme operation requirements of automated instruments on vertical walls, and is widely used in various industries[1]. As an important branch of wall-climbing robots, the detection of wall-climbing robots is a technology that integrates machinery, detection, sensing, control and other technologies and is applied in the industrial field, especially equipment detection in the petrochemical industry[2]. However, limited by the material, shape, defect morphology and detection methods of the object to be inspected, relevant research at home and abroad is not much and it is not mature enough.

2. Wall Climbing Robot Mechanical Body

The wall-climbing robot in this paper is a wall-climbing robot that uses permanent magnet adsorption, electric drive and wheel movement. It can bear a total load of 15kg, can overcome obstacles (8-12mm) in height, and its body size is 265 × 300 × 180mm. When a wall-climbing robot moves on a plumb or inclined wall with a certain angle, it is necessary to take into account the efficiency and safety of the operation. Therefore, a reasonable moving speed is the key to ensure that the robot can operate safely and efficiently, and a reasonable speed is also the choice of motor Considering the key parameters that may be carried, the wall-climbing robot can only function properly when the wall-climbing robot is running at a low speed, and the torque required for wall-climbing is large. Therefore, the moving speed is expected to be 3m / min.

3. The Overall Design of the Wall-climbing Robot Circuit

In this design, the DMA (direct memory access) method is used to store the remote control data without occupying the CPU; the communication protocol with the inclinometer is RS232; the optocoupler is isolated between the motor and the single chip to prevent the single chip from being damaged when the drive is damaged High current burned. Among them, the encoder adopts A \ B at the same time counting, which overcomes the single-phase pulse interference that is easy to occur; the remote control receiving module is DBUS protocol; the two microcontrollers communicate through the CAN bus, which is convenient for subsequent expansion of more slaves, supplement And improve the functions of the robot to make it more in line with the task requirements.

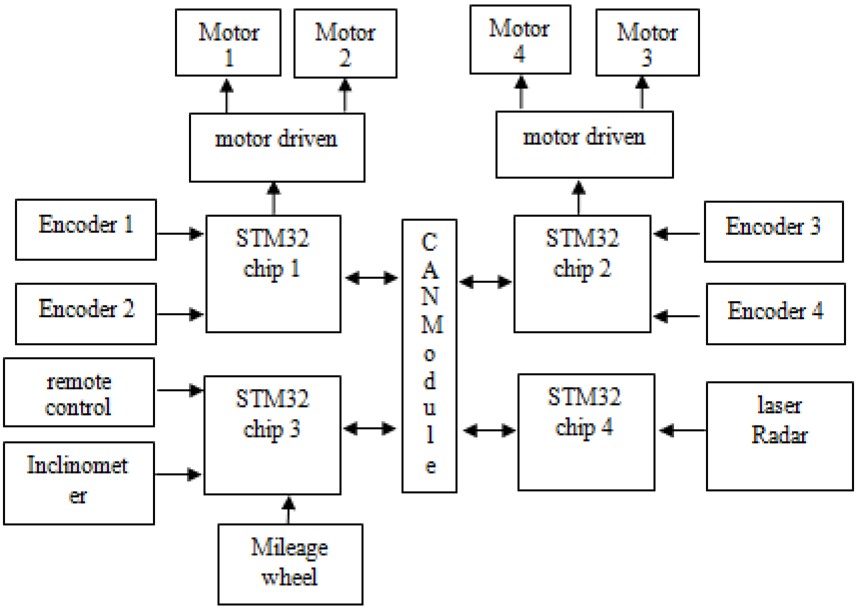

Fig. 1 overall circuit design

4. Hardware Design

4.1. Voltage Regulator Module

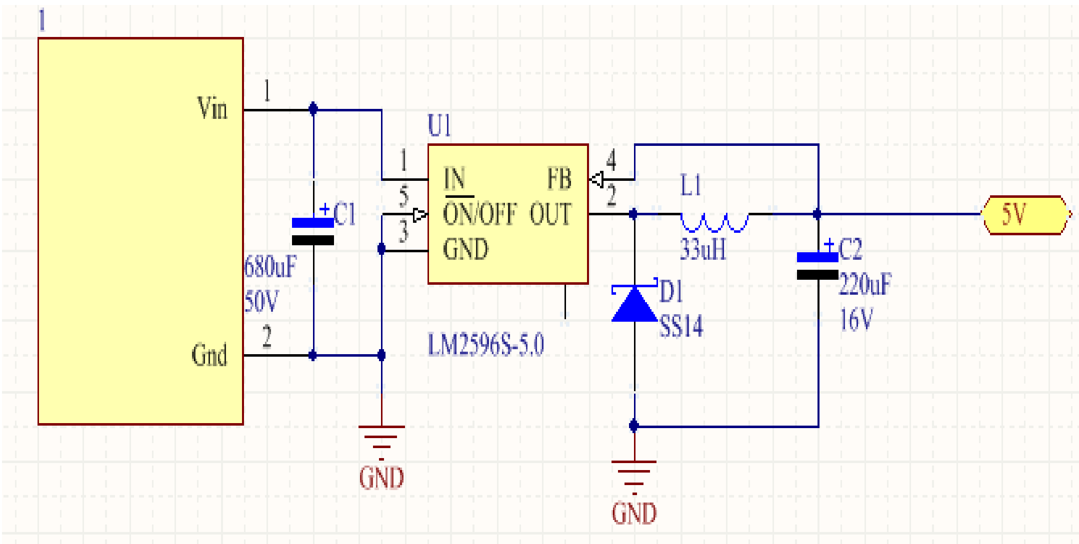

Fig. 2 Power conversion circuit

The choice of the power conversion chip is LM2596S-5.0. The maximum input voltage of this chip is 45V, the output is 5V, and the output current is 0.2A to 3A. In order to reduce ripple and stabilize voltage, 680uf electrolytic capacitor was connected to the power supply input port, and 220uf electrolytic capacitor was connected to the input port [3].

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4.2. Drive Module

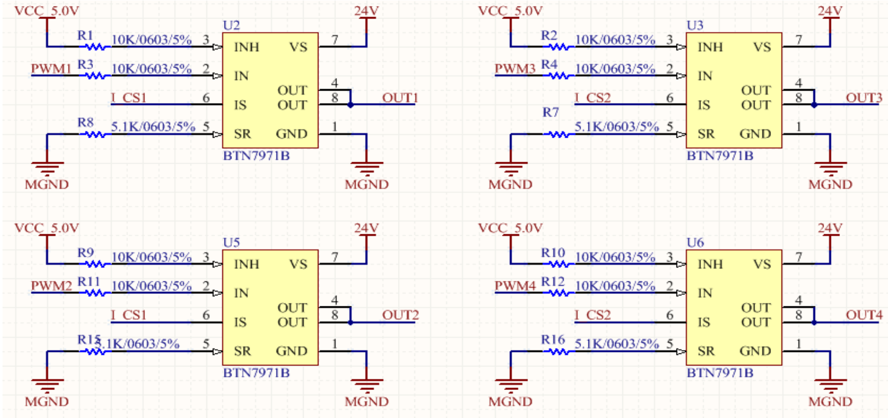

Fig.3 Motor drive circuit

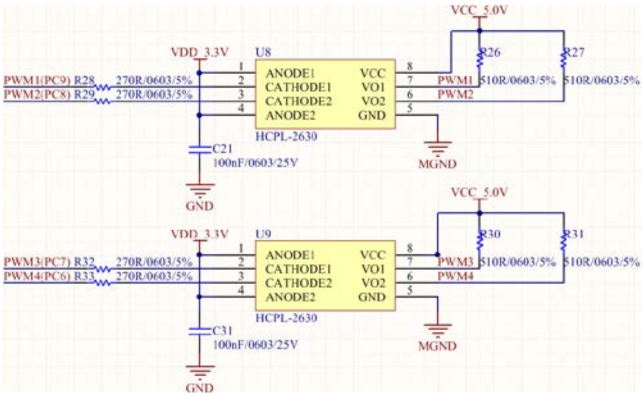

Fig.4 Optocoupler isolation

BTN7971B is an integrated high-current output half-bridge driver chip used in motor drive, with overvoltage, high temperature, low voltage, overcurrent and short circuit protection functions. The maximum power supply voltage is 45v, the logic level is 0.3A-5.3v, and the output current can reach a maximum of 40A, which can fully meet the requirements of this design.

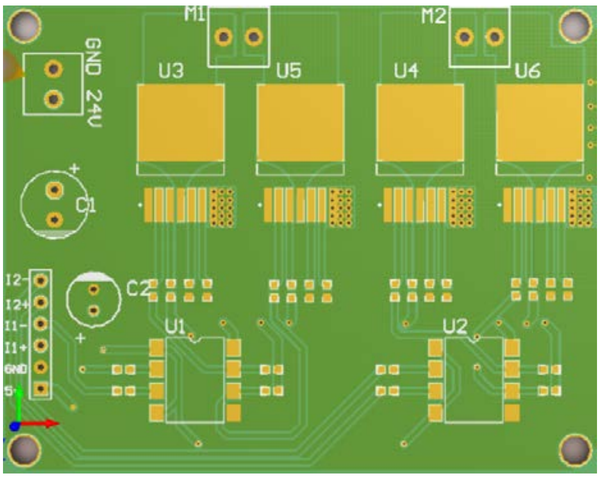

Fig.5 Driver module PCB diagram

In order to prevent excessive recoil current from damaging the STM32 chip when the BTN7971B is damaged, the driver chip and the STM32 are isolated by optocoupler isolation,

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and a pull-up resistor is added to the output end of the optocoupler chip to remove 3.3V of the STM32 The PWM wave is pulled into a 5V PWM wave.

4.3. CAN Module

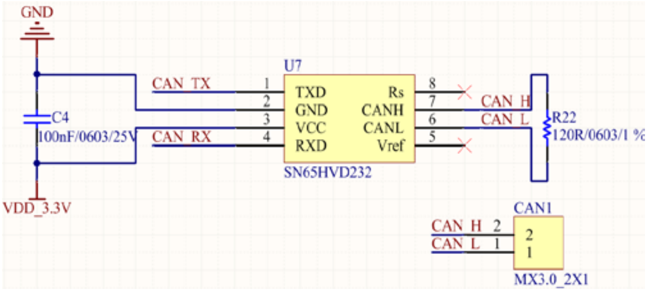

Fig.6 CAN module

The CAN communication protocol is now the standard protocol for automotive networks in Europe and is widely used in industrial automation, ships, medical equipment, industrial equipment, etc [4]. Since four STM32F103ZET6 are used in this design, in order to better communicate with it, CAN chip is used for communication.

4.4. RS232 Module

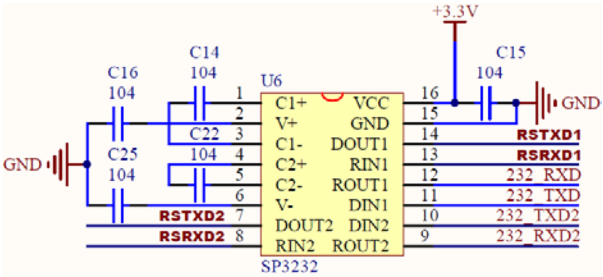

Fig.7 RS232 module

In order to communicate with the inclinometer, an RS232 module must be used. DB9 interfaces are generally used now. The pins used by DB9 are 3 (RXD), 3 (TXD), and 5 (GND).

4.5. Central Control Module

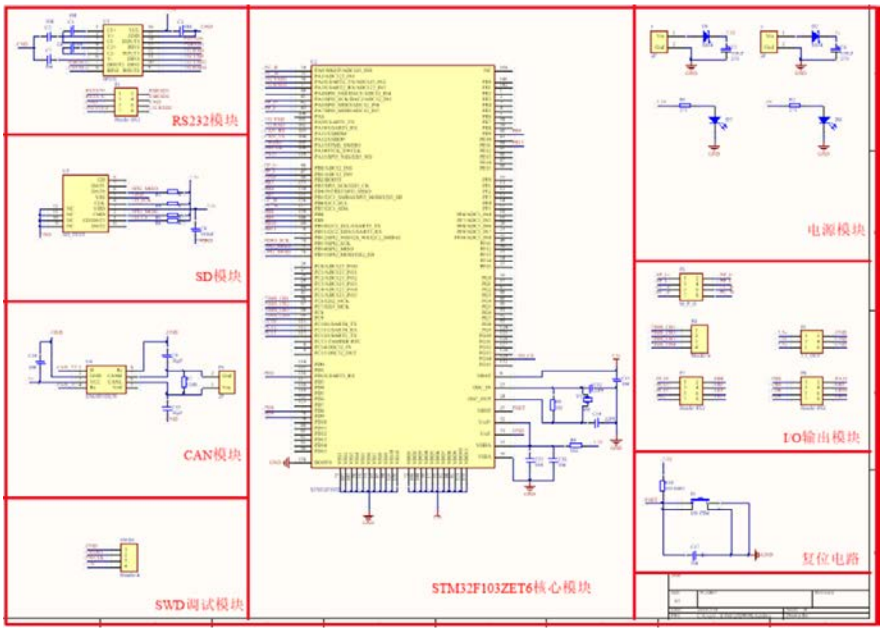

Fig.8 Schematic diagram of the central control module

As the control core of the wall-climbing robot, the central control module is responsible for receiving and processing sensor data, controlling the drive control circuit board, and receiving data from the remote control. The central control MUC used in the design is STM32F103ZET6. The STM32F103ZET6 chip is based on the ARM Cortex-M3 core 32-bit microcontroller, 512K on-chip FLASH, 64K on-chip RAM, up to 72M frequency, supports off-chip high-speed crystal oscillator (8M), support JTAG, SWD debugging. Up to 80 IO (mostly compatible with 5V logic), 4 general-purpose timers, 2 advanced timers, 2 basic timers, 3 SPI interfaces, 5 USARTs, one USB slave interface , A CAN interface, 3 channels with 16 channels of 12-bit AD input, 2 channels with 2 channels of 12-bit DA output, support off-chip independent voltage reference. CPU operating voltage range: 2.0-3.6V[5].

Based on the on-chip functions of STM32F103ZET6, the design of the STM32F103ZET6 timer, CAN, DMA and other modules is used to complete the design of the entire robot control system.

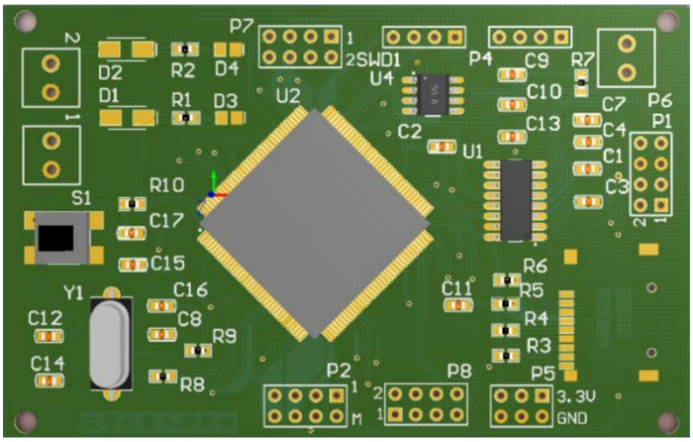

Fig.9 PCB diagram of central control module

4.6. Motor Drive Control Board

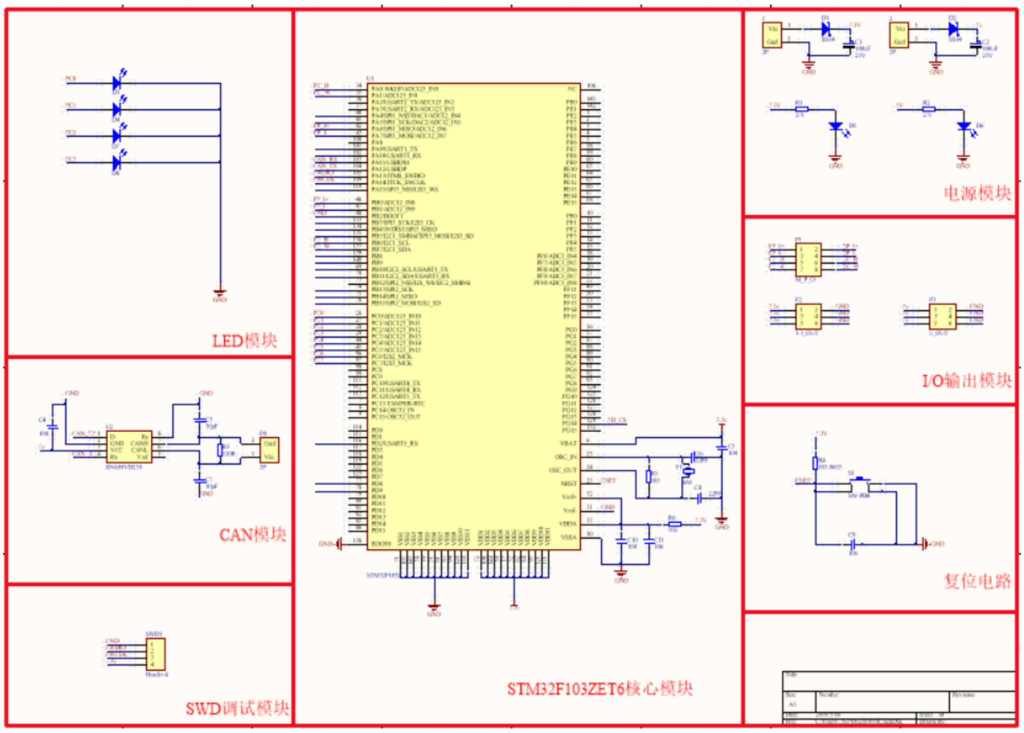

Fig.10 Schematic diagram of motor drive control board

The motor drive control board outputs control pulses to the drive module by receiving the control signal sent by the central control module, thereby achieving stable control of the motor [6]. Similar to the central control module, the central control MUC used in the motor drive control board is STM32F103ZET6. The STM32F103ZET6 chip is based on the 32-bit microcontroller of the ARM Cortex-M3 core, and uses its timer and CAN module to achieve its functions.

The motor drive control board adopts a double-layer board and a reasonable layout, which greatly reduces the area of the circuit board and improves its working stability.

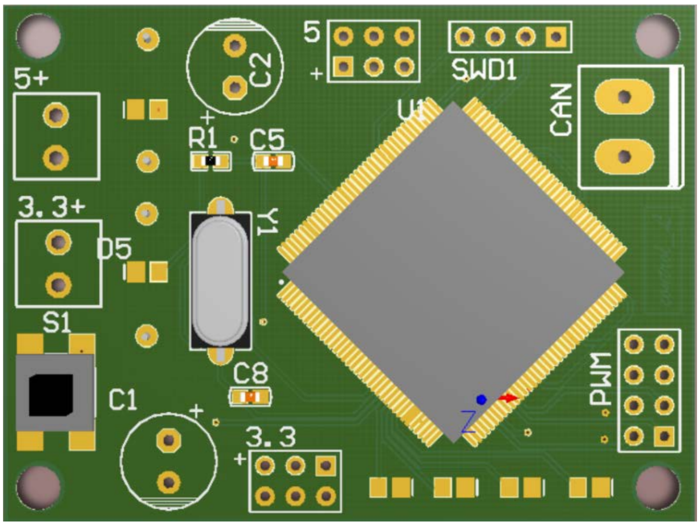

Fig.11 PCB diagram of motor drive control board

5. Experiment and Analysis

The real body of the robot is shown in the figure:

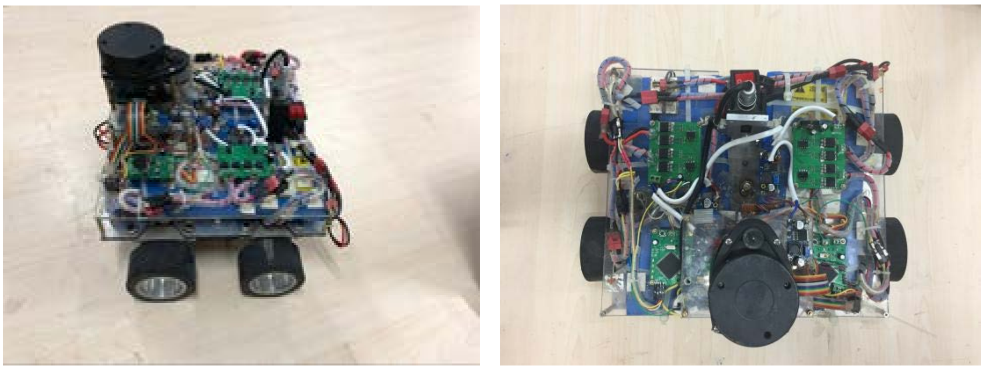

Fig.12 Robot physical map

Next, we test each function separately.

First of all, we use the oscilloscope that comes with MDK4 to observe the PWM waveform of a certain motor.

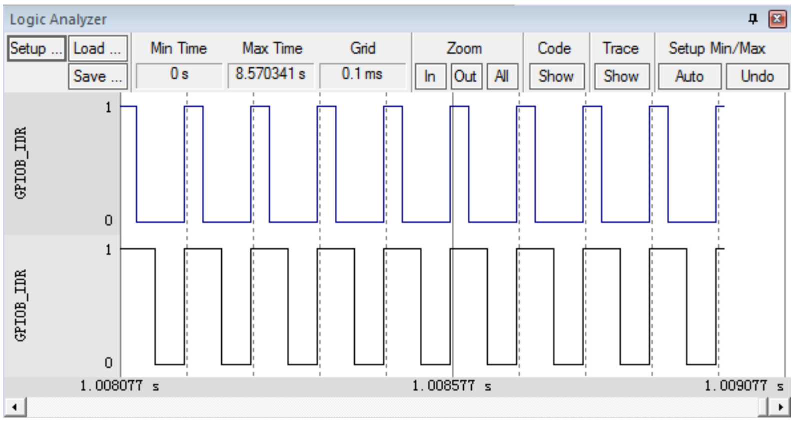

Fig.13 PWM waveform

Use a multimeter to test the PWM wave of the control circuit board and check whether it can output the corresponding PWM waveform under the action of the remote control, thereby driving the corresponding motor to complete the correct action.

Fig.14 PWM wave voltage test

After using the remote controller to test the PWM wave voltage of the control circuit board, the results show that the circuit can work normally.

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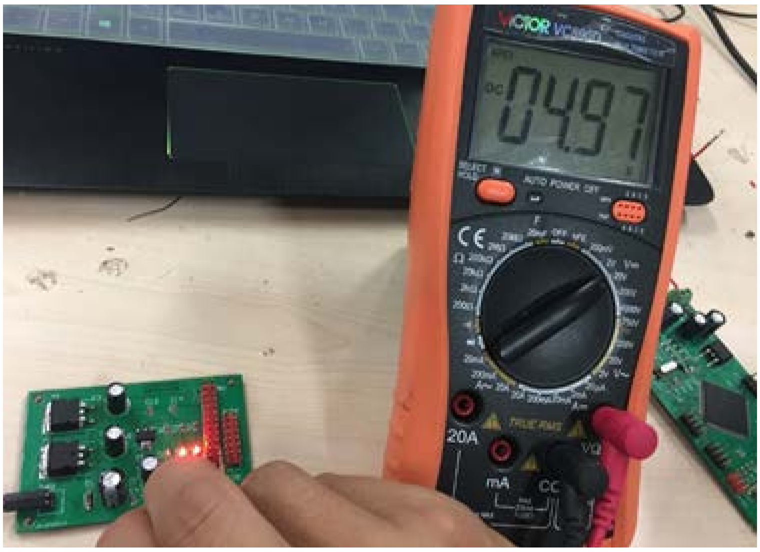

Fig.15 Power circuit board voltage test Summary

According to the test of the power supply circuit board voltage, the power supply voltage can reach the required voltage amplitude, which can fully meet the power supply requirements of actual robot control.

At the same time, the communication module of the designed robot control circuit board is tested. The CAN bus communication for data transmission between the single-chip microcomputers is normal, and the USART communication serial port for data transmission between the single-chip microcomputer and the sensor works normally.

Next, the remote control device is used to control the robot control circuit in two different states, automatic mode and manual mode, and a multimeter is used to detect whether the output voltage of the motor drive circuit is normal. The results show that the motor drive circuit can work normally. At the same time, it can drive the motor to complete the corresponding action under the load of the motor. It has many characteristics such as high accuracy and good stability. It can fully assume the function of robot drive. References.

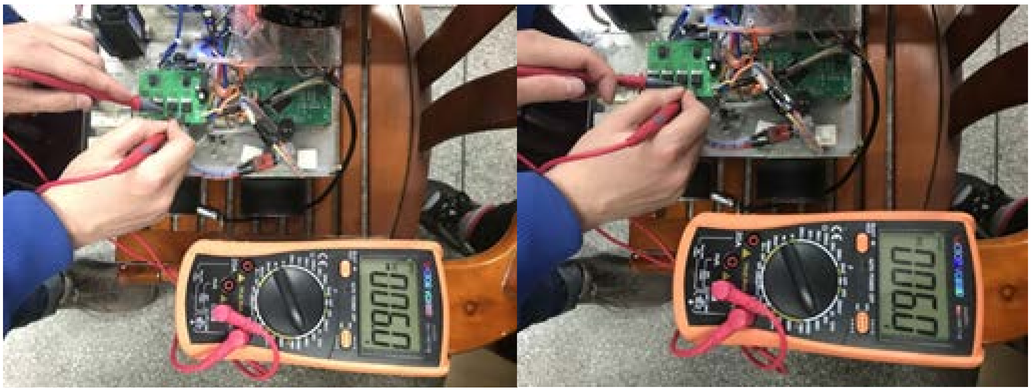

Fig.16 Motor drive experiment

6. Conclusion

This paper designs the overall circuit of the wall-climbing robot based on the STM32 microcontroller, completes the overall design of the wall-climbing robot's motion control system, the circuit design of the motor drive circuit, communication circuit, control circuit, etc. The designed circuit layout is reasonable and the function is perfect. The wall-climbing robot equipped with this circuit has a simple mechanical structure, stable and reliable adsorption,

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flexible motion control system, and is suitable for working on the wall surface of ferromagnetic materials.

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