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Design of Smoke Alarm Disperser Based on Single-chip Microcomputer

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Abstract. With the rapid development of society and economy, various laboratories have become more complete in number and equipment, but subsequent laboratory accidents frequently occur. Therefore, it is imperative to construct a laboratory safety management system to ensure the safety of laboratory personnel and complete equipment. This article intends to design a smoke alarm, which mainly includes measuring the sensitivity of the smoke sensor to the concentration of smoke in the air, and the linear change of the sensor converting the corresponding analog signal into a digital signal. By designing the fan speed to be controlled by the change of smoke density, the speed of the motor is adjusted. And the alarm module can sound an alarm when the smoke concentration is certain, and at the same time, it can automatically cancel the alarm when the smoke concentration decreases. Finally, a simulation experiment is designed to simulate the effect of the sound alarm of the smoke alarm disperser on the dispersal of smoke under different working environments.

1. Introduction

With the development of science and technology, laboratory equipment and facilities have become more and more complete, but the safety performance of the facilities is still a major hidden danger in the laboratory, especially the safety accidents caused by improper operation of the laboratory, especially the laboratory fire and Explosion accidents are particularly frequent[1]. This project hopes to design a new type of smoke alarm device that can give out sound and light alarms when a fire occurs in the laboratory[2]. This research can inform the personnel to put out fire and evacuate the dangerous area in the early stage of fire, which can effectively reduce the casualties caused by fire.

Figure 1.Smoke sensor

The Design of smoke alarm disperser

The smoke alarm disperser is based on the smoke concentration signal collected by the smoke sensor and input into the single-chip microcomputer for analysis. When the smoke concentration is higher than the alarm threshold, it has an alarm and smoke dispersal function. Its components include: smoke signal collection circuit, Motor drive module circuit, analog-to-digital conversion circuit, Arduino microcontroller control circuit[3].

1.1. The Principle of MQ-2 Smoke Sensor

The main semiconductor component of the MQ-2 smoke sensor is tin dioxide. When tin dioxide comes in contact with smoke, it causes a change in surface conductivity[4]. When the smoke concentration becomes larger, the conductivity of the sensor increases, the output resistance becomes smaller, and the output analog voltage signal increases. Therefore, the output voltage analog signal can be used to indicate the level of smoke concentration in the environment.
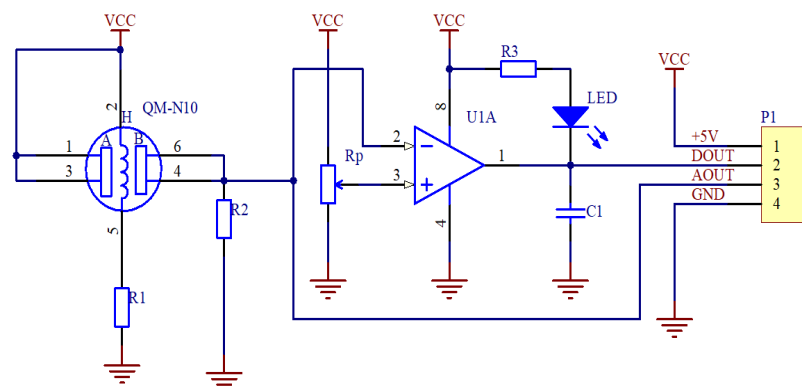

Figure 2.Schematic diagram of mq-2 smoke sensor circuit

This experiment scheme adopts the comparator circuit, in which the MQ-2 smoke sensor outputs analog signals into Pin 6 of the Arduino control board through the LM393 comparator digital tube. Pin 6 has an analog-to-digital conversion function, which can convert the input analog signals into digital signals[5].

1.2. The Working Principle of Smoke Alarm Disperser

In this paper, based on The Arduino microcontroller, MQ-2 smoke sensor is used to collect smoke concentration information and transmit it to the Arduino. The microcontroller itself is the voltage signal amplification module. Analog signals are converted into digital signals for analysis through analog-to-digital conversion, and the concentration of smoke is calculated[6]. When the smoke concentration value is higher than the alarm threshold, the buzzer gives an alarm, and the single-chip microcomputer controls the motor speed to drive the fan to rotate, so as to achieve the effect of dispersing the smoke. When the smoke concentration continues to increase and reaches a certain limit, the microcontroller controls the motor acceleration, so the fan speed increases, if the smoke concentration is still rising, the microcontroller controls the motor speed to reach the maximum, in order to achieve the effect of dispersive smoke; When the smoke concentration falls to the alarm threshold, the buzzer and motor stop working and return to normal[7].

2. The Hardware Setting of Smoke Alarm Disperser

This chapter mainly introduces the hardware settings of the smoke alarm disperser, especially the circuit analysis and characteristics of each functional module, and explains the working principles and related technologies of the buzzer, MQ-2 smoke sensor and motor fan module in the smoke alarm in more detail index[8].

2.1.Selection of MCU

In the design of this paper, the single-chip microcomputer is the core component of the entire smoke alarm disperser. First of all, it must meet the computing power and the number of external interfaces required by the smoke alarm disperser. At the same time, the overall model of the alarm is small. Reduce costs as much as possible in terms of calculation accuracy, stability, reliability and anti-interference.The single-chip microcomputer used in this paper is Arduino and software Arduino IDE.

2.2.Hardware Circuit Design of Smoke Alarm Disperser

Buzzers are generally divided into two types: active buzzers and passive buzzers. Compared with passive buzzers, active buzzers are easier and more convenient to operate. At the same time, they can send out sound source signals with prompt frequencies. , So it can meet the requirements of the design scheme. Since the output of the Arduino UNO control board is a DC signal, an active buzzer is selected to sound an alarm when the smoke concentration is higher than the alarm threshold.

The motor speed is controlled by the PWM signal, so as long as the speed range of 0~1023 is input to the IA pin, the speed can be controlled. In the design of this paper, the smoke density analog signal in the environment is read through the Arduino single-chip microcomputer, and the smoke density is converted into an electrical signal through the A/D analog-to-digital conversion circuit. The corresponding interval of the smoke density is [0,1023].

The MQ-2 smoke sensor outputs an analog voltage signal through the LM393 comparator, and inputs the signal into the Arduino single-chip microcomputer. Especially the ADC analog-to-digital conversion module of the single-chip microcomputer converts the analog signal into a digital signal. For the single chip microcomputer to analyze the data to determine whether the existing alarm conditions are met.
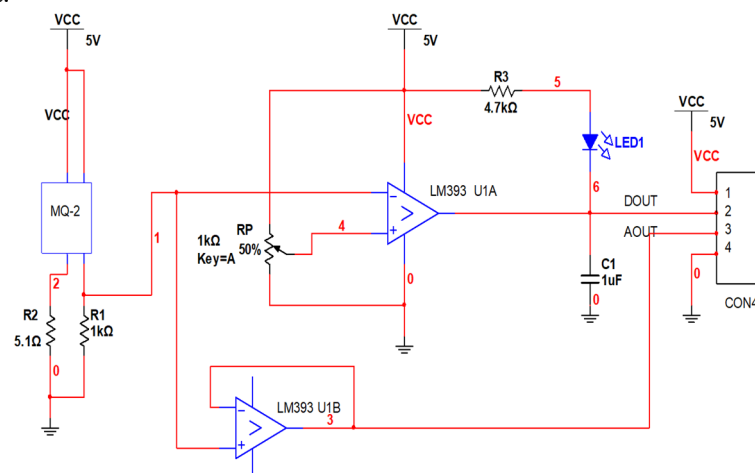

Figure 3. MQ-2 smoke sensor comparator circuit

For the schematic diagram of the MQ-2 smoke sensor circuit, LM393U1A is used as a comparator to compare the analog voltage input by the Rp sliding rheostat and the analog voltage input by MQ-2, U1A outputs high and low levels; LM393U1B is used as an operational amplifier, adding In the negative feedback link, the magnification is 1, which is used to follow the voltage and play a certain buffering effect[9].

3. Software Design of Smoke Alarm Disperser

This chapter mainly describes the software design of the smoke alarm disperser, mainly the introduction of the development environment ArduinoIDE and the design of the program flow chart. When the smoke alarm disperser responds to different smoke concentrations, the single-chip microcomputer adjusts the PWM wave to control the motor speed through data analysis, so as to

achieve the purpose of controlling the speed of the electric fan, ensuring that the speed of the electric fan in the environment can be adjusted independently according to the ambient smoke concentration[10].
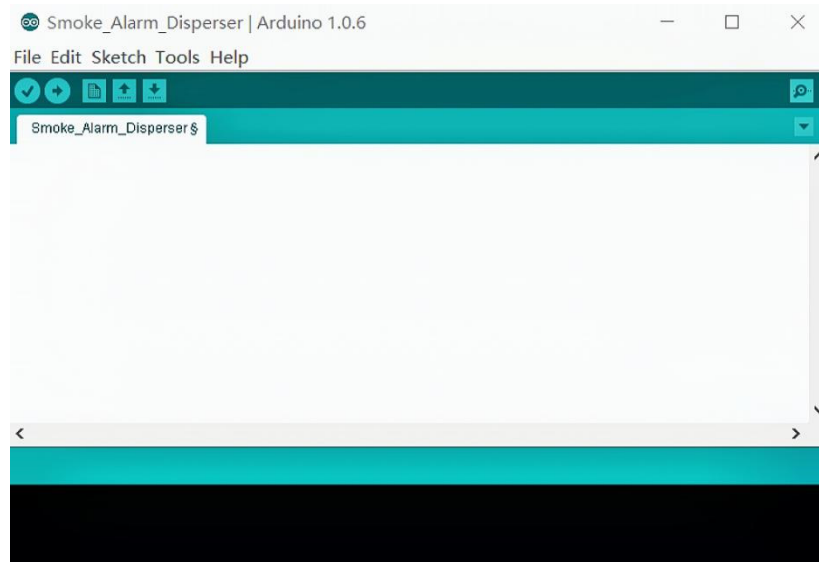

Figure 4. Arduino development environment

Arduino series MCU debugging and R&D tools：The software programming of this system adopts ArduinoIDE software, built-in open source Simple I/O interface version, and has a Processing/Wiring development environment similar to Java and C language. The main language of the Arduino core library is C language, and the latest Arduino core library is written in a mixture of C/C++.

Through the program initialization, MQ start work - 2 type smoke sensor, acquisition environment of smoke concentration and enter into the Arduino microcontroller, through the ADC modulus conversion, the smoke concentration corresponds to the voltage analog signal is converted to facilitate analysis of digital signal, through processing compared with alarm threshold, in order to judge whether the smoke concentration exceeds the alarm threshold, If the threshold is exceeded, an acoustic alarm should be issued and the motor should be started to control the fan to disperse the smoke, so as to achieve the purpose of reducing the smoke concentration[11].

4. Experimental Verification
This experiment mainly uses the Arduino control board, MQ-2 smoke sensor, buzzer and motor fan dispersing module to realize the simulation of the smoke alarm disperser[12]. For the smoke produced by the proposed cigarette, the speed threshold of the fan, the concentration threshold of the MQ-2 smoke sensor and the change of the fan speed at different concentrations are measured.

4.1. The relationship between fan speed and Arduino input voltage
The experiment mainly verified the sensitivity threshold of the MQ-2 smoke alarm, the minimum speed and maximum speed that the fan can reach, and the relationship between the fan speed and the digital input of the Arduino control board.
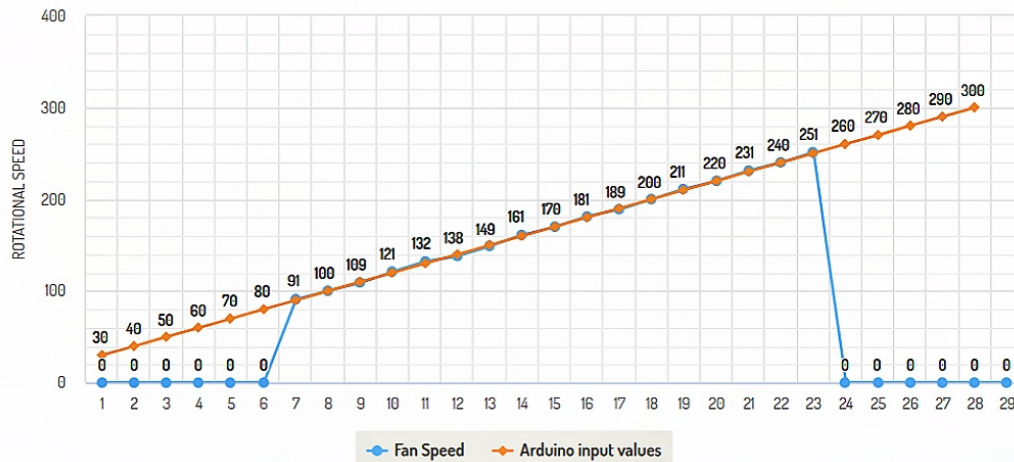
Figure 5. The relationship between the fan and Arduino input voltage.

Through the above data, we carry out corresponding mathematical analysis and draw the following conclusions:

1. There is a certain area for the speed of the fan driven by the motor. The minimum and maximum speeds of the motor correspond to 90 and 270 of the digital signal respectively.

2. The fan speed and the motor speed change in a linear relationship. At the same time, the higher the motor speed, the faster the fan speed.

4.2. Smoke concentration signal collection

Through the design, the smoke alarm disperser is measured in a smoke-free environment. As a calibration value, the experimental results can tell that, under normal circumstances, the smoke concentration collected by the smoke sensor is 255~275.When the paper is ignited, the concentration detected by the smoke sensor is indefinite between 285 and 310. When the toilet paper is gradually burned sufficiently, the concentration of smoke gradually increases. At this time, the concentration detected by the smoke sensor is indefinite between 350 and 400.
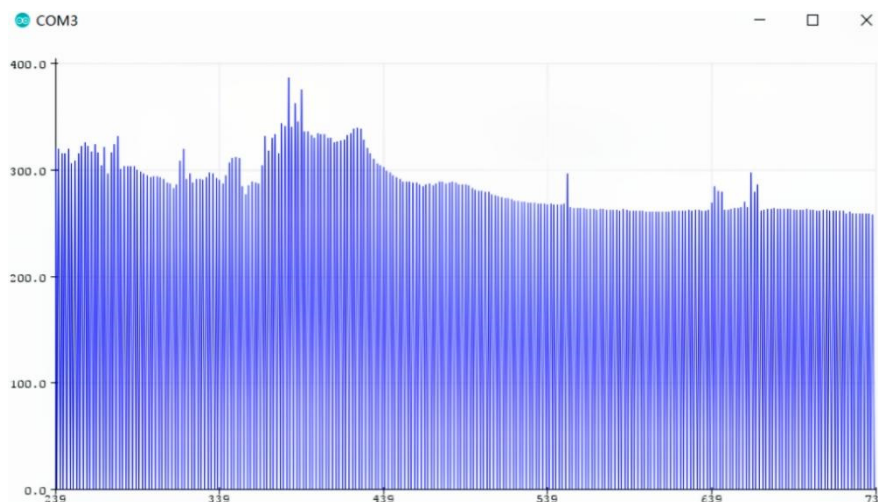

Figure 6. Smoke sensors measure the concentration of paper when it ignites

According to the chart drawn by the serial port plotter, it can be seen that when the concentration continues to rise, the motor speed increases, and the dispersing ability is strengthened. After a certain period of time, the concentration gradually decreases, which has a certain effect of dispelling smoke.

5. Conclusion

The research and design content of this paper is based on the Arduino microcontroller to add smoke sensor module, motor fan module, sound and light alarm module design, so that in a certain sealed environment, when the smoke reaches a certain concentration, it can timely send sound and light alarm, start the steering gear, control the fan wind speed, and achieve the alarm and disperse function. For the smoke alarm dispeller, as long as the smoke concentration reaches a certain concentration value, the alarm will be issued, can not have according to the different gas to set the corresponding alarm threshold for some low concentration harmful to the human body can not be detected in time. Next, we hope to combine fire extinguishing devices with wireless communication modules.

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