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Design of Portable Air Quality Detector

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Abstract

This article takes STC89C52 as the core and designs a portable intelligent air quality Detector. With the detecting of toxic and dangerous gases in the indoor air as the background, it can realize the real-time acquisition, processing, display, and alarm of indoor temperature and VOC gas. Function. The instrument uses LCD screen to display menus and has a good man-machine dialogue interface. At the same time, the sound and light alarm system is designed to realize timely alarm when the parameters exceed the standard. The indoor intelligent air quality Detector is small in size, low in power consumption, and simple in operation. It is suitable for medical and health care in homes and communities, and can know the quality of indoor air in real time.

Keywords

Air Quality Detection; Man-machine Interface; VOC Gas.

1. Introduction

The quality of air reflects the degree of air pollution, which is judged based on the concentration of pollutants in the air. The discharge of man-made pollutants is one of the most important factors affecting air quality. The types of air quality testing include decoration pollution, office air monitoring, workplace hazardous substances monitoring, canteen oil fume testing, boiler air and industrial kiln testing, and factory emission industrial waste gas testing.

This design mainly researches and designs an "air quality detector" system based on quantitative detection. This system aims to realize early warning and monitoring of indoor air temperature, gas, and smoke, which is conducive to comprehensive evaluation of indoor air quality and creates a healthy environment for humans. Indoor living space. The air quality detector is small in size, low in power consumption, and simple in operation. It is suitable for medical and health care in families and communities, and can know the quality of indoor air in real time.

2. Working Principle

The indoor portable intelligent air quality detector studied in this paper is based on STC's 8-bit ultra-low power single-chip STC89C52 as the control core. The harmful gas in the indoor air outputs a voltage signal corresponding to the gas concentration through the sensor. The signal is converted into a digital signal by an A/D conversion circuit at a certain sampling frequency and sent to the single-chip microcomputer for data collection for display processing. The sensor is directly connected with the microcontroller. The single-chip computer performs digital processing on the sampled value and drives the liquid crystal display to respectively display the VOC gas concentration and temperature in the indoor air under test. If the concentration of VOC gas in the tested indoor air exceeds the national standard or the set dangerous value or the temperature exceeds the set range, the alarm circuit will send out an audible and visual alarm signal.

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3. The Minimal System Design of STC89C52 Single-chip Microcomputer

With the development of computer technology, single-chip microcomputers are used in many fields such as process control, data acquisition, mechatronics, intelligent instrumentation, household appliances, and network technology due to their high integration, small size, fast speed, and low price. It is widely used, which greatly improves the technical level and automation in these fields. According to the above aspects and the actual situation of this subject, the selection of the single-chip microcomputer model is mainly considered from the following two points: one is to have a strong anti-interference ability; the other is to have a higher cost performance. Due to the high versatility and excellent stability, this system uses the low power consumption and high performance CMOS 8-bit microcontroller STC89C52 produced by Macro Crystal as the controller. The chip contains 4k bytes of system-programmable Flash read-only program memory. It integrates Flash program memory which can be programmed online (ISP) or can be programmed with traditional methods and a general 8-bit microprocessor in a single chip. It can provide many cost-effective applications and can be flexibly applied to various control fields.

The minimum system of the single-chip microcomputer is composed of a clock circuit and a reset circuit.

3.1 Clock circuit module

The clock circuit consists of a crystal oscillator 11.0592MHZ and two 30pF ceramic capacitors. The clock circuit is used to generate the clock signal required for the work of the single-chip microcomputer, and the timing study is the relationship between the signals in the execution of the instruction. The one-chip computer itself is like a complicated synchronous sequential circuit, in order to guarantee the realization of synchronous working mode, the circuit should work strictly under the control of the only clock signal. The circuit is shown in Figure 1:

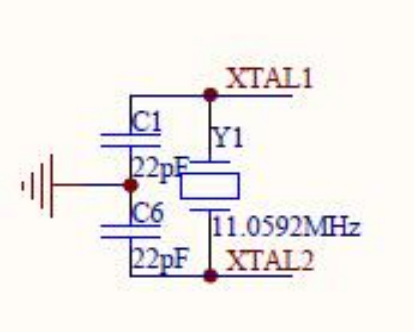

Figure 1. Clock circuit module

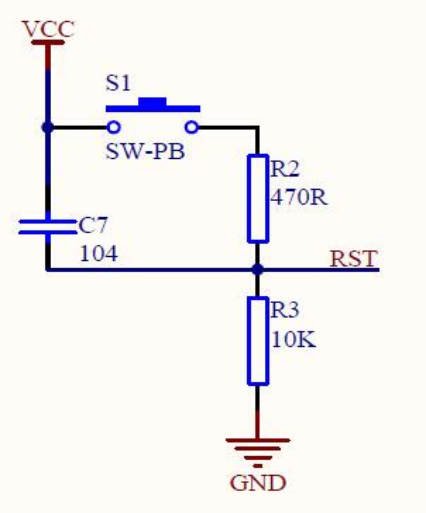

Figure 2. Reset circuit module

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3.2 Reset circuit module

The reset circuit is to make the CPU or other parts of the system in a certain initial state, and start working from this state. In addition to entering the normal initialization of the system, when the system is in a deadlock due to a program operation error or an operation error In order to get rid of the predicament in the state, it is also necessary to press the reset circuit to restart. This design uses a button reset circuit. The circuit is shown in Figure 2.

4. Sensors

4.1 Gas sensor

4.1.1 Basic knowledge of gas sensors

According to the gas sensitivity characteristics, gas sensors are mainly divided into: semiconductor type, electrochemical type, solid electrolyte type, contact combustion type, photochemical type and other gas sensors, and the former two are the most common.

Based on the real-time requirements and cost-effectiveness of this article, this system selects the constant-potential electrolytic gas sensor in the electrochemical sensor.

4.1.2 Introduction to MQ-2 sensor

The gas-sensitive material used in the MQ-2 gas sensor is tin dioxide (SnO2) with low conductivity in clean air. When there is combustible gas in the environment where the sensor is located, the conductivity of the sensor increases with the increase of the combustible gas concentration in the air. Using a simple circuit, the change in conductivity can be converted into an output signal corresponding to the gas concentration. MQ-2 gas sensor has high sensitivity to liquefied gas, propane and hydrogen, and it is also ideal for the detection of natural gas and other combustible vapors. This sensor can detect a variety of flammable gases and is a low-cost sensor suitable for a variety of applications.

When the temperature is 200~300°C, tin dioxide adsorbs oxygen in the air, forming oxygen negative ion adsorption, which reduces the electron density in the semiconductor, thereby increasing its resistance value. When in contact with smoke, if the barrier at the crystal grain boundary is modulated by the smoke and changes, it will cause a change in surface conductivity. By using this, information about the existence of this kind of smoke can be obtained.

When encountering combustible smoke (such as CH4, etc.), the originally adsorbed oxygen is desorbed, and the combustible smoke is adsorbed on the surface of tin dioxide semiconductor in the state of positive ions; the desorption of oxygen releases electrons, and the adsorption of smoke in the state of positive ions also releases electrons, So that the electron density of the conduction band of the tin dioxide semiconductor increases, and the resistance value decreases. When there is no smoke in the air, the tin dioxide semiconductor-will automatically restore the adsorption of oxygen negative ions, increasing the resistance value to the initial state. This is the basic principle of the MQ-2 combustible smoke sensor to detect combustible smoke.

4.2 Temperature Sensor

The read and write sequence and temperature measurement principle of DS18B20 are the same as DS1820, but the number of digits of the temperature value obtained is different due to different resolutions, and the delay time during temperature conversion is different. The oscillation frequency of the low temperature coefficient crystal oscillator is little affected by temperature, and is used to generate a fixed frequency pulse signal and send it to the counter 1. The crystal oscillator with high temperature coefficient changes its oscillation rate obviously with temperature, and the generated signal is used as the pulse input of counter 2. Counter 1 and the temperature register are preset to a base value corresponding to -55°C. Counter 1 counts down the pulse signal generated by the low temperature coefficient crystal oscillator. When the preset value of counter 1 decreases to 0, the value of the temperature register will increase by 1, the preset of counter 1 will be reloaded, and counter 1 will restart. Count the pulse signals generated by the low temperature coefficient crystal oscillator,

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and loop until the counter 2 counts to 0, stop the accumulation of the temperature register value, at this time the value in the temperature register is the measured temperature.

5. Analog-to-digital conversion circuit design

The signal from the gas sensor is an analog signal, and the microprocessor STC89C52 can only process digital signals, so it is necessary to convert the analog signal into a digital signal that the processor can recognize, due to the range of analog voltage changes from the test circuit In the range of 0~5V, the ADC0809, which is more cost-effective, is selected for analog-to-digital conversion. Its pin definition is shown as in Fig. 3.

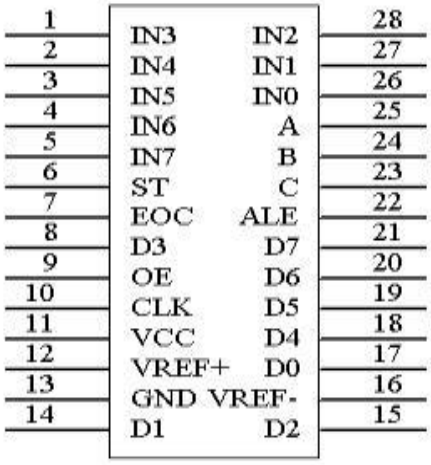

Figure 3. Schematic diagram of ADC0809 pin

ADC0809 requires the input analog quantity: the signal is unipolar, the voltage range is 0-5V, if the signal is too small, it must be amplified; the input analog quantity should remain unchanged during the conversion process, if the analog quantity changes too fast, it needs Add sample and hold circuit before input. The timing interface of ADC0809 is the standard bus interface of the 51 series single-chip microcomputer, which is easy to operate. Like the memory or I/O operation, the A/D conversion accuracy is 8 bits, which meets the requirements of this subject. The input analog voltage is 0~5V, and an A/D conversion time is 100μS.

6. Sound and light alarm circuit design

In order to make the monitoring of indoor air quality more intuitive by this system, an audible and visual alarm circuit composed of 2 light-emitting diodes and a buzzer is adopted as shown in Figure 4. When the temperature exceeds the limit, the D1 light will be on and the buzzer will alarm, and when the dangerous gas content exceeds the standard, the D2 light will be on and the buzzer will alarm.

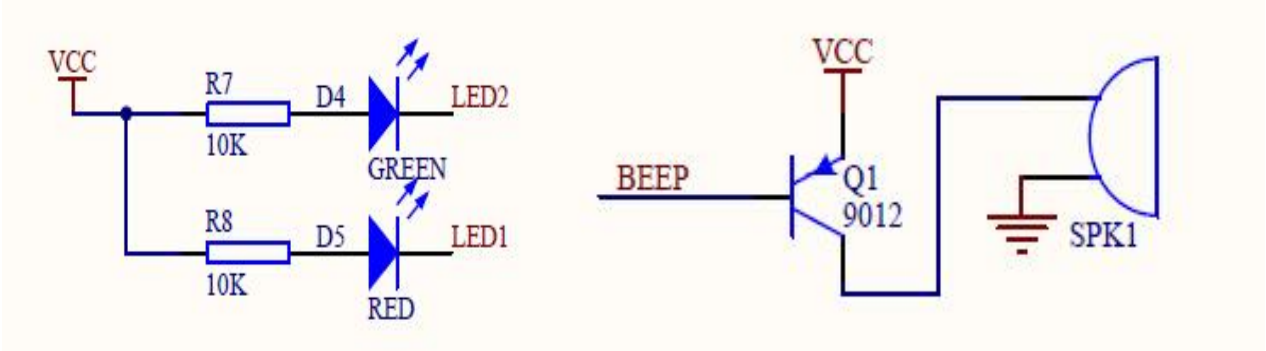

Figure 4. Sound and light alarm circuit

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7. Liquid crystal display circuit design

There are two data to be displayed in this design, which are the concentration of toxic gas and the indoor temperature range and measurement value. Therefore, the LCD1602 with 2 lines and 16 characters is selected as the display module to meet the display requirements. The liquid crystal display module has the characteristics of small size, low power consumption, and rich display content. Now the character liquid crystal display module is the most commonly used information display device in the application design of the single-chip microcomputer.

The main display circuit designed this time uses LCD1602 as the display module this time, and its interface circuit is shown in Figure 5.

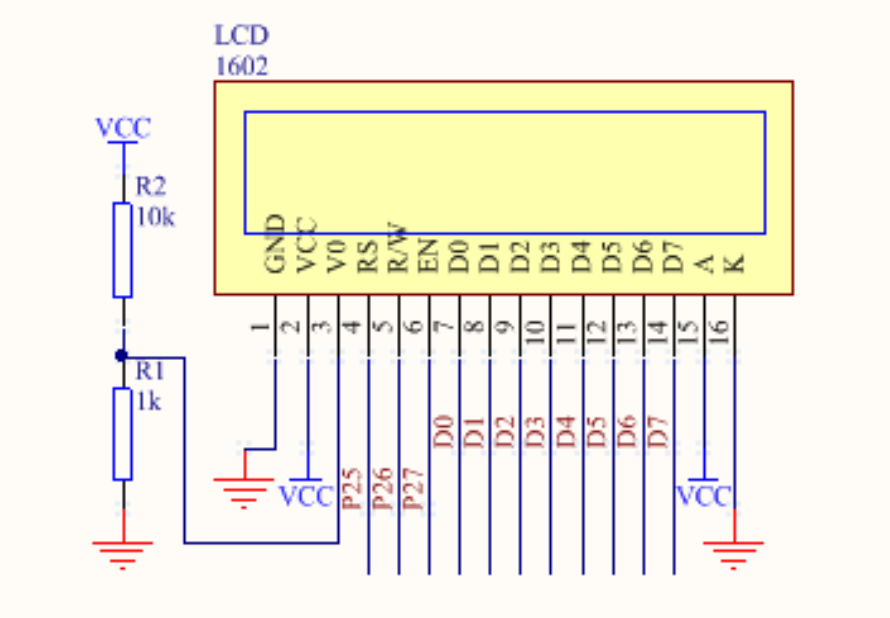

Figure 5. LCD1602 and MCU interface circuit

The general initialization process at work is:

Delay 15mS

Write instruction 38H (do not detect busy signal)

Delay 5mS

Write instruction 38H (do not detect busy signal)

Delay 5mS

Write instruction 38H (do not detect busy signal)

Every subsequent write instruction, read/write data operation needs to detect the busy signal

Write instruction 38H: display mode setting

Write command 08H: display off

Write command 01H: display clear screen

Write instruction 06H: display cursor movement setting

Write command 0CH: display on and cursor setting

8. Power circuit design

This design uses an integrated voltage regulator 7805, C2 and C5 are input and output filter capacitors respectively, and D1 is a freewheeling diode. When the output current is large, the 7805 should be equipped with a heat sink. The power supply circuit is shown in Figure 6:

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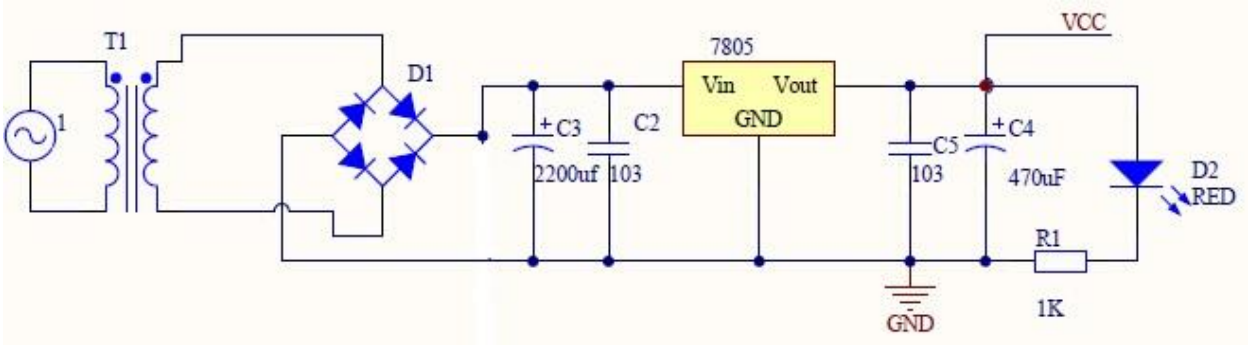

Figure 6. Power circuit

9. Conclusion

This design first introduces the hardware structure and system functions of the portable indoor air quality detector. The instrument uses the 8-bit single-chip STC89C52 as the control core, designs and builds the hardware platform of the system, and completes the harmful gas concentration signal acquisition and conversion circuit and liquid crystal display. Design of circuits, sound and light alarm circuits, etc. The instrument can realize the functions of toxic gas concentration signal and temperature signal acquisition and display, as well as over-standard sound and light alarm. This chapter focuses on the design and working principle of the signal acquisition analog circuit and the digital circuit centered on the main controller. First, it discusses the selection of sensors in the toxic gas acquisition module, and finally discusses the peripheral interface circuit modules of the system, including liquid crystal display, sound and light alarm, etc., and realizes the hardware interface design of each peripheral interface circuit module and STC89C52.

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