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Hardware Structure and Control System Design of Glass-wall Cleaning Robot

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Abstract

This article introduces hardware structure and software structure of the glass-wall cleaning robot. After the introduction of the composition and working process of the robot, a reasonable and efficient tracing algorithm is designed based on the walking style of glass-wall cleaning robot. The glass-wall cleaning robot consists of the adsorption system, sports system and single chip microcomputer control system. In this paper, the design ideas and implementation methods of these three parts are described in detail.

Keywords: glass-wall cleaning robot, adsorption system, single-chip microcomputer control, tracing algorithm

1. Introduction

At present, with the development of city modernization and the rise of high-rise buildings, the application of the wall structure which is represented by the glass wall is more and more high in urban construction. It doubles the difficulty of cleaning. Therefore, applying the robot to the tall glass wall cleaning has become a hot research topic.

In the early 1970s, people began the research of the glass-wall cleaning robot. In the 1980s, various types of cleaning robot appeared on the market in succession. In 1986, America made the climbing robot used for the skyscraper washing. In addition, in 1990, the Russian machinery research institute developed a single suction cup robot used for cleaning task. In 1996, Osaka Prefecture University produced the world's first vertical wall mobile robot. In China, since 1987, Shanghai University took the lead in the study on climbing wall cleaning robot. In 2000, the robotics institute of Harbin institute of technology cooperation and China national blues chemical cleaning company successfully developed "the blue superman" CLR-2 wall cleaning robot.

The key technique of the glass-wall cleaning robot is meeting the stability of mobile, the operation of simple flexibility as well as the safety and reliability in the working process. In this paper, based on the current use condition of the glass-wall cleaning robot, a practical, safe, stable glass-wall cleaning robot is designed. And the way of walking, the adsorption system, motor system and chip microcomputer control system of the robot are analyzed and discussed.

2. The design of external structure

The glass-wall cleaning robot is designed to square. Four corners are in arc shape and are equipped

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with corner wheels, which can't be too large, so as to ensure the robot will not be jammed when turning. The front of the robot is equipped with infrared obstacle avoidance sensor, and the both sides are equipped with light touch switches. When it meets the windowsill, the sensor outputs low level and microcontrollers processing signals and command robot turn. When robot cleans to the top of the window, collisions with windowsill would appear when turning. At this time the light touch switch gives a low level to the microcontroller, and then the microcontroller initiates new instructions. If the left-side switch is closed, the robot rotates clockwise 90° and walks straight to the bottom right corner. If the right-side switch is closed, the robot rotates counterclockwise 90° and then goes straight to the bottom left corner. There is a cloth wipe at the bottom of the robot, during the robot walking process, it can wipe a window. Fig. 1 shows the external structure of the robot.

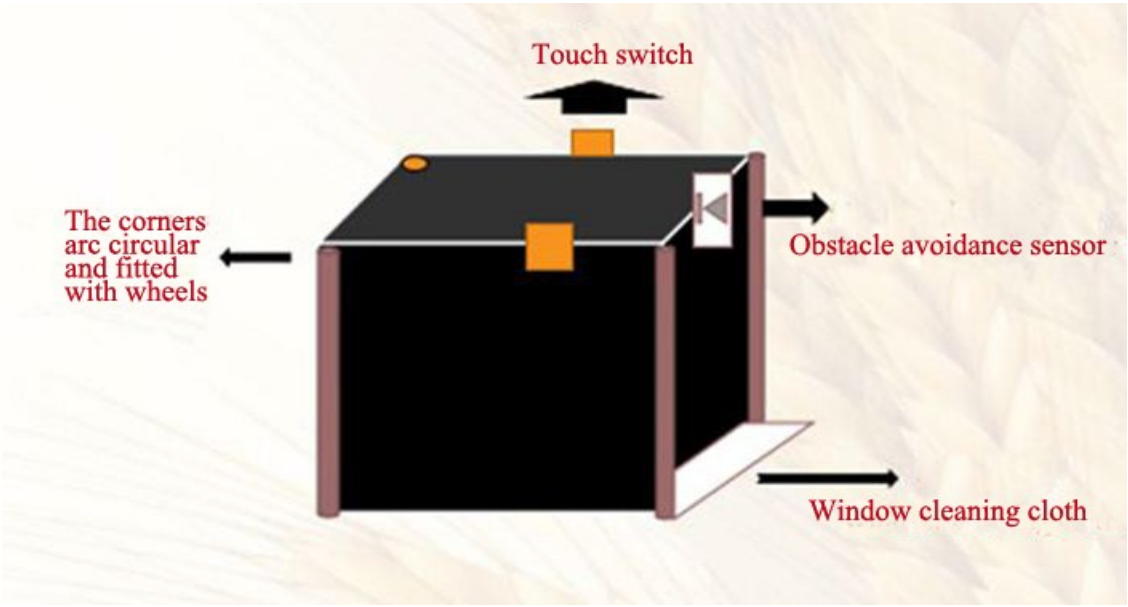

Fig. 1. External structure of the robot.

3. The design of adsorption system

This design adopts the vacuum adsorption system. The vacuum adsorption system has the following characteristics, such as lightweight, compact structure, high reliability, etc. Therefore, this adsorption system is widely used in a variety of pneumatic robots, at the same time; it is also one of the key technologies in this design.

Two negative pressure values are set. The maximum negative pressure is P1 and the minimum pressure is P2.When the vacuum pump starts, chuck cavity pressure begins to fall. When the negative pressure value reaches P1, the vacuum switch turns to a low level and the vacuum pump stops working. When the negative pressure value reaches P2, the switch turns to a high level, and the vacuum pump starts to work. The rules of P1 and P2 are shown in equation Eq. 1 and Eq. 2 respectively.

$$P1 = F1/S \tag{1}$$

$$P2 = F2/S \tag{2}$$

F1 is the sum of the gravity and biggest driving force and P2 is the gravity of the robot. S is sucker area. The relation is shown in Fig. 2.

When glass-wall cleaning robot starts to work, suction cup system starts up, and the vacuum pump starts to work. At this time, the air pressure sensor detects air pressure value. When the chuck negative

pressure value reaches P2, the pressure sensors generate positive indicator, and the pilot lamp changes from red to green. When the chuck negative pressure value reaches P1, the pressure sensors generate negative indicator, and the vacuum pump stops working. During the robot walking, the chuck negative pressure value declines. When the chuck negative pressure value reaches P2, the pressure sensors generate negative indicator, and the vacuum pump starts to work. So it circulates all the time until the external interrupt orders it to stop working. The flow chart is shown in Fig. 3.

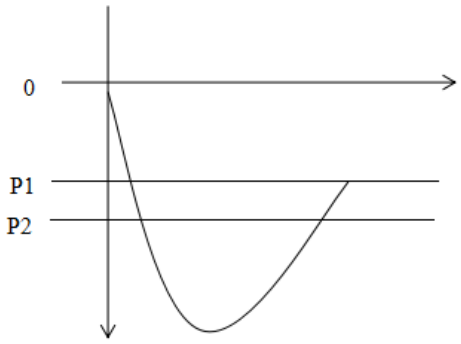

Fig. 2 Negative pressure coordinate curve of vacuum generator.

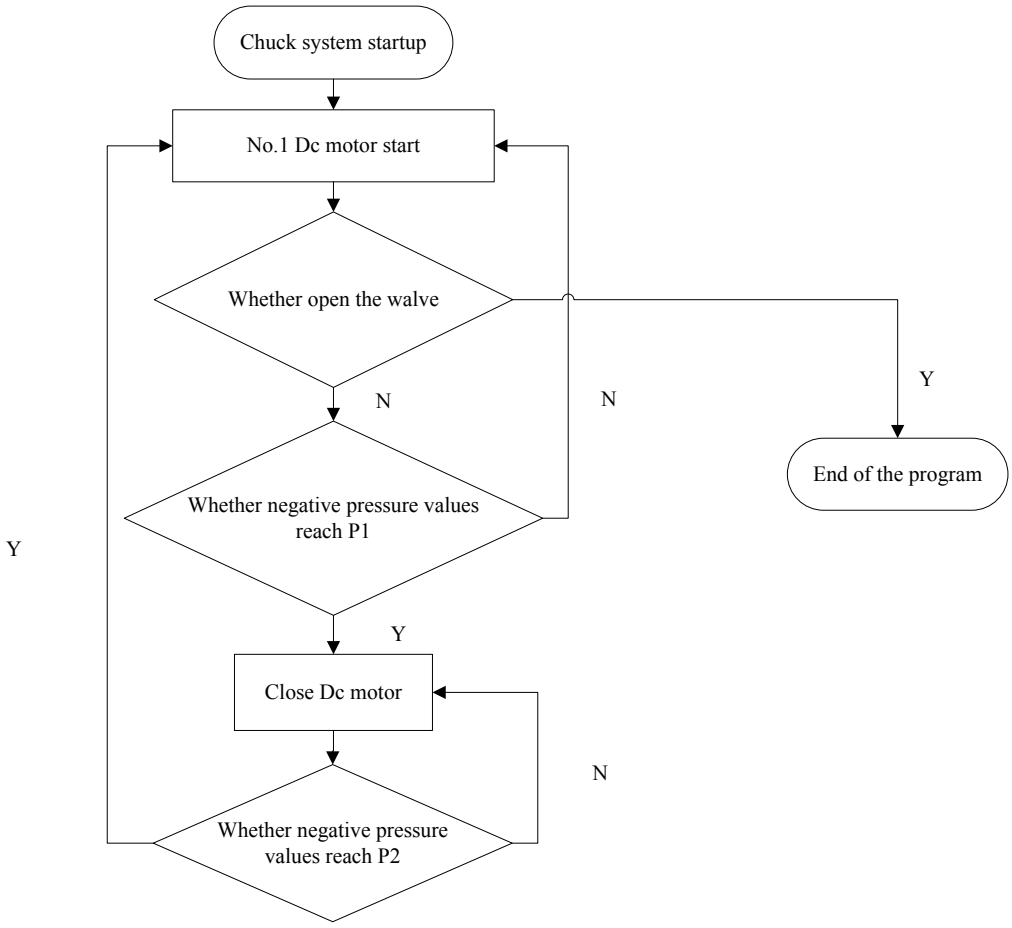

Fig. 3. The adsorption system flow chart.

4. The design of motor system

The key of this part is turning, and the robot begins to walk a straight line from the bottom left corner. When the infrared sensors detect obstacle, it outputs low level immediately and the microcontroller counts and judges the output is even or odd times. When it is odd times, the robot goes back the length of L and then rotates counterclockwise 90°. And then the robot goes forward the length of L and then rotates counterclockwise 90°, and then it goes straight. If it is even times, robot goes back the length of L and then rotates clockwise 90°, and then the robot goes forward the length of L and then rotates clockwise 90°, then go straight and then it goes straight. The motor system flow chart is shown in Fig. 4.

Two relays are used to control overturn and forward of the motor. When a relay is closed and another is disconnected, the motor starts to go forward. In turn, it starts to overturn. The total circuit of Motor system diagram is shown in Fig. 5.

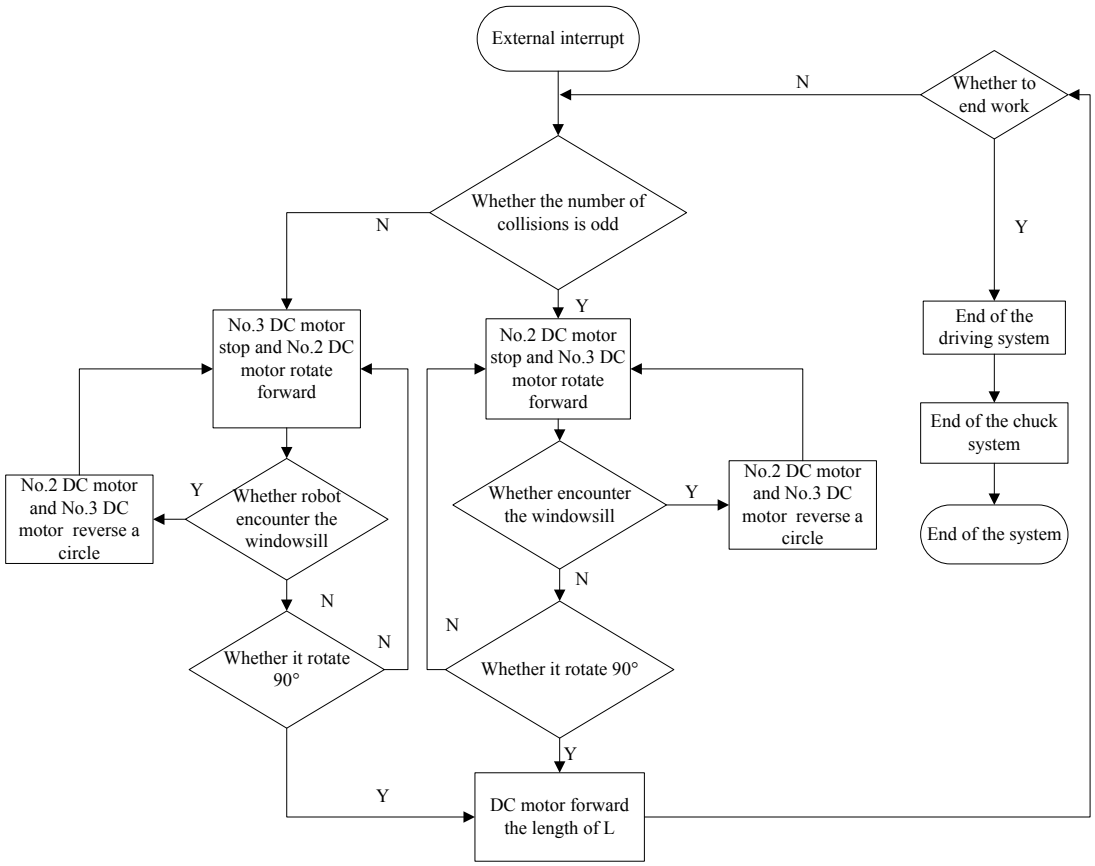

Fig. 4. The motor system flow chart.

5. The design of control system

The control system mainly includes two aspects: the sucker control and motion control system. When the main switch opens, MCU initializes and the chuck system begins to work. When the robot is absorbed onto the glass, the motion system is started, and the robot starts working to clean the window. The total flow chart of the control system is shown in Fig. 6.

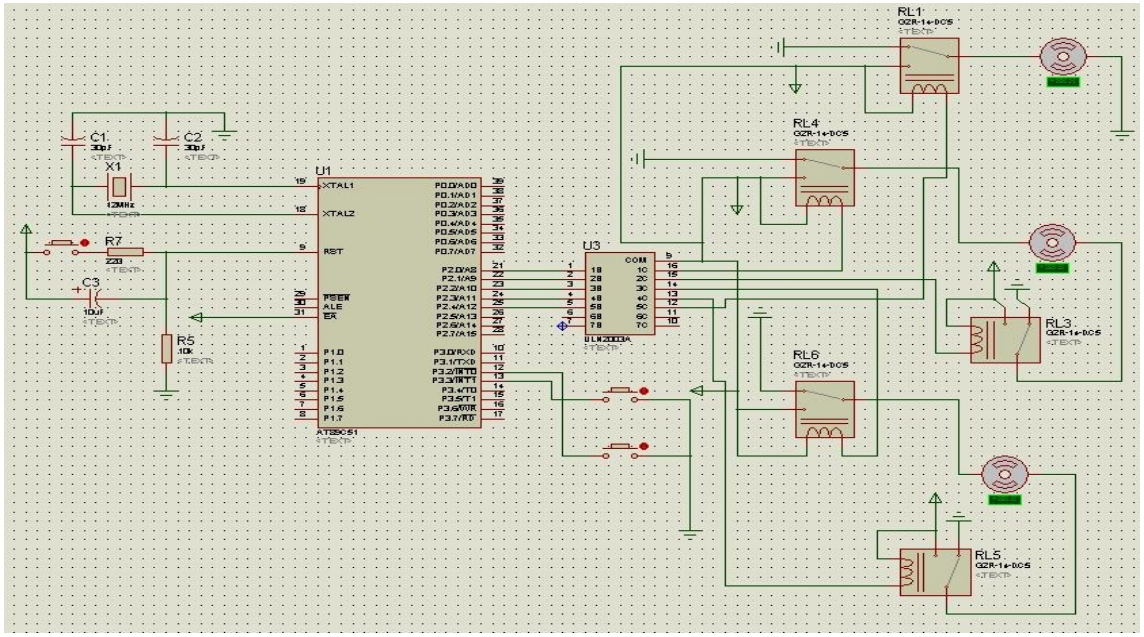

Fig. 5. The total circuit of Motor system diagram.

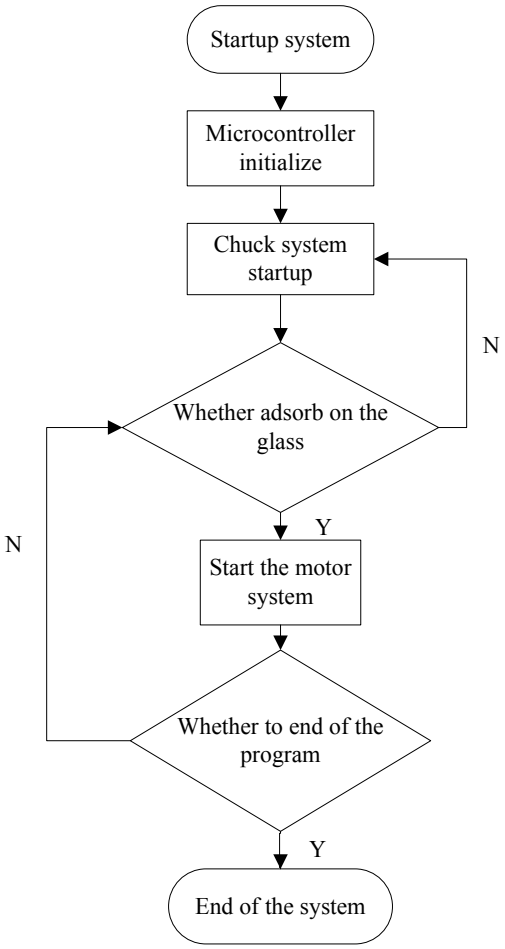

Fig. 6. The total flow chart of control system.

This glass-wall cleaning robot achieves the goal of cleaning windows by controlling the path of the robot. Therefore, the path planning of motion system is particularly important.

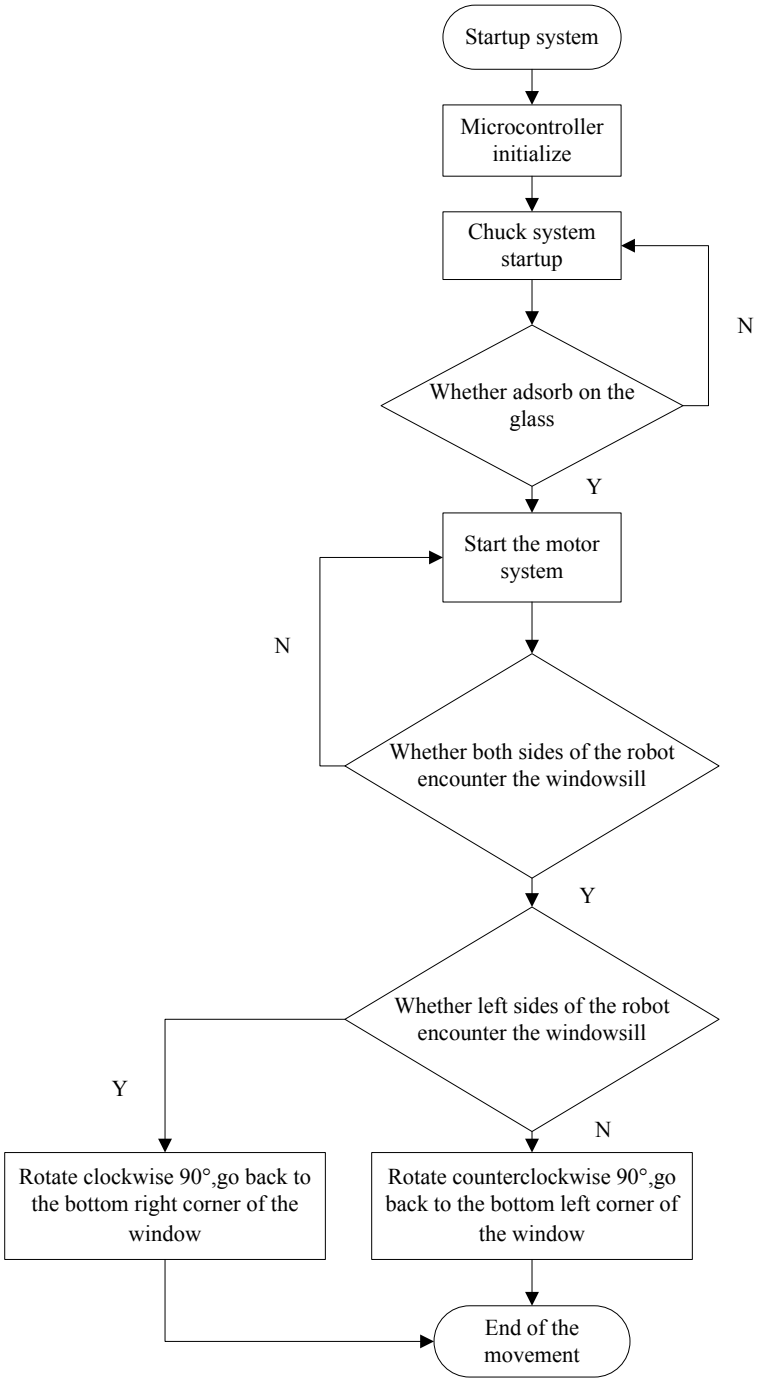

Fig. 7. The whole movement flow chart.

The working principle of the figure is show as follows: the robot starts to clean from the bottom left corner of the glass window, and then the robot goes straight to the right. There are IR evading obstacle sensors in front of the robot, when the robot senses obstacles in front, the robot goes back the length of L. And then the robot rotates counterclockwise 90°, then the robot goes forward the length of L. And then

the robot rotates counterclockwise 90° and then turns left and goes straight until the next closest obstacle. When the robot senses obstacles in front, the robot goes back the length of L and then rotates counterclockwise 90°, and then the robot goes forward the length of L. And then the robot rotates clockwise 90° and then goes straight. When the detected number of obstacles is odd, the robot rotates counterclockwise. When the detected number of obstacles is even, the robot rotates clockwise. If the left switch of robot is touched, the robot rotates clockwise, and then goes back to the bottom right corner of the window. If the right switch of robot is touched, the robot rotates counterclockwise, and then goes back to the bottom left corner of the window. The whole movement flow chart is in Fig. 7.

In this design, the vacuum pump and the DC motor rated voltage is 12v. The transistor is directly connected to the port. The total control circuit diagram is shown in Fig. 8.

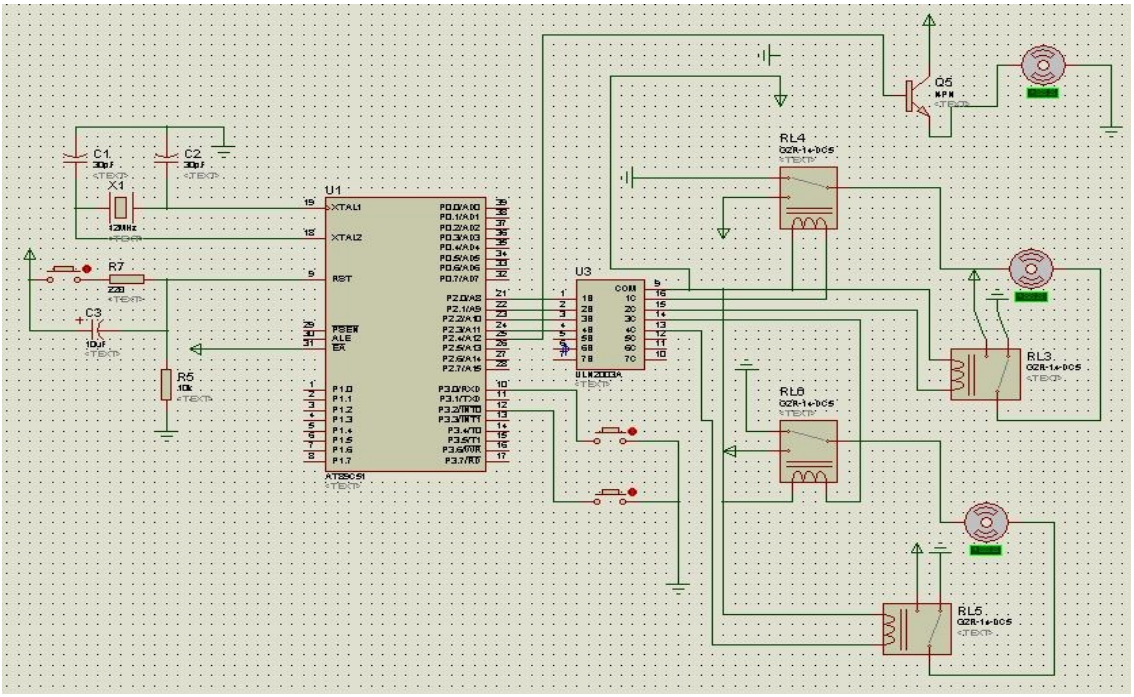

Fig. 8. Total control circuit diagram.

6. Conclusion

This robot is designed according to the modular production and based on the working principle of robot. The robot can be divided into three parts. Each module is relatively independent, so it effectively prevents the error spread in the whole structure and it is conducive to correct mistakes, so as to improve the reliability of the system. Due to the character of a simple structure and light weight, this design breaks complex structure of the previous robot situations. Experiments show that the robot is stable, reliable and can meet the most of the requirements of work environment when performing the duty of cleaning window.

Acknowledgements

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