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Design and Implementation of an Intelligent Pro-Environment Waste Bin

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***Abstract* – In order to solve the problems of insufficient waste collection facilities and difficulty in storage and classification in public places, an intelligent pro-environment waste bin is designed. The single chip microcomputer is proposed as the core controller, combining with the voice circuit, driving motor circuit, ultrasonic circuit, photoelectric induction circuit, liquid crystal display circuit, sound and light alarm circuit and GSM circuit. Test results show that the functions of automatic dumpster flap, environment detection, voice prompt, fire alarm and message sending have been realized. At the same time, the system is low cost, high reliability and simple structure,. Thus, it has widely application value in the society.**

***Keywords* – Intelligent, Pro- Environment, Waste Bin, Voice Broadcast, LCD, GSM.**

I. INTRODUCTION

Waste sorting is a social problem with people's livelihood and social sustainable development. Perfect classification regulation is an important part of environmental protection. In recent years, the waste sorting regulation has been implemented and the related work has been carried out step by step in China. But some cities still have some shortcomings, such as insufficient waste sorting and collection facilities, mixed loading and transportation, and lagging construction of treatment facilities. Environmental pollution caused by waste is a long-standing problem that is difficult to solve. The environment is affected by the efficiency of waste collection. Thus, an intelligent pro-environment waste system needs to be invented urgently [1].

The single chip microcomputer is proposed as the core to design an intelligent pro-environment waste bin, combined with voice circuit, driving motor circuit, ultrasonic circuit, photoelectric induction circuit, liquid crystal display circuit, sound and light alarm circuit and GSM circuit. Several functions of waste classification, smoke detection, temperature test, sound and light alarm, and message transmission can been realized [2]. The system has the characteristics of simple operation, rich functions, low price, convenience and quickness.

II. SYSTEM DESIGN

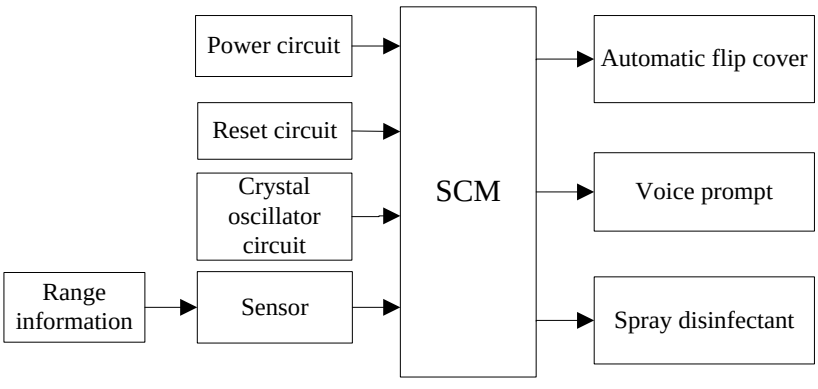

Fig. 1. Block diagram of detection part.

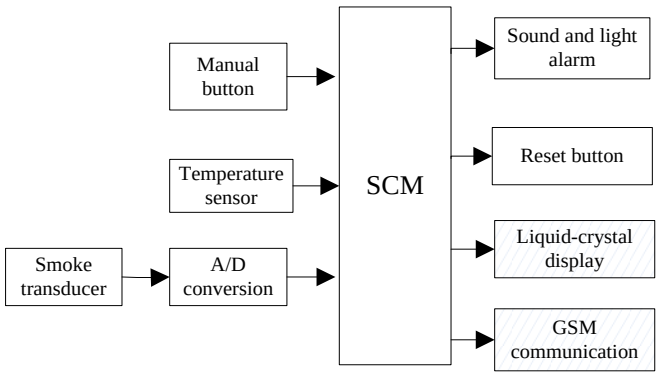

Fig. 2. Block diagram of alarm part.

The intelligent pro-environment waste bin is divided into the detection part and alarm part. The block diagram of detection part is shown in Fig. 1. When someone approaches the waste bin, the distance will be automatically detected and information will be sent to the single chip microcomputer. Thus, the waste bin can be opened. If the waste reaches the maximum capacity, the voice circuit will automatically alarm and disinfectant is sprayed. The block diagram of alarm part is shown in Fig. 2. The temperature and smoke can be detected by sensors. If the single chip microcomputer receives the fire signal, the diode flashes and the buzzer alarms. On the other hand, the signal is sent to GSM through serial port. When the signal is received, alarm information will be sent to the reserved telephone number.

III. System Hardware Design

A. *The Single Chip Microcomputer System*

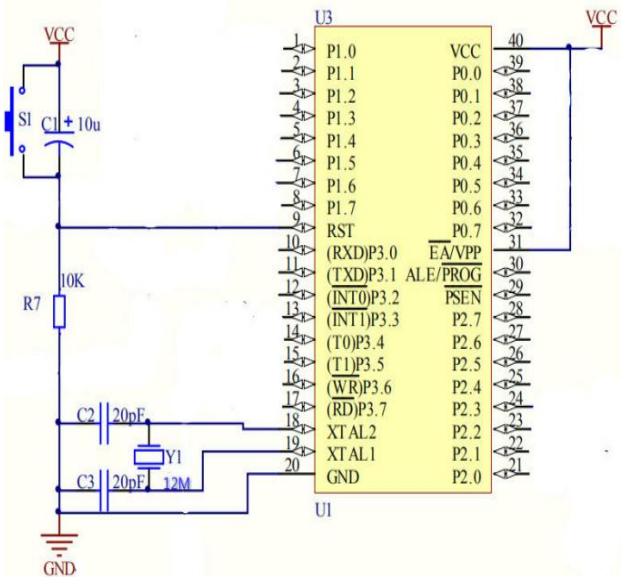

Fig. 3. Single chip microcomputer system.

The SCM system is shown in Fig.3. The STC89C52RC microcomputer is consisted with the reset and crystal oscillator circuit. The reset circuit is connected to the port RST of the SCM. When the SCM is started, the system can be initialized by the reset circuit. The crystal oscillator circuit is connected to port XTAL1 and XTAL2. The frequency of the system can be controlled by the crystal oscillator circuit. The higher the frequency, the faster the speed of SCM [3].

B. *Ultrasonic Circuit*

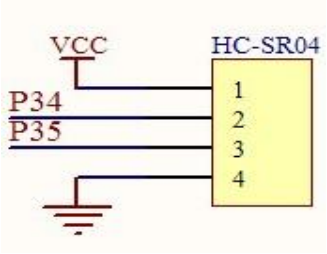

Fig. 4. Schematic diagram of ultrasonic circuit.

The schematic diagram of ultrasonic circuit is shown in Fig. 4. The HC-SR04 ultrasonic device is used in the detection part. It has four pin, where pin 1 and 4 are connected to 5V power supply and ground respectively, pin 2 are the input terminals of trigger signals, pin 3 are the output terminals of echo signals, pin 2 and 3 are connected to port P3.4 and P3.5 of the SCM respectively. When the ECHO is at high level, the timer inside the SCM is started to work. When the ECHO is at low level, the timer inside the SCM is stopped to work [4] [5].

C. *Photoelectric Induction Circuit*

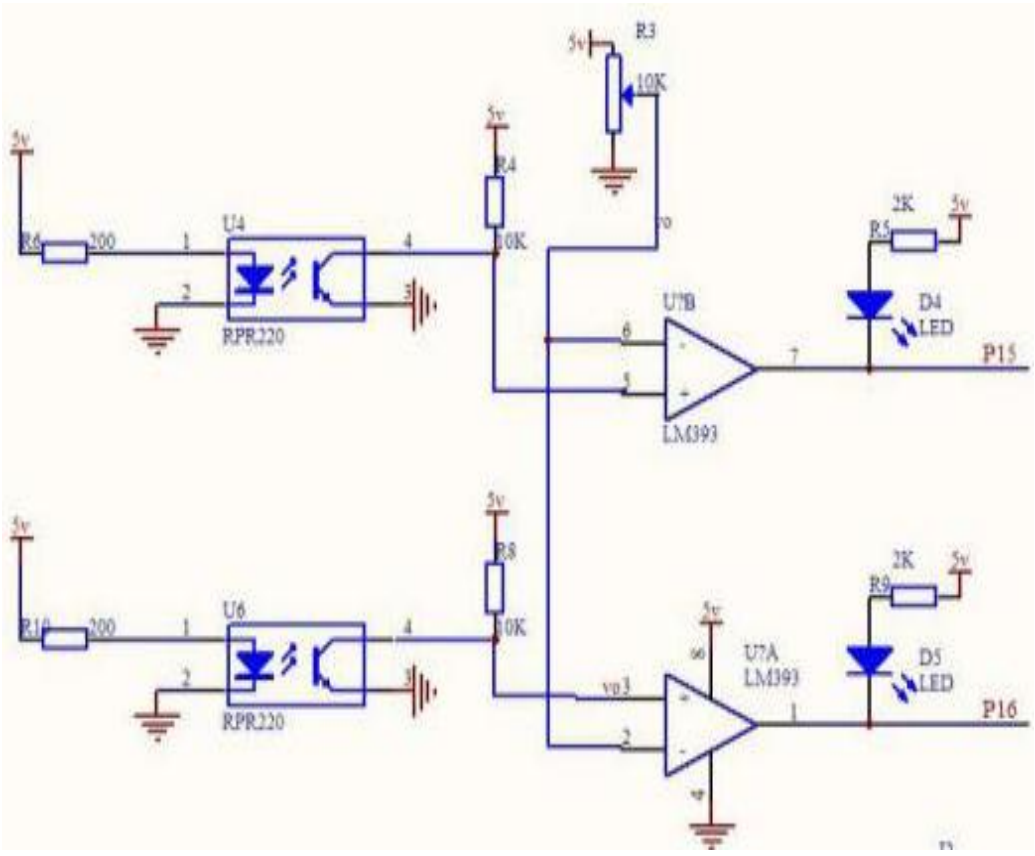

Fig. 5. Schematic diagram of photoelectric induction circuit.

The schematic diagram of photoelectric induction circuit is shown in Fig. 5. Two RPR220 sensors are parallel connected in the detection part. The four pins of RPR220 are connected to the positive input terminal of LM393, and the negative input terminal of LM393 is connected to a sliding rheostat. When RPR220 detects that light is incident, U4 voltage is about 0 V. The low level is output from the output terminal. Finally, the program is executed. On the contrary, the high level is output and the program is not executed [6].

D. *Temperature Sensing Circuit*

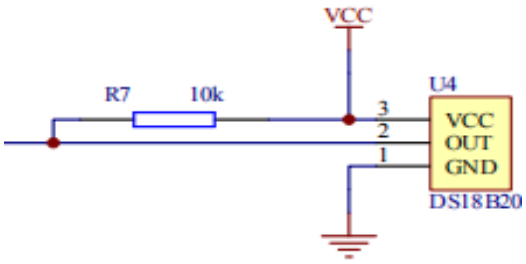

Fig. 6. Schematic diagram of temperature sensing circuit.

The schematic diagram of temperature sensing circuit is shown in Fig.6. The DS18B20 temperature sensor is used in the alarm part. The pin 2 is connected to the port P2.1 to complete the temperature detection.

E. *A/D Conversion Circuit*

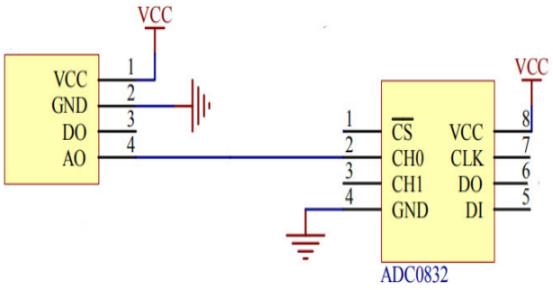

Fig. 7. Schematic diagram of A/D conversion circuit.

The schematic diagram of A/D conversion circuit is shown in Fig. 7. The ADC0832 is used in the alarm part. The output of smoke sensor is connected to CH0 port of ADC0832. When A/D conversion is completed, EOC is changed to high level. At this time, the conversion is ended and an interrupt is generated. In the interrupt service program, the converted data is sent to the designated storage unit [7]. Besides, the pin 1, 7 and 6 are connected to port P1.0, P2.0and P3.0 of the SCM, respectively. Thus, A/D conversion is completed.

F. *Voice chip circuit*

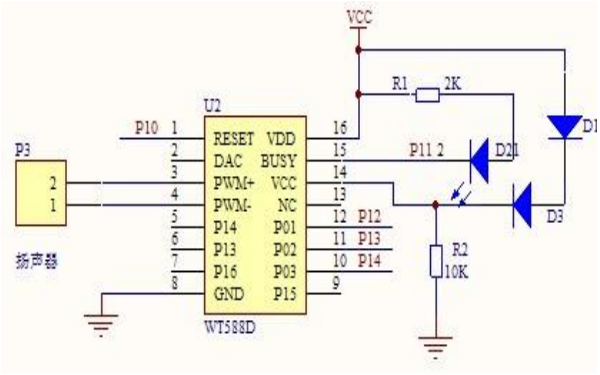

Fig. 8. Schematic diagram of voice chip circuit.

The schematic diagram of voice chip circuit is shown in Fig. 8. The WT588D is used in tin the detection part. Pin 1 is connected to the P1.0 port of the SCM. The reset function can be implemented. The pin 10, 11 and 12 are connected to P1.4, P1.3 and P1.2, respectively. Thus, voice playback and volume change are completed [8].

G. *Driving Motor Circuit*

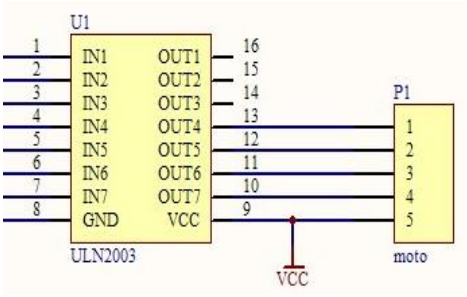

Fig. 9. Schematic diagram of driving motor circuit.

The schematic diagram of the driving motor circuit is shown in Fig. 9. ULN2003 is used in the detection part. Its pin 4, 5, 6, and 7 are respectively connected with the port P2.4, P2.3, P2.2, and P2.1 of the single chip microcomputer. These are used for data transmission between SCM and motor drive. Its pin 10, 11, 12, 13 are respectively connected with port 1, 2, 3 and 4 of the stepping motor. They are used to control the forward and reverse rotation of stepping motor. Its pin 9 is connected with the pin 5 of the stepping motor. The pin 8 are grounded [9] [10].

H. *Liquid Crystal Display Circuit*

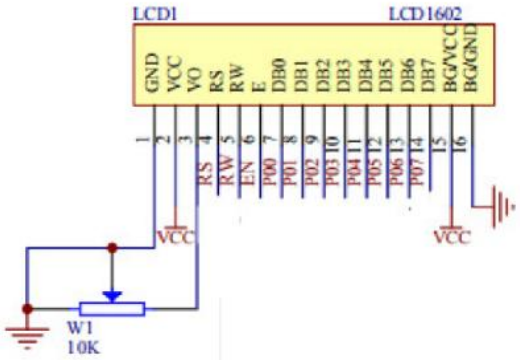

Fig. 10. Schematic diagram of liquid crystal display circuit.

The liquid crystal display circuit is shown in Fig. 10. The LCD1602 is used in the alarm part. It has 16 standard interfaces. The interfaces 4-14 are connected to corresponding ports of SCM. The 32 characters can be displayed at the same time [11].

I. *Sound and Light Alarm Circuit*

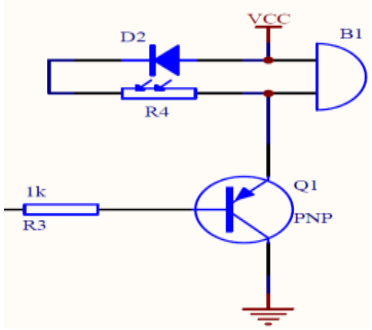

Fig. 11. Schematic diagram of sound and light alarm circuit.

The schematic diagram of sound and light alarm circuit is shown in Fig. 11. The base of the dynatron is connected to the port P1.7 in the alarm part. When the user system confirms that there is a fire, the low level is output, the PNP transistor is turned on, and the LED is illuminated.

J. *GSM Circuit*

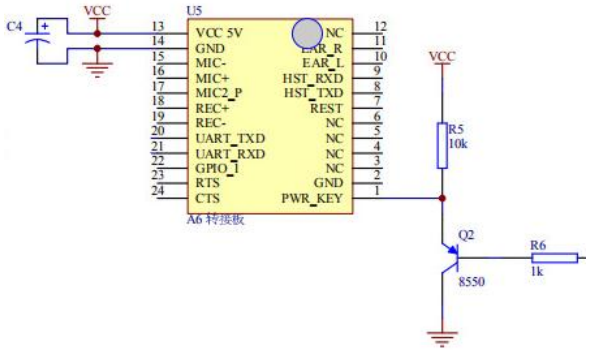

Fig. 12. GSM circuit schematic diagram

The Schematic diagram of GSM circuit is shown in Fig.12. SIM800C is used in the alarm part. The pin 20, 21 are connected to port P3.0, P3.1 of the SCM, respectively. When there is a fire, communication is generated between SIM800C and RXD port. Then text messages are sent to the reserved number via TXD port [12].

IV. System Software Design

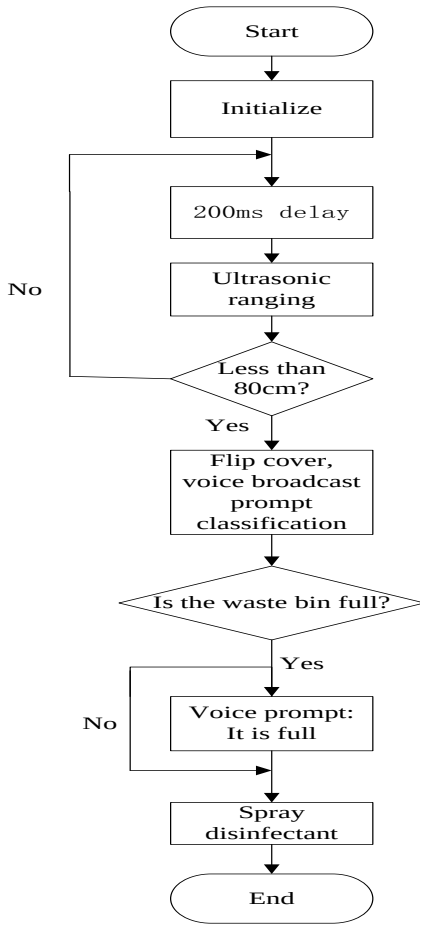

Fig. 13. Main program diagram of detection part.

The C language is used in software design [13]. The flow chart of the main program of the detection part is shown in Fig. 13. After power-on, the circuits are initialized by the system. In order to make the ultrasonic circuit measure distance normally, a delay of 200ms is set. After the delay is over, the timer starts to time. If the set time is reached, disinfectant will be sprayed. If the distance between the person and the waste bin is detected less than 80cm by ultrasonic, the stepping motor is rotated forward. At the same time, "Please classify waste placement" will be broadcasted. Once the capacity of the waste bin is reached, a reminder message will be given.

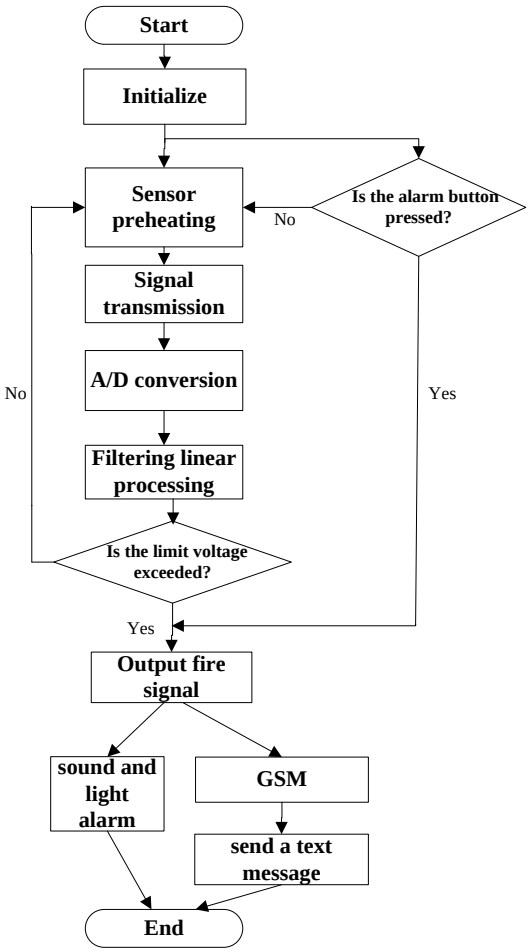

Fig. 14. Main program diagram of alarm part.

The main program flow chart of alarm part is shown in Fig. 14. The system will be initialized at the beginning to ensure the normal function of I/O port. -MQ-2 sensor is used in this part. Smoke and combustible gas can be detected. MQ-2 will be preheated for 1-2 hours before working. When preheating is completed, the detected signal is converted into a digital signal after a series of processing. If the alarm threshold is exceeded, the fire signal output by the single chip microcomputer will be transmitted to the audible and visual alarm and GSM communication circuits. Alarm reminders are sent to remind people to deal with them. Otherwise, it returns to the detection place and wait for the next signal.

V. SYSTEM FUNCTION DEMONSTRATION

According to the system schematic diagram, the physical objects are soldered on PCB, and the software and hardware tests are carried out. The physical drawings of the system are shown in Fig. 15 and 16 respectively.

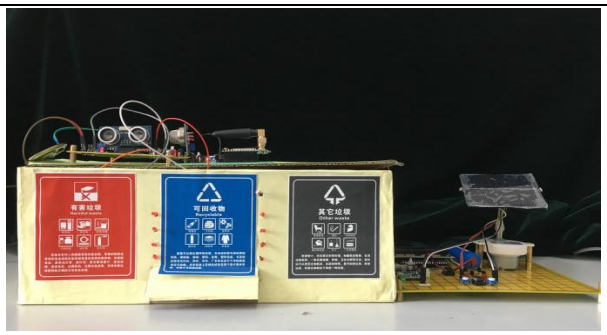

Fig. 15. Physical drawing (front).

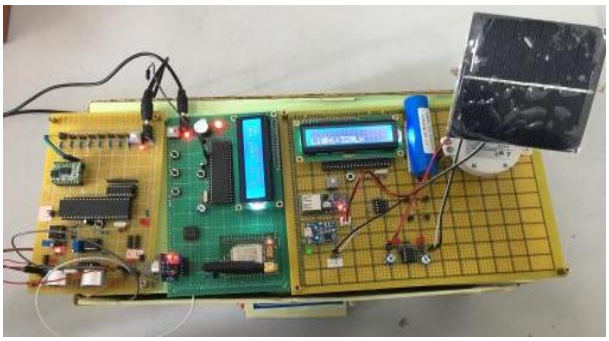

Fig. 16. Physical drawing (top view).

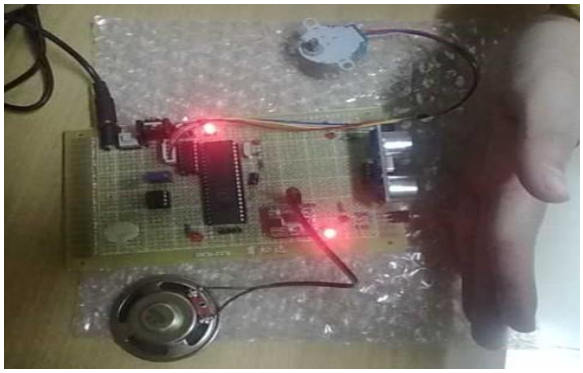

Fig. 17. Waste bin flip cover test chart.

The test results of waste bin flip cover are shown in Fig. 17. After the system is connected to 9V power supply, the system operation indicator is turned on. If the distance between the person and the waste bin is detected less than 80cm by ultrasonic, the stepping motor is rotated forward. At the same time, “Please classify waste placement” will be broadcasted.

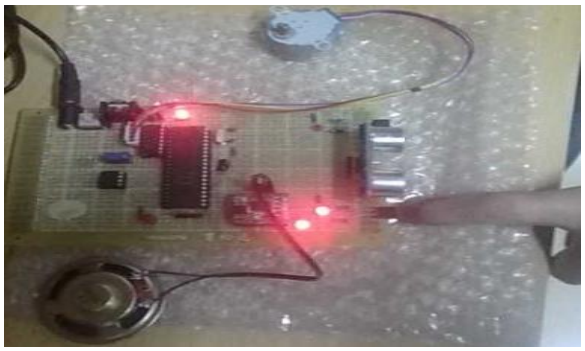

Fig. 18. Waste bin capacity test chart.

The test results of waste bin capacity test are shown in Fig. 18. In this design, two photoelectric sensors RPR220 are used. When they are covered by an object, the waste bin indicator lights are turned on, indicating that the capacity of the waste bins have reached the maximum and the voice circuit will indicate that the bin is full. At the same time, the diode will be illuminated regularly to indicate that the disinfectant is being sprayed. After the power is off, the working indicator light is off.

Fig. 19. Temperature and smoke test chart.

The test results of temperature and smoke are shown in Fig. 19. It can be seen that the temperature and smoke can be detected by sensors. When the temperature reaches 50℃ and the carbon dioxide concentration reaches 500PPM, the automatic alarm can be sent out for at least 10 seconds. In the whole sampling process, the maximum and minimum data are cleared. Then the remaining data are averaged. The influence of environment or other factors can be reduced by this way. The accuracy of temperature and smoke detection is guaranteed.

Fig. 20. SMS sending test chart.

The test results of SMS sending are shown in Fig. 20. GSM system is composed of control circuit and controlled circuit. The control circuit may be mobile phone, TC35I module or PC. In this design, TC351 is used in this system. When there is a fire in the waste bin, the fire alarm signal is received by GSM circuit and an alarm message will be sent to the reserved mobile phone number via GSM. The time of the fire can also be known.

VI. CONCLUSIONS

In this paper, an intelligent pro-environment waste bin is designed. The single chip microcomputer is proposed as the core, combined with voice circuit, driving motor circuit, ultrasonic circuit, photoelectric induction circuit, liquid crystal display circuit, sound and light alarm circuit and GSM circuit. The functions of automatic dumpster flap, surrounding environment detection, voice prompt, fire alarm and short message sending have been realized. In the latest researches, it rarely involves sending fire messages to mobile phones when waste bins are on fire, but this problem has been solved to some extent in this design. In order to solve the problems of waste pollution, the function of disinfectant is specially added. The function of environmental

protection is realized. The system protects the environment and has low price. At the same time, it has good intelligence, wide application range and great application prospect.

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