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A Design of Small Freight Robot Based on Single Chip Microcomputer

Shouxi Zhu and Wenlai Ma

Aviation Information Technology R&D Center,
Binzhou University,
Binzhou, Shandong, China

ABSTRACT: In many workplaces, we need to carry some heavy stuff along a fixed route, in order to reduce the workload of staff, this paper proposed a kind of small freight robot based on single chip microcomputer. In this design, we use AT89S52 chip as the main control chip, design the electromotor drive circuit use L298N chip. The robot is driven by gear motor, using black and white line sensor, infrared photoelectric switch and wireless transceiver etc. to achieve the following functions: automatic tracing, sound and light alarm, obstacles avoidance, remote control and so on. At the same time, the freight robot can carry about 100 kg weight and has the characteristics of low cost and easy to maintain. The design is suitable for the transportation of small amount of goods, such as a workshop, airport and quick distribution station. It is flexible and the transportation cost is low, so it has a broad application prospect.

KEYWORDS: Single Chip Microcomputer, Freight Robot, Gear Motor, Tracking, Obstacles Avoidance.

1 INTRODUCTION

In some places such as factories or docks, the staff often needs to carry some heavy stuff. Although now there are a lot of vehicles, such as a forklift, etc., but in practice, the workload of staff is still great. In this case, we designed a freight robot to replace the manual freight transport operations. It cannot only reduce human workload but also improve labor efficiency. This small freight robot uses the microcontroller of AT89S52 as the control center [1], uses L298N chip as the core of drive circuit and uses gear motor as the driving force [2]. This small freight robot can achieve the functions including automatic tracing, sound and light alarm, obstacles avoidance, remote control and so on. In order to facilitate maintenance, this robot adopts many electric bicycle accessories. This small freight robot is mainly designed for the transportation of a small amount of goods, it can be applied to airport baggage transportation, warehouse cargo transportation, etc.. Because of its small size and large load capacity, it can also work in a more complex situation and have some alternative capacity to replace the traditional trolley.

2 DESIGN REQUIREMENTS

Design a battery powered freight robot which can travel back and forth along the black guide line between location A and B to realize the transportation of the goods. It should has a certain ability to adapt different roads, at the same time, it also need to meet the requirements of safety.

- It can travel back and forth along the black guide line between location A and B and can automatically judge whether offtrack and automatically adjusts the direction.
- In location A and B, it can stop automatically.
- The load shall not be less than 100 kg.
- It can avoid the obstacles along the way, such as pedestrian or other object.
- It has two driving modes of remote control and automatic.

Corresponding Author: Shouxi Zhu

3 DESIGN OF HARDWARE

The hardware frame of the freight robot is shown in fig. 1.

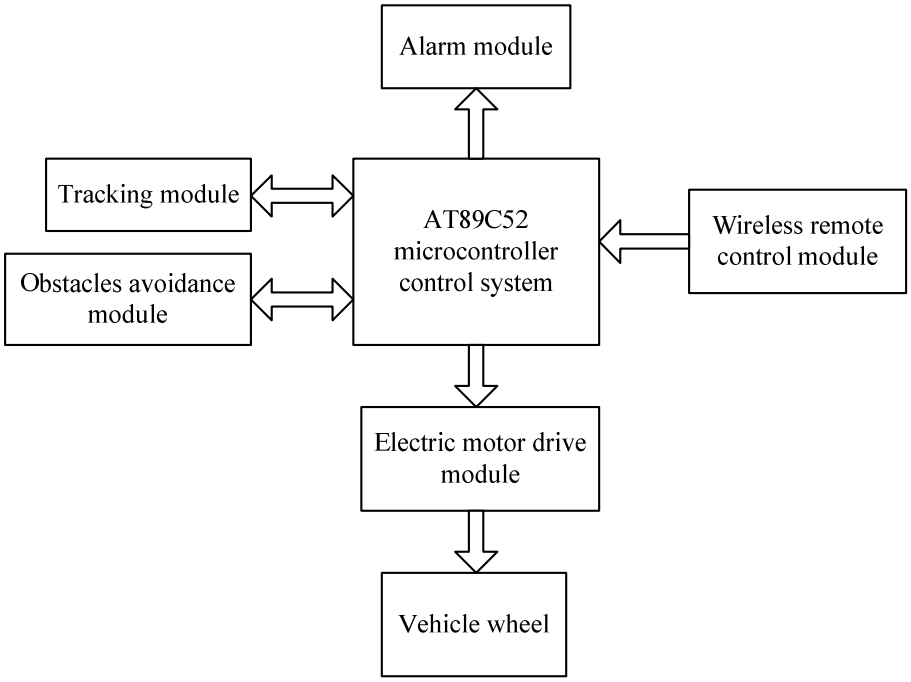

Fig. 1. Hardware Frame of The Freight Robot

3.1 CHOICE OF MAIN CONTROL CHIP

This robot adopts AT89S52 chip as the main control chip, this chip has enough storage space, it can be convenient to download procedures through in system programming to meet the needs of the system software [3]. The chip provides two counter interrupt and is enough for this design. Using this chip, we can choose the control chip of the system modules more flexible and can be able to calculate the time accurately [4], so as to have a good real-time performance.

The minimum system circuit of AT89S52 chip is shown in fig. 2.

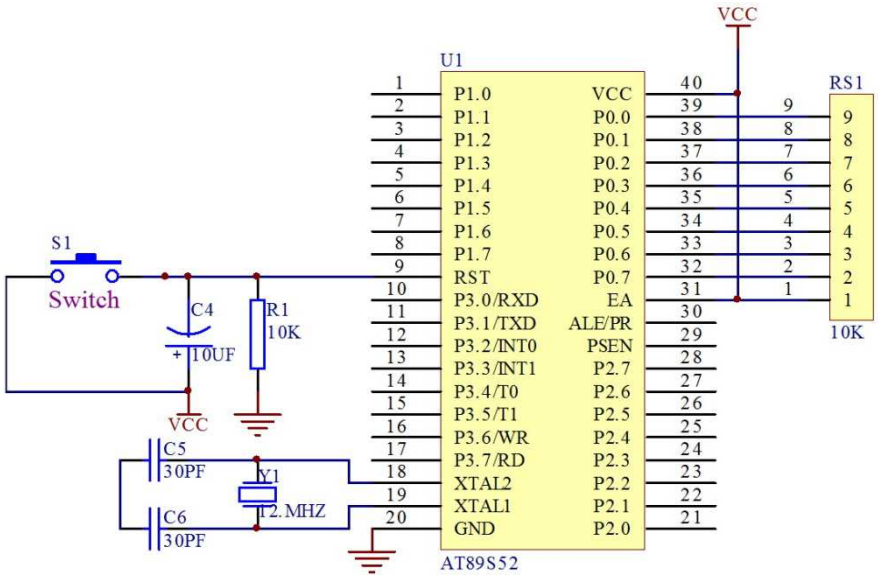

Fig. 2. Minimum System Circuit of AT89S52 Chip

3.2 WIRELESS TRANSCEIVER MODULE

This robot uses radio transmitting and receiving device for wireless transceiver [5]. In this design, we use the wireless transceiver chip SC2264 and SC2272. SC2262/2272 is a set of wireless remote control transmitter/receiver chip with address and data encoding function. The transmitter chip of SC2262 has integration of carrier oscillator, encoder and transmitter unit, so the transmitter circuit can be very simple. The receiver chip SC2272-M4 is non-latch type 4 data output and there are eight address code [6], so as to effectively prevent the interference between each wireless modules. The set of wireless transceiver chip is easy to use, cheap and has good job stability.

The pins of SC2272-M4 chip are shown in table1.

Table 1. Pins of SC2272-M4 Chip

Pin	Name	Function description
1	D3	Data output
2	D2	Data output
3	D1	Data output
4	D0	Data output
5	GND	power negative
6	VT	Output status indication
7	5V	power positive
8	ANT	Connect the antenna

The receiving module has wide bandwidth, generally is ±10MHz, its factory set value is 315MHz or 433.92MHz, it uses DC5V power supply. The design of wireless receiving circuit is shown in fig. 3.

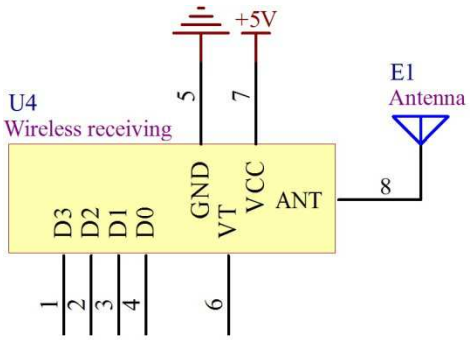

Fig. 3. Wireless Receiving Circuit

3.3 OBSTACLES AVOIDANCE MODULE

This robot adopts photoelectric switch as a sensor for obstacles avoidance, using the blocked or reflected beam from the detected object, after synchronization loop gating circuit to detect whether there is an obstacle, the detection distance can reach more than two meters. The object is not limited to metal, all the objects which can reflect light can be detected. The input current at the transmitter is converted to an optical signal by the photoelectric switch and emitted, the receiver based on the received light intensity to detect the presence or absence of the target object. We use a buzzer and lights as a reminder. Buzzer has the characteristics of small size, light weight, low price, solid structure and so on, while this module can be used as turn reminder. When the microcontroller judging arrive, it will control the buzzer sounds, which utilize the P0.7 pin to control.

The alarm module circuit is shown in fig. 4.

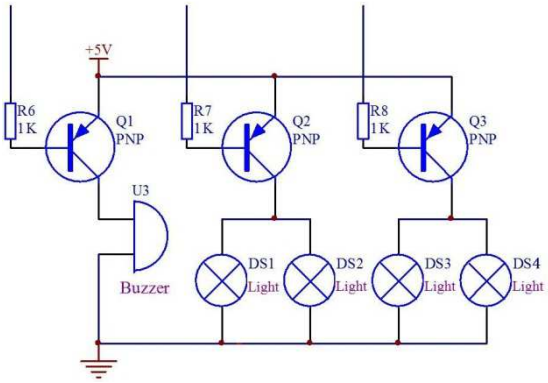

Fig. 4. Alarm Module Circuit

3.4 MOTOR DRIVER MODULE

The robot adopts L298N chip to design motor drive circuit [7]. This chip has the advantages of small volume, fast response, high safety reliability and strong anti-jamming capability. The chip has a larger current drive capacity. It is a special drive integrated circuit which belongs to the H bridge integrated circuit. Its output current is 2A, highest current is 4A, the highest working voltage is 50 V. It can drive the inductive load, such as high power DC motor, step motor, solenoid valve, etc.. Its input can be associated with the microcontroller directly, thus it can be easily controlled by the microcontroller, so the connection is convenient and simple.

The motor we choose is a DC gear motor, gear motor is refers to the integration of speed reducer and motor, it can also be called geared motor, usually assembled by the professional manufacturer and delivery supply in a full set. Using gear motor, the design can be simplified and save space, what's more, meet the requirements of the moment of force.

This design uses L298N chip to drive the vehicle wheels. The enable pin is controlled by P2.4 and P2.5 respectively [8], while the wheels using P2.0, P2.1, P2.2 and P2.3 to control respectively. The motor driver circuit is shown in fig. 5.

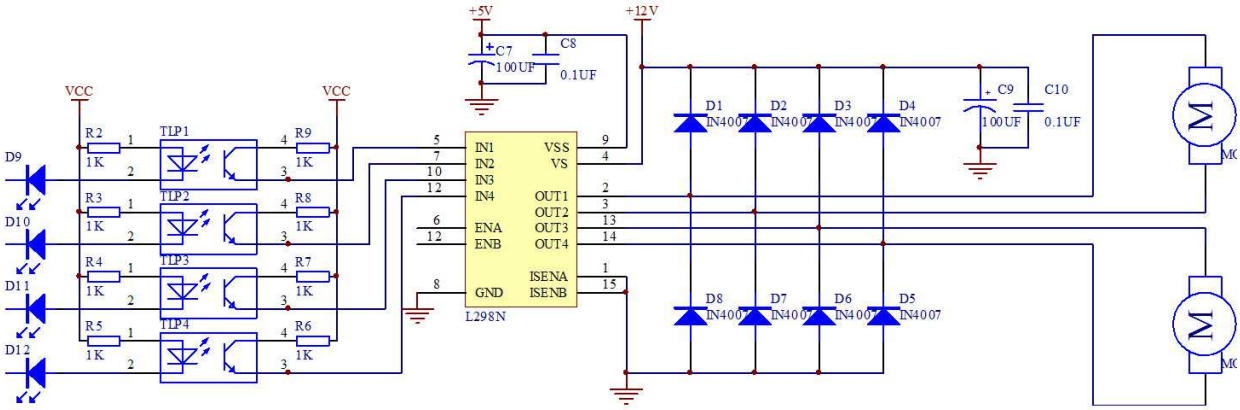

Fig. 5. L298N Motor Driver Circuit

When driving the DC motor, we can directly control the motor rotate in forward and inversion direction, implement this function only need to change the logic level of the input. In order to avoid the motor disturbance to the single chip microcomputer, this module adds an optical coupler for photoelectric isolation, so that the system can work stable and reliable.

This module has four lights to indicate the motor running state. The effect of the optical coupler in peripheral circuit is to prevent the large current flow through the single chip microcomputer and burn it if the L298N chip burned. The diode can prevent the countercurrent generated by the DC motor and burn the L298N chip.

The design rendering of the driven motor is shown in fig. 6.

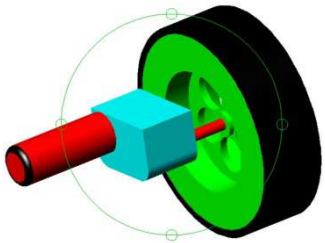

Fig. 6. Design Rendering of The Driven Motor

3.5 TRACKING MODULE

The robot adopts black and white line sensor. Black and white sensor is designed to detect the white line on a black background or a black line on white background. Black and white line only appears high or low level, the change is evident and easy to be identified, so it is very suitable for car tracking. TK-20 black and white line sensor is the upgrade version of TK-10 [9], its effective detection range can be up to 5cm. By adjusting the potentiometer, it can be achieved as far as 10cm (in this distance, detecting precision will be reduced). This sensor is not susceptible to visible light interference, its output signal is switching value which will be easy to process and easy to use. This sensor adds a detection range regulator which can increase the detection distance and improve the detection accuracy. If we use a laser tube replaces the luminous diode, the detection distance can reach up to 20cm and even better [10]. So in order to ensure accuracy, we use laser tube.

Fig. 7 is the design of black and white line sensor circuit diagram, in which the signal lines use P3.1 and P3.2 pins of microcontroller respectively to detect and control.

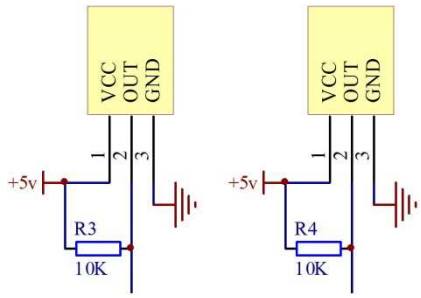

Fig. 7. Black And White Line Sensor Circuit

3.6 POWER MODULE

In this design, there are three voltages: 5V, 9V and 24V. Sensors and microcontroller require 5V power supply, the wireless transmitter module need 9V and the gear motor voltage need 24V. All the system power is provided by a storage battery. The 5V and 9V voltage is provided by the chip of L7805 [11]. Although the circuit is more complex, but it is more convenient to use and maintenance, and it is also economic. At the same time, the use of independent lead-acid battery power can make the robot more flexible and can accommodate more roads.

4 DESIGN OF SOFTWARE

The whole software design include forward, backward, turn left, turn right, brakes, alarm, remote control, interrupt function and others. IO port of microcontroller can produce high and low level, then the drive circuit generates a corresponding high and low level, so as to achieve the motor forward and backward movements, such as walking and other motion. The interrupt function is used to obstacles detection and the following action, achieve unloading operations and so on.

The program flow chart is shown in fig. 8.

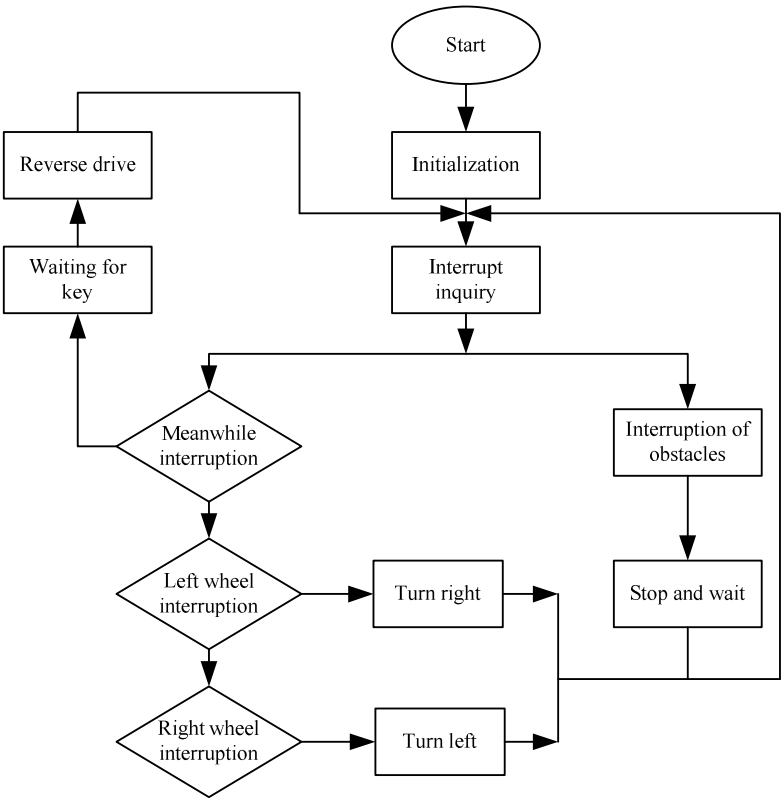

Fig. 8. Program Flow Chart

5 MODULE CONTROL AND FUNCTION IMPLEMENTATION

5.1 REALIZATION OF AUTOMATIC MOVE

When the robot accepts start command, the microcontroller will acquire the sensor signals. Under normal circumstances, A and B black and white sensors will not detect the black track and then output high level to the microcontroller, the microcontroller through the port output the corresponding level to driving circuit, indirect control the two gear motors C and D forward at the same tine to achieve straight. When the robot walk left, A will output high level and B output low, in this case, the microcontroller control C forward and D reverse to achieve steering. When the robot walk left, A will output low level and B will output high, then the microcontroller control C reverse and D forward, to correct the driving direction. When the output level of A and B are all low, it is considered to reach the stop line, C and D will simultaneously reverse to achieve braking.

The motion status of the robot is shown in fig. 9.

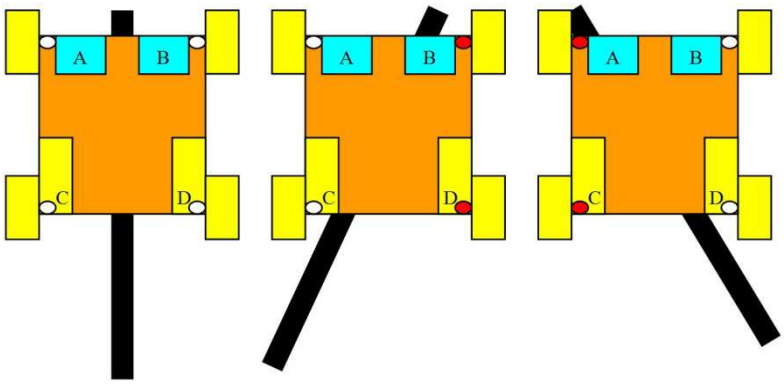

Fig. 9. Motion Status of The Robot

5.2 REALIZATION OF REMOTE CONTROL

When the accident or other external problems happened that the robot can't identify the road conditions, we can use remote manual control to control the robot work. There are four keys to remote control A, B, C and D respectively, when press a key. The corresponding port at the receiving end will produce a corresponding low level signal to the microcontroller, after the microcontroller receiving, it will choose corresponding walking style, forward, backward or steering.

5.3 REALIZATION OF SECURITY MEASURES

When the robot rounds a turn, the corresponding turn signal will flash and buzzer will beep to alert the staff in front and back of the robot. When infrared tube E detects obstacles ahead, it will output high level signal to the microcontroller, then the microcontroller will control C and D reversal to realize brake. At the same time, the buzzer will siren with the left and right two lights flashing, the robot will not move on until the obstacle is clear. When the robot closer to the finish line, it will brake and stop, until it receives a new start command.

The schematic diagram of robot obstacles avoidance and brake is shown in fig. 10.

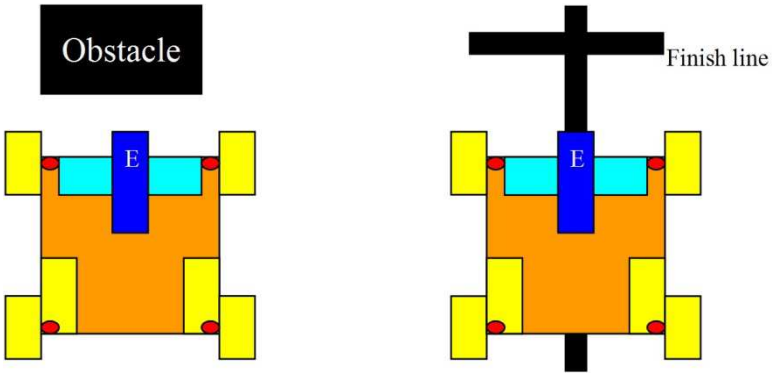

Fig. 10. Schematic Diagram of Robot Obstacles Avoidance and Brake

5.4 DESIGN SKETCH

Design of freight robot sketch is shown in fig. 11, all control circuits are on the bottom of it, the upper platform are for cargo. This design can not only protect the control circuit, but also can achieve the goal of more cargo.

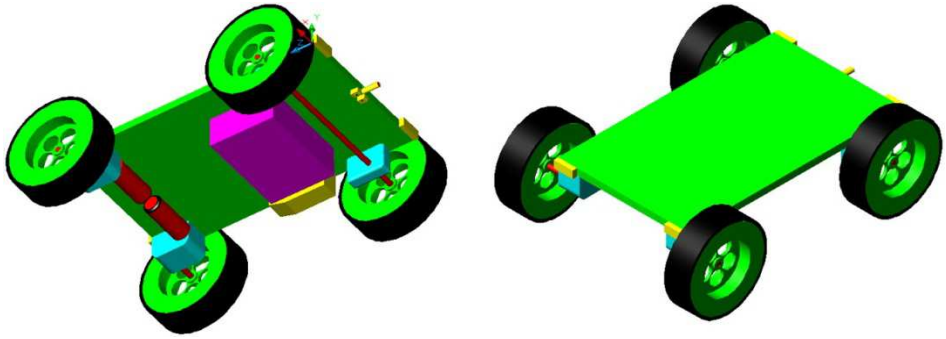

Fig. 11. Design of The Freight Robot Sketch

6 CONCLUSION

In this paper, we design a small freight robot which using a single chip microcomputer as the control chip. Combining with the black and white detection sensor, the robot can travel back and forth along the black guide line between A and B two locations, automatically determine whether off track and automatically adjust the direction. The robot has reserved ports and the user can modify the program, so it is convenient for function extension. Using the infrared tube, the robot can detect the front obstacles and realize automatic obstacle avoidance. The response of L298N driver circuit is fast and stable performance, which can realize the robot braking, forward, speed governing and steering. The gear motor power and torque

can conform to the design requirement of the load that shall not be less than 100kg. Using single chip microcomputer and the wireless transceiver module, the robot realizes the function of remote control. On application, the design makes a comprehensive argumentation, has considered the influence of various factors on the automatic control. Therefore, the small freight robot can satisfy the design tasks and requirements. The small freight robot is low cost and easy to maintain, so it can apply to the workshop, airport and distribution station for the rapid transport of a small amount of goods. Its flexibility and low cost will make it have a broad application prospects.

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