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Design of Environmental Monitoring and Alarm System Based on Microcontroller

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Abstract: ***With the development of society, the improvement of science and technology, and the continuous optimization of production and life, people's living standards are also constantly improving. Therefore, people are starting to pay more and more attention to the comfort level of indoor environment. Housing is not only a place for family reunion and living, but also an important material guarantee for people's lives. However, with the rampant use of decoration materials and the increasing popularity of daily necessities, the hidden dangers of the living environment have greatly increased. Indoor environmental pollution has become one of the serious killers affecting modern human health, seriously affecting people's production and life. Therefore, it is particularly important to monitor the indoor environment, which not only needs to sensitively detect the concentration of various harmful gases, but also has an alarm function to constantly remind of dangers. The main functions of this design include: Connecting the microcontroller with temperature, humidity, and gas sensors to achieve real-time collection and reading of indoor temperature and humidity values, as well as monitoring gas concentration, and achieving the expected results. The display circuit was designed using LCD. The buzzer alarm function was used to automatically alarm when the gas concentration and temperature/humidity values exceeded the set standard values. When the temperature and humidity exceed the limit, the LCD display can immediately prompt and combine with LED alarm. When the gas concentration exceeds the limit, LED alarm is used.***

Keyword: Microcontroller; Sound and light alarm; LCD display circuit; Indoor environmental monitoring.

1. INTRODUCTION

With the development of society, science and technology, the optimisation of production and life, people's standard of living is also improving, so people also began to pay more and more attention to the indoor environment and the degree of comfort. Residence is an important material security of people's life, but also the family reunion and production of life places, people's health and indoor environmental quality has an inseparable relationship. Temperature and humidity changes in different seasons will also affect human health. Each season of the year, temperature and humidity will change, with the temperature and humidity change frequency is not the same more or less will have a certain impact on people's health. U.S. researchers have shown that: suitable for human health temperature range is 18.5℃ - 23.6℃, the health of the humidity range is 45% - 65% RH, if in this kind of1 If you live in this kind of indoor environment, the cellular activity in the human body will have a certain increase, compared with the polluted environment, it also makes people mentally happy, the human body life longer. When the humidity of the air is lower than 42.6%RH, the metabolism of the human bronchial and mucous membrane tissue cells will slow down, which poses a great threat to the safety of people's lives. When the humidity of the air exceeds 63.7% RH, the human body will secrete too much pineal hormone, which will inhibit the secretion of growth hormone and thyroid hormone in the body, so that the receptor proteins will be reduced and the regulation will be disturbed, at the same time, people will feel mentally unstable and weak. This shows that the research on indoor environmental monitoring devices is of great significance. In foreign countries, due to the rapid development of society, with relatively developed environmental testing technology, the results of scientific research is relatively mature, so the relevant instruments in the research and development of the importance of the use of all widely spread. Although China's research on environmental monitoring system started late, indoor detection technology and foreign advanced technology, is still relatively backward, the gap is still very large, in terms of sensors, can not achieve intelligent, its products have not been used in large quantities, but to the developed countries to learn from the spirit of the developed countries has always been unshakable, a lot of manufacturers or research institutes are learning and the introduction of foreign advanced environmental monitoring technology programmes. In summary, the content studied in this design has great theoretical significance and important practical use value.

2. OVERALL PROGRAMME DESIGN

2.1 Justification of design options for each module

2.1.1 Selection and justification of microcontroller modules

Scheme 1: Select AT89C51 as the main control chip, it is a high-performance CMOS 8-bit microprocessor with 4K bytes of FLASH memory with low voltage, with programmable and erasable functions. In the memory can also be three levels of fast program lock, 32 I / O interface, can be applied to the serial channel mode, two 16-bit timer and the same number of counters, 128 * 8-bit internal RAM, low power consumption and power-down specific modes, five interrupt control source, the chip contains an oscillator and send out pulses of the clock circuit.

Scheme 2: Select AT89S52 as the main control chip, it is a low-power, high-performance CMOS 8-bit microcontroller with 8K system programmable Flash memory. It includes 32-bit I/O port lines, watchdog timer has reached the real-time monitoring function, with 256 bytes of RAM, three counters and the same number of 16-bit timer, there are also 2 data pointers.AT89S52 can also be reduced to 0Hz state for programming, can provide 2 kinds of software can be in the microcontroller can be performed in the power-saving mode operation. When the CPU is in idle operation, it is not running, but the support RAM, timer/counter, and interrupts can continue to run. When the microcontroller is in power-down mode, the internal data of RAM is stored, the oscillator stops working, and all the functions of the microcontroller are in a sleep state until the next interrupt signal arrives or the reset command is executed, and the microcontroller starts to work again.

Comparison of the two microcontrollers: AT89S52 can be used not only for ISP in line function but also for parallel programming, compared to AT89C51 which can only be used for parallel programming. In terms of calculation speed, AT89C51 running frequency is only 24MHz, while AT89S52 limit running frequency up to 33MHz. from the output programming voltage can be seen, AT89S52 only 4-5V, while AT89C51 not only to support the normal operation of the work of the 5V but also need to be powered by the Vpp 12V. Therefore, the choice of AT89S52 microcontroller.

2.1.2 Temperature and humidity monitoring module selection and justification

Option 1: Use independent components to connect the circuit. The temperature sensor LTC2996 and humidity sensor TC623CEOA together connected to the microcontroller, from the microcontroller display module to read the parameter values sent to the display circuit. Using this method of composition of the circuit is very troublesome, programming is more difficult, and many components in the welding process operation is prone to errors, debugging is a little more complex, and at the same time greatly increase the cost of connecting the circuit.

Programme 2: The temperature and humidity sensor DHT11 connection circuit composed of digital acquisition technology and temperature sensor technology is used. It has good practicality and solidity, the effective temperature range is 0 ~ 50 ℃, the measurement accuracy is 5%, the humidity range is 20%RH ~ 90%RH, very suitable for the needs of the system. DHT11 signal transmission distance of at least 20m, is with a single bus data transmission, is conducive to a variety of MCU for connection. The DHT11 has a voltage range of only 3.3 to 5.5V DC, a resolution of 1% RH humidity and 1℃ temperature, long-term stability, complete interchangeability and ultra-low power consumption.

In summary, Option 2 is not only simple to operate and low cost, but also greatly reduces external interference with the system and has a high measurement accuracy. The digital sensor essentially simplifies the system's procedures and reduces the utilisation of space. Can be read directly from the microcontroller after the A/D converter signal transformation output of digital signals. Therefore after analysis and comparison, the second option is adopted.

2.1.3 Gas monitoring selection and justification

Option 1: Choose catalytic combustion sensor. It is a combustible gas in the air through the catalytic combustion of the sensor to detect the proportion of its concentration in the air to reach the ignition point of the explosion. The sensor is through the chemical reaction so that the resistivity of the metal surface changes to form a Whisden detection bridge. When the air contains flammable gas in contact with the detection element, the gas rapid flameless combustion, and produce heat, with the increase in heat the resistance of the metal surface gradually increases, from the bridge will produce a voltage signal, the voltage signal strength and the detected concentration of flammable gases is proportional to. Its advantages are: good stability, short response time, high sensitivity, low error rate, controllable performance, and a service time of about 3 years.

Option 2: Choose gas sensor MQ-5 to connect the circuit. The material it chooses is SnO_2 with large resistance, and its working principle is that the chemical reaction of combustible gases on the surface of SnO_2 makes the resistance change with it, so as to achieve the purpose of monitoring.The reason why SnO_2 sensor can be valued by a lot of scientific researchers is that it is able to operate in a low-temperature environment, its performance is relatively more stable, and the detection range is wider and other characteristics.

After comparing the two solutions, the combustible gas sensor MQ - 5 is easy to operate, powerful and economical, more suitable for home use.

In summary, this design uses the semiconductor type sensor MQ - 5.

2.2 Overall programme selection

The system is based on the AT89S52 microcontroller as the core, through the connection of the A/D module, the role of the temperature and humidity sensor signal processing module, temperature and humidity of the automatic alarm function, LCD1602 display and microcontroller control and other parts of the system to achieve the desired results. Through the sensor to detect the indoor combustible gas concentration, temperature and humidity values, and the detected data and the set value comparison, if greater than the preset value of the alarm module to start, if less than the preset value does not start. Thus, it realises the function of processing the data of temperature and humidity, concentration of combustible gas, etc., and connects with the sound alarm system to display the detected data of temperature and humidity on LCD1602, so that people can deal with it in time. The flow chart is shown in Figure 1 below:

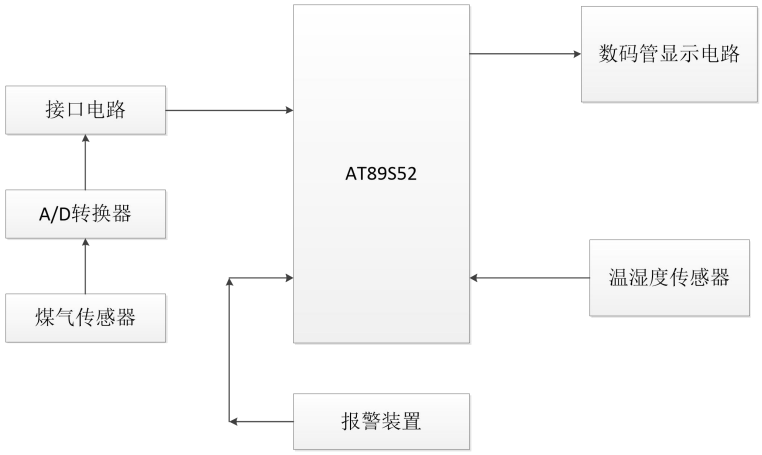

Figure 1

3. UNIT MODULE DESIGN

3.1 Temperature and humidity detection module design

The DHT11 is a comprehensive sensor that integrates digital acquisition with a temperature and humidity sensor and can accurately transmit the signal to a microcontroller, and its technical parameters are shown in Table 1.

Table 1: Temperature and humidity sensor DHT11 Technical parameters

Parameter name	Technical condition	Parameter name	Technical condition
Supply Voltage	3.3-5.5V DC	exports	Single bus digital signal
Measurement range	Temperature 1-50 ℃ Humidity 20-90% RH	Measurement accuracy	Humidity ±5%RH Temperature ±2℃
resolution (of a photo)	Humidity 1%RH, humidity 1℃	interchangeability	completely interchangeable
long term stability	<±1% RH/year		

The development of this module provides an important guarantee for people's home environment detection, which contains the characteristics of durability, stable working performance and low supply voltage. Very easy to connect the circuit of the single-wire serial interface, long-lasting use, super stability, so that the DHT11 for all types of environments, in a similar module has its own unique advantages, it is the use of a single-row pin package technology. the DHT11 and the AT89S52 connectivity as shown in Figure 2.

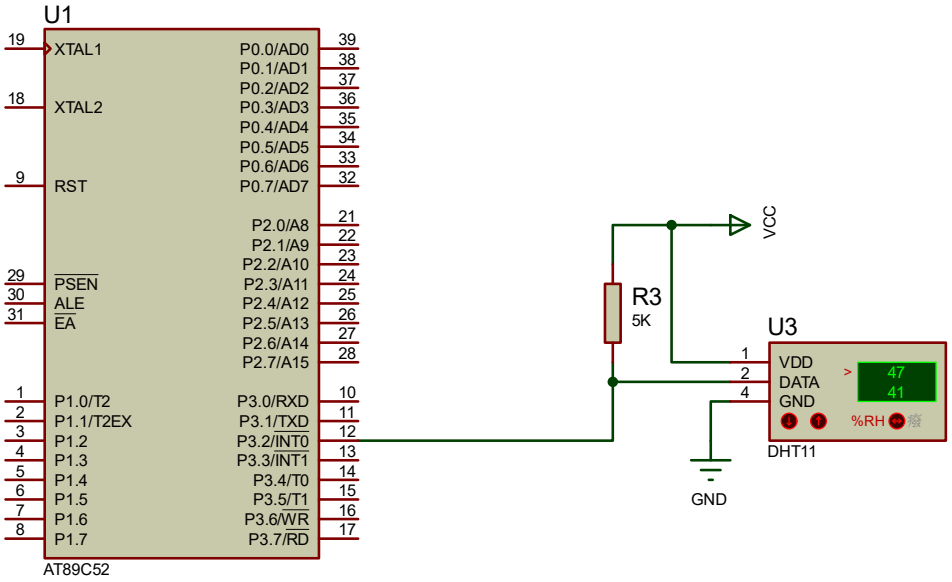

Figure 2: DHT11 and AT89S52 wiring diagram

3.2 Gas monitoring module design

MQ-5 Sensor The construction mainly consists of a miniature AL2O3 ceramic tube, a SnO_2 sensitive layer and a small heater. The finished gas sensitive component has 6 pins, 4 pins on it are used to receive the signal and the remaining 2 pins output current through the heater.The MQ-5 data are shown in Table 3.2 and Table 3.3.Gas sensors of the type MQ are made of highly reactive metals whose oxides are obtained through a series of chemical reactions to form a semiconductor material.The change in the resistance of the MQ-5 is realised by this process. When conditions permit, the sensor can also be used as a reducing agent, where the negatively charged semiconductor under these conditions undergoes a general chemical reaction that reduces the oxygen on the surface of the semiconductor to such an extent that the potential energy on the surface of the conductor decreases, thus lowering the resistance of the sensor. At the right gas concentration, the resistance value of the sensor is nearly inversely proportional to the gas concentration and can be expressed by the following formula:

$$RS = A[C]^{-\alpha} \tag{1}$$

Where: Rs-sensor resistance;
A - constant;
[C] - gas concentration;
α - Slope of the curve.

MQ-5 sensor contact with combustible gases, it will immediately respond to the combustible gases through the sensor into an electrical signal, through the signal amplifier to amplify the signal to the A/D converter, the signal through the converter to convert the signal into a digital signal, and finally send the signal into the microcontroller internal, and then by the microcontroller to send commands for the next step in the operation. Specific wiring as shown in Figure 3.

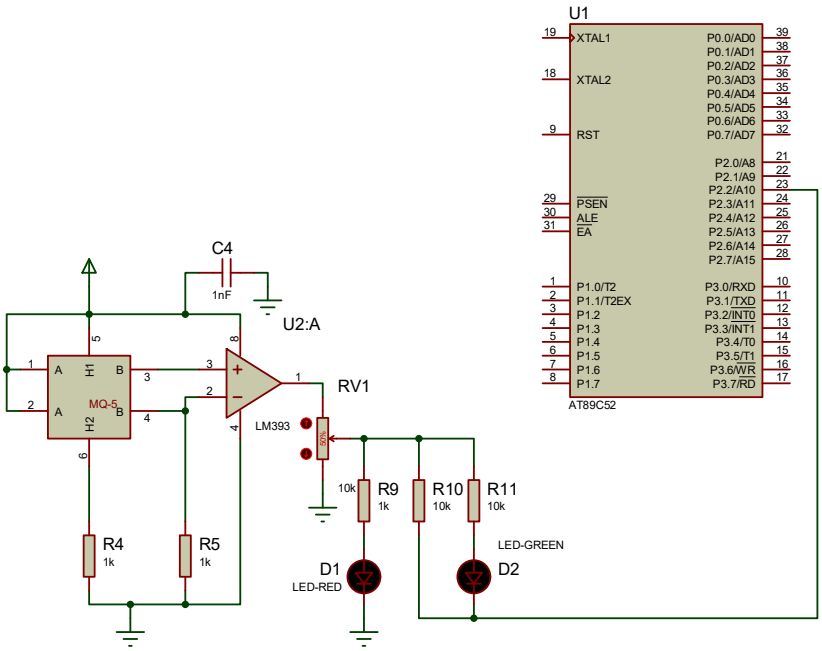

Figure 3: MQ-5 Sensor Connected to ADC0832 Converter

3.3 Display circuit design

The microcontroller is used to control the LCD1602 display, and the maximum value of temperature and humidity is controlled by pressing the key. If a change in temperature and humidity is detected, the LCD display immediately makes corresponding changes to achieve the purpose of real-time display. The circuit diagram is shown in Figure 4.

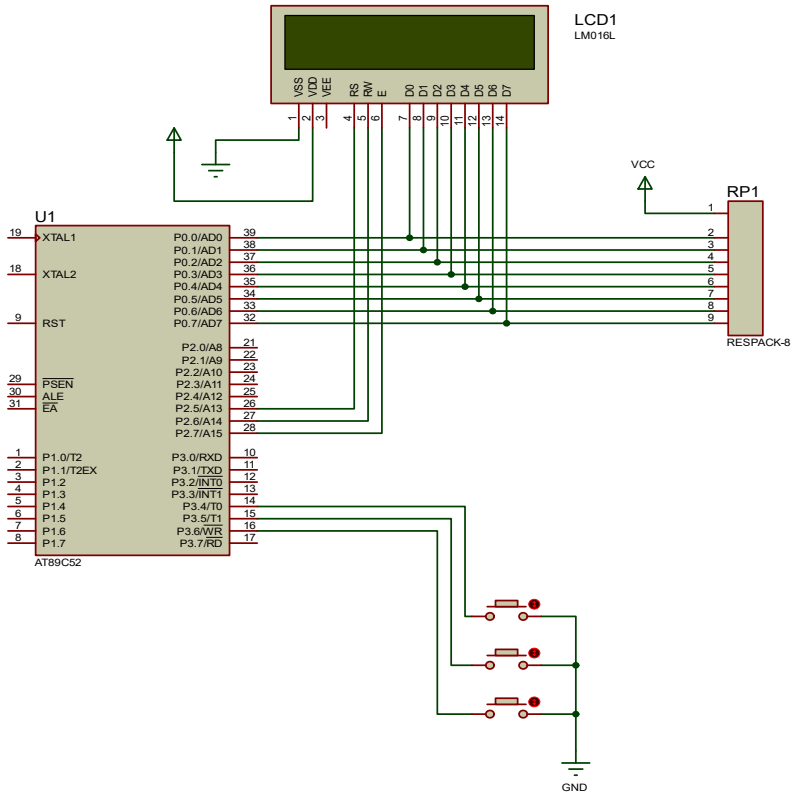

Figure 4: Microcontroller Display Circuit

3.4 Alarm Module Design

The acoustic alarm function is controlled by pin P1.5 of the microcontroller and the buzzer realises the acoustic alarm function. As the temperature and humidity value is greater than the preset value, the pin gets a high level signal and the VT tube conducts, which makes the buzzer conductive. The acoustic alarm circuit diagram is shown in Figure 5.

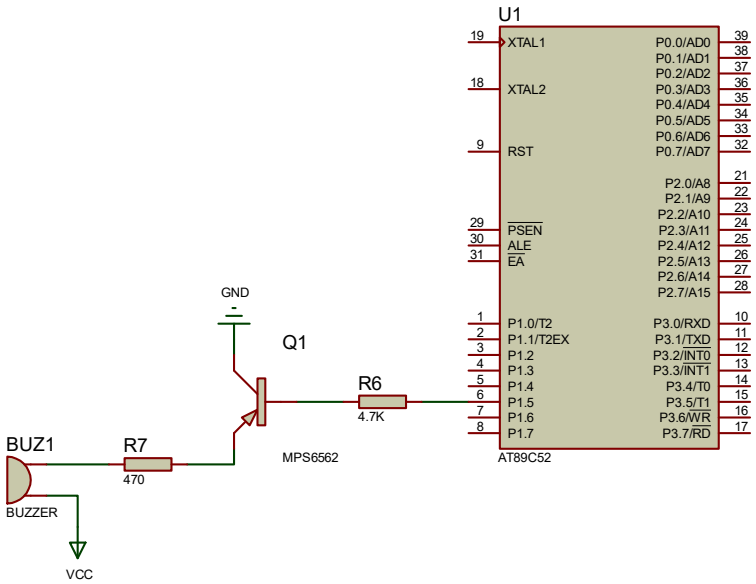

Figure 5: Alarm Module

3.5 AT89C52 Microcontroller Reset Circuit

A reset command is when the processor returns to the start state and then executes the start command again. When the RES pin gets a command with a low input from the processor, the processor immediately enters the reset state until the next time the RES pin gets a high command from the processor, and the processor can continue to run. This is shown in Figure 6.

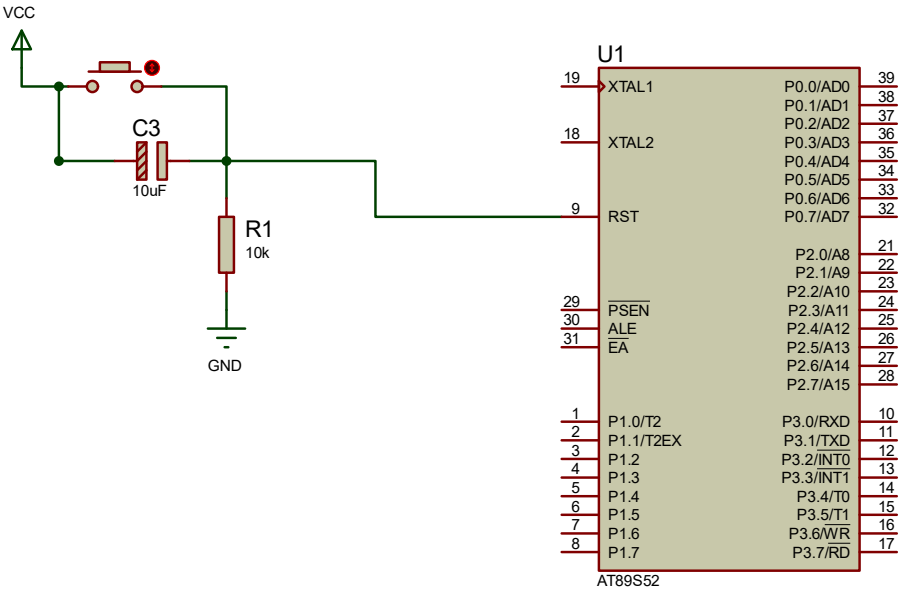

Figure 6: Microcontroller reset circuitry

3.6 Master Control Module

This design selects AT89C52 microcontroller as the main control element, AT89C52 is an 8-bit general-purpose microprocessor, adopting the industry-standard C51 core, which is the same as the general-purpose 8xc52 in terms of internal function and pin layout, and is mainly used for the function control of convergence adjustment. Functions include the initialisation of internal registers, data RAM and external interfaces of the convergence master IC, convergence adjustment control, convergence test map control, IR remote control signal reception and decoding and communication with the motherboard CPU. The main pins are: XTAL1 (pin 19) and XTAL2 (pin 18) are oscillator input/output ports with external 12MHz crystals; RST/Vpd (pin 9) is a reset input port with external resistor/capacitor reset circuit; VCC (pin 40) and VSS (pin 20) are power supply ports connected to the positive and negative terminals of the +5V power supply, respectively; P0~P3 are programmable general-purpose I/O pins whose functions are determined by the software; P0~P3 is a general-purpose I/O pin whose function is determined by the software; P0~P3 is a general-purpose I/O pin whose function is determined by the software. P0~P3 are programmable general-purpose I/O pins whose functions are defined by the software. In this design, the P0 port (pins 32~39) is defined as the N1 function control port, which is connected to the corresponding function pins of the N1, pin 13 is defined as the IR input, pins 10 and 11 are defined as the I2C bus control ports, which are connected to the N1's SDAS (18 pins) and SCLS (19 pins) ports, respectively, and pins 12, 27 and 28 are defined as the handshake signal function ports, which are connected to the positive and negative ends of the +5V power supply, respectively. Pin 12, pin 27 and pin 28 are defined as handshake signal function ports, which are connected to the corresponding function terminals of the CPU of the motherboard, and are used for the detection of the current standard and the control function of the convergence adjustment state entry. The pin diagram is shown in Figure 7.

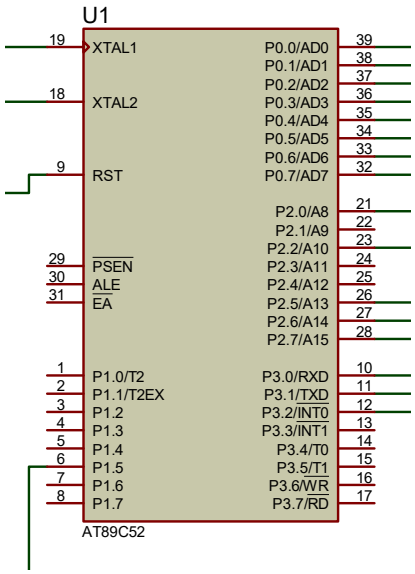

Figure 7: AT89C52 pinout diagram

The functions of each pin of the microcontroller AT89C52 are shown in Table 2:

Table 2: AT89C52 Pin Function Description

Pin number	Pin Name	Function
1	P2.0	External interrupt 0 input, T0 count input
2	P2.1	External interrupt 1 input, T0 count input
3	P2.2	T0 count input, T0 count/overflow output
4	P2.3	T0 count output, T1 count input, ISP program download/reset control pin
5	P2.4	T1 count output, ISP data download/reset control pin
6	P2.5	On-board LED indicators
7	P2.6	UART1 transceiver data output, ISP program/data download data input
8	P2.7	UART1 transceiver data input, ISP program/data download data output
9	RST	On-chip reset, external reset

10	P3.0	TXD1 serial port data output
11	P3.1	RXD1 serial port data input
12	P3.2	TXD2 serial port data output
13	P3.3	RXD2 serial port data input
14	P3.4	External interrupt 2 input
15	P3.5	External interrupt 3 input
16	P3.6	External interrupt 4 input, T1 count/overflow output
17	P3.7	External interrupt 5 input, reset pin
18-20	VCC	Supply Positive
21-23	GND	Structural particle: used before a verb or adjective, linking it preceding the verb or adjective
24	P1.0	OE output enable control pin
25	P1.1	WR write control pin
26	P1.2	RD read control pin
27	P1.3	ALE address latch signal output
28-35	P0.0-P0.7	parallel port data bus (computing)
36	XTAL1	External Crystal Input
37	XTAL2	External Crystal Output
38	P1.4	Analogue input/comparator positive input
39	P1.5	Analogue input/comparator negative input
40	P1.6	Comparator Output

4. SOFTWARE DESIGN

4.1 Programming Language Selection

C is one of the most widely used programming languages in the world, it can directly control the computer, but also covers most of the advantages of the programming language, its structure is rich and varied, more convenient to use, the language syntax is simple, the program structure is clear, can be used for a variety of programming platforms to adapt to a stronger.

4.2 Programming process

4.2.1 Temperature and humidity measurement module

Corresponding to the design of the temperature and humidity measurement circuit, the software module is designed to convert the actual value sensed by the DHT11 sensor into a digital signal through the microprocessor for A/D conversion and display it on the digital tube. Comparing this value with the preset value, if the set value is between 10 and 24 degrees Celsius, there is no alarm; if it is outside this range, the red diode lights up and the alarm circuit is activated. If the measured value obtained from the next monitoring is within this range, the diode alarm circuit will stop working.

The microprocessor sends out a start signal and the DHT11 is switched on from the low power mode to the high speed mode. After the main controller has completed the start signal, the temperature and humidity sensor sends out the 40bit data, and at the same time opens up the acquisition circuit, which is adjusted automatically to return to the low power mode when the data acquisition is finished. In the interaction between the microprocessor and the temperature and humidity sensor, the bus is kept at a high voltage, and the main controller reduces the voltage to wait for the response from the temperature and humidity sensor. This is shown in 8.

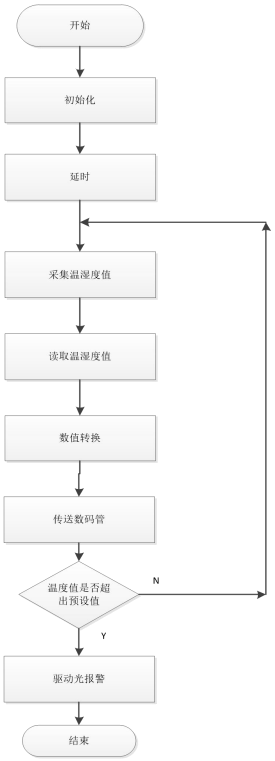

Figure 8: Flowchart of temperature and humidity measurement module

4.2.2 Gas monitoring module

If the gas concentration exceeds the preset value, the microprocessor AT89S52 converts the digital quantity into analogue quantity through the CHO pin, triggering the light alarm system When the gas concentration is lower than the set value, the light alarm program stops working. The flowchart is shown in Figure 9 below.

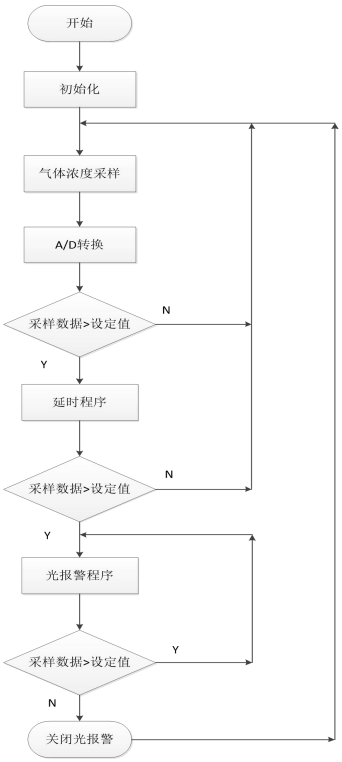

Figure 9: Gas detection module

5. SYSTEM COMMISSIONING

5.1 Introduction to the software

Proteus software is an EDA tool software published by Lab Centre Electronics in the UK. It not only has the simulation function of other EDA tools, but also can simulate microcontroller and peripheral devices. It is a better tool for simulating microcontroller and peripheral devices. Although the promotion of domestic just started, but has been by the microcontroller enthusiasts, engaged in the teaching of microcontroller teachers, dedicated to the development and application of microcontroller science and technology workers favour.

Proteus is the UK's famous EDA tools (simulation software), from the schematic layout, code debugging to the microcontroller and peripheral circuit co-simulation, a key to switch to the PCB design, the real concept from the concept to the product of the complete design. Is the world's only circuit simulation software, PCB design software and virtual model simulation software three-in-one design platform, the processor model supports 8051, HC11, PIC10/12/16/18/24/30/DSPIC33, AVR, ARM, 8086 and MSP430, etc., and in 2010 added Cortex and DSP series processors, and continues to add other series of processor models. In terms of compilation, it also supports various compilers such as IAR, Keil and MATLAB.

5.2 Simulation test results

Through the AT89S52 control, temperature and humidity sensor DHT11 measured data, and finally in the LCD1602 display to show the final value, and the MQ-5 sensor has a detection of gas and alarm function.

The LED display module will display the information in real time after the sensor detects the information, in the simulation test to simulate the sensor detects the information of an environment, the display module test information obtained is shown in Figure 10.

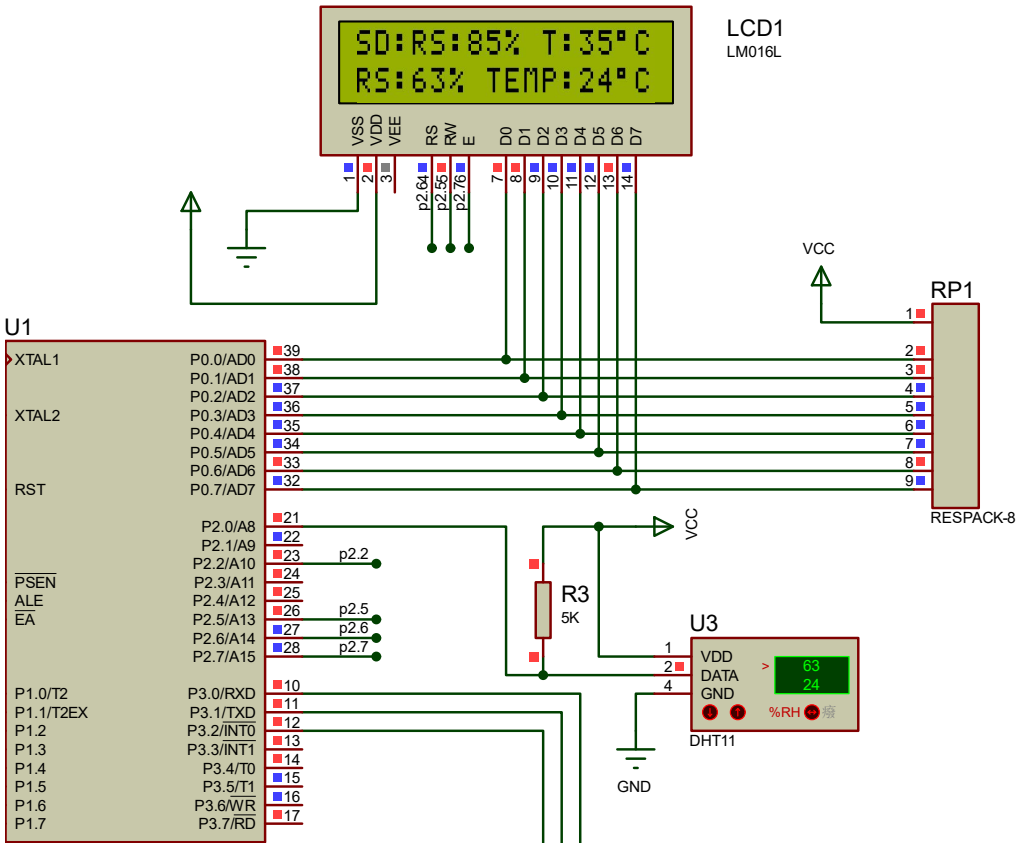

Figure 10: Test data

If the sensor detects that the temperature, humidity or combustible gas concentration in the environment exceeds the set upper limit the LED will light up red and the buzzer will produce a continuous beep. The simulation test results are shown in Figure 11.

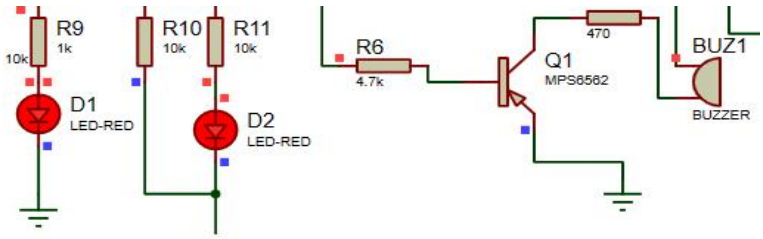

Figure 11: Audible and visual alarm module simulation

6. INDICATOR PARAMETERS FOR EACH COMPONENT

DHT11 is a digital acquisition and temperature and humidity sensor integration, and can accurately transmit the signal to the microcontroller comprehensive sensor, its technical parameters are shown in Table 3.

Table 3: Temperature and humidity sensor DHT11 Technical parameters

Parameter name	Technical condition	Parameter name	Technical condition
Supply Voltage	3.3-5.5V DC	Exports	Single bus digital signal
Measurement range	Temperature 1-50˚C Humidity 20-90% RH	Measurement accuracy	Humidity ±5% RH Temperature ± 2℃
Resolution (of a photo)	Humidity 1% RH Humidity 1˚C	Interchangeability	Completely interchangeable
Long term stability	<±1% RH / year		

The MQ-5 sensor parameters are shown in Table 4 and 5.

Table 4: MQ-5 Standard Working Conditions

Notation	Parameter name	Technical condition	Note
VC	Circuit voltage	≤ 15 V	AC or DC
VH	Heating voltage	5.0 ± 0.2 V	AC or DC
RL	Adjustable load resistance		
RH	Heating Resistance	31Ω±3Ω	
PH	Heating power consumption	≤900m VV	

Table 5: MQ-5 Sensitivity Characteristics

Notation	Parameter name	Technical parameters	Note
Rs	Sensitive body resistance	10 KΩ - 60 KΩ (1000ppm methane)	Detection range: 300-5000ppm liquefied gas, natural gas, gas
α	Concentration slope	≤0.6 (R1000ppm/R500ppm)	
Standard working conditions	Temperature, humidity	20℃±2℃; 65%±5%RH	
	Standard Test Circuit	Vc:5.0V±0.1V VH: 5.0V±0.1V	
	Preheating time	Not less than 48 hours	

7. CONCLUSION

With the development of society, science and technology to enhance the production and life of the continuous optimisation of people's living standards are also continuously improved, so people have begun to pay more and more attention to the indoor environment of the degree of comfort. Residence is not only a place for family reunion

and life, but also an important material protection of people's life, whether people's health and indoor environmental quality has an inseparable relationship, we know that temperature and humidity and harmful gas concentration is an indispensable parameter to calibrate the environment, and its accurate measurement is of great significance. This paper is designed for the indoor air quality of people's long-term residence or workplace. In addition to realising the monitoring of multiple indoor gases as well as temperature and humidity monitoring, it also has an acoustic alarm function. This paper comprehensively utilises the technology of microcontroller, sensor and LCD display to complete the design of each function and systematically introduces the design method of hardware and software.

(1) This paper combines microcontroller and sensing to achieve the collection and reading function of ambient temperature and humidity as well as the alarm function of gas concentration, which achieves the expected detection effect.

(2) The design of the display circuit was completed using LCD digital tubes.

(3) Using the buzzer alarm function, when the gas concentration value and temperature and humidity value exceed the set standard value, to achieve automatic alarm function.

(4) When the temperature and humidity exceed the limit, LCD display can immediately prompt and combined with light-emitting diode alarm, when the gas concentration exceeds the limit using light-emitting diode alarm.