Design of Gas Early Warning System Based on Bluetooth Technology

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Abstract. Gas alarm has now become a kind of home necessary products, but most gas alarms on the market integrate concentration monitoring and alarm functions in one part, mainly installed in the kitchen. For people who rest in the bedroom, they cannot be informed of the danger in time, which may lead to serious consequences. Taking this hidden danger into account, a warning system that can simultaneously alarm the kitchen and the bedroom was designed. The system uses Bluetooth technology as the communication basis with two STC89C52 single-chip microcomputers as the CPU to realize the function of delivering the concentration information obtained by the kitchen to the bedroom, and thus achieve the sound and light alarm in multiple positions.

1. Introduction
Gas explosion and gas poisoning accidents caused by gas leakage have been plaguing people for many years. There are two main reasons for the accidents: users forget to close the valve or fail to close it properly; gas pipelines and cylinder aprons are prone to aging. It is inevitable for people to forget to close the valve or not close tightly, and the damage of pipelines and steel rings can also not be inspected and repaired in time under most circumstances. Therefore early warning of gas leakage becomes the most reasonable method to adopt.

The design of gas alarm has undergone three generations of changes. At present, the popular intelligent alarm devices in the market are mainly based on the single chip computer as the core, with typical peripheral integrated chips and separation components as the rest parts [1]. But these alarms also have some problems. For example, most alarm devices and sensors are concentrated together and can only be used in the kitchen to alarm. For people who rest in the bedroom at night, it is likely that the alarm sound will not be heard because the door is closed. There are also some alarm apparatus that transmit information based on Wi-Fi wireless communication modules, but Wi-Fi consumes a lot of power, which is too expensive for a system that needs real-time monitoring and transmission. Considering the close distance between kitchen and bedroom in common residential houses, Bluetooth is chosen as the wireless communication tool in the gas warning system with two STC89C52 microcontrollers, aiming to alarm in both kitchen and bedroom to improve the alarm effect.
2. Design scheme of the pre-warning system
The system consists of concentration acquisition module, MCU (single-chip microcomputer) control module, Bluetooth transmission module, and acousto-optic alarm module and power supply circuit. Considering the gas leak when people are not at home, a remote communication module can be added to transmit the alarm information to the owner's mobile phone. The architecture of the whole system is shown in figure 1. Firstly, the concentration signal is collected by gas sensor and converted into electrical signal. Then the electric signal is input into the AD conversion module, and the digital signal after conversion is transmitted to the MCU I installed in the kitchen. The information processing is completed here, and the level of gas concentration is judged, then the corresponding alarm instructions are sent out to OLED display screen and buzzer. At the same time, the single-chip I also transmits digital information to the single-chip microcomputer II in the bedroom through Bluetooth. The MCU II performs the similar tasks as the MCU I.

If the situation of people not at home is need to take into account, a remote communication module, such as GSM and Wi-Fi, can be appended in the system to send alarm signals to remote places. When the danger level is reached, the system will start the remote communication module and send information to people's phones to achieve higher security early warning.

![Figure 1. Block diagram of system structure](image)

3. System composition
The alarm function of the system has a great relationship with the selection of system components. And the following is a detailed description of the selection of components and the connection between modules.

3.1. Selection of Gas Sensor and A/D Conversion Circuit
At present, there are three main types of household gas: natural gas (mainly composed of \(CH_4\)), liquefied petroleum gas (LPG) and water gas (mainly composed of \(H_2\) and \(CO\)). Monitoring gas leakage is mainly to monitor these kinds of gas. According to the requirements of surveillance, MQ-9 gas sensor is selected in the design of this system. It is suitable for detecting the concentration of LPG, \(CO\) and \(CH_4\). And it has the excellent characteristics of large detection range and high sensitivity. With \(SnO_2\) as the sensitive layer component, MQ-9 also has good stability and can be used for almost 5 years. At the same time, the power consumption is very low, no more than 0.34W.

The working principle of the MQ-9 gas sensor is to convert the detected gas concentration signal into an analog voltage signal as output. When the gas concentration increases, the output voltage of the gas sensor will correspondingly rise. And its sensitivity can be adjusted by changing the potentiometer [2].
Since the output is an analog quantity, only in virtue of the A/D conversion circuit to convert the voltage signals into digital signals can it be received by the microcontroller. This system uses the PCF8591 conversion module to achieve this function. PCF8591 is a low power 8-bit CMOS data acquisition device integrated on a single chip and powered separately. It has 4 analog inputs and realize DAC gain with one analog output. As shown in Figure 2, the four analog input ports are A1N0, A1N1, A1N2, and A1N3 respectively, and AOUT is the analog output port. However, in this system, the connection between MQ-9 and AD module can be realized by using only one input port. P3 is the port group used to connect with MCU, where SDA is the data line and SCL is the clock line. When SCL is in high level, SDA jumps from high level to low level, and transmits data to the single chip. Correspondingly, SDA jumps from low level to high level and ends the transfer when SCL is in high level. In this way, the data can be transmitted to the single chip computer one by one.

![Figure 2. Partial schematic diagram of AD conversion module](image)

### 3.2. Selection and Function of Single Chip Microcomputer

Two microcontrollers are required in this system. The MCU I connected to PCF8591 needs to further process the collected information, compares it with the system setting alarm threshold, then makes an instruction on whether to alarm. It also further transmits the information to the next-level MCU. The MCU II located in the bedroom judges whether to issue an alarm instruction according to the data sent by the MCU I. When choosing MCU, it is necessary to reduce power consumption and save cost as far as possible on the premise of ensuring the sensitivity and reliability of the system.

In this design, we use STC89C52 MCU. This kind of single-chip microcomputer with low power consumption and good stability is a microcontroller produced by STC Company. It uses the classic CS-51 kernel [3]. Its functions are: 8 K byte Flash, 512 bytes of RAM, 32 I/O ports, watchdog timer, built-in 4 KB block of EEPROM, MAX810 reset circuit, three 16-bit timers/counters, 4 external interrupts, 7-vector and 4-level interrupt structure (compatible with the 5-vector and 2-level interrupt structure of the traditional 51 MCU) [4]. And it has two full duplex serial communication ports-P3.0 and P3.1-to communicate with connected module, realizing the transmission of information.

### 3.3. Selection of bluetooth module and its functions

As a wireless communication mode, bluetooth has the advantages of small size, low power consumption, stable and reliable transmission, which make it very appropriate for this kind of household system that requires real-time monitoring. The Bluetooth used in this design is the HC-05 bluetooth module of version 2.0, and it can be switched between master and slave mode. Its working frequency band is 2.4G and communication current is only 40 mA. The transmission distance is about 10 meters. Its working principle is shown in figure 3. The single chip microcomputer on the left sends serial port data to the module, and the RXD port of the module automatically sends the data to the air in the form of radio waves once receiving the serial port data. The right module can automatically receive and restore the serial data sent by the original device on the left and then send it out from TXD port. Because of full duplex transmission of the serial port, the information can also be transmitted from right to the left.
Figure 3. Bluetooth communication schematic

In this system, the MCU on the left side of Figure 3 is the MCU connected to the gas sensor module, and the Bluetooth module on the left is set as slave while the right one as the host. The device on the right in the picture is the master microcontroller in the bedroom.

3.4. Acousto-optic alarm module

The sound and light alarm part of the system consists of passive buzzer and OLED display screen. Passive buzzer is equivalent to a small loudspeaker and must be driven by oscillating current. Compared with active buzzer, passive buzzer costs lower and is more flexible to use[5]. Meanwhile, the method of paralleling resistance between the collector and emitter of a triode or between the base and emitter enables the buzzer to achieve multi-gear control on the frequency control of the power pole [6], making the buzzer emit different sounds to express different alarm situations.

The traditional 1286-screen LCD display requires backlighting and has a high power consumption. While the selected OLED display is made of very thin organic coating and glass substrate, can be self-luminous and does not need back light source, so the OLED panel can be thinner and more energy-saving [7]. Meanwhile, although its volume is relatively small, OLED display has a wide viewing angle, high resolution and fast response speed. Through the program control display screen can show different colors, patterns and flashing mode, achieving multi-level alarm display. The display screen uses IIC communication, with VCC, GND, SCL and SDA four pins, and its connection mode with single chip computer is similar to AD conversion module.

3.5. Connection between modules

3.5.1. The connection of sensor part and single chip computer. The sensor and MCU I are concatenated through the PCF8591-AD conversion module as an intermediate bridge. The connection diagram is shown in Figure 4. When the power is supplied to the microcontroller, the sensor and the AD converter are simultaneously powered. The voltage signal measured by the gas sensor is input to the PCF8591 via the AIN0 port and the serial communication between PCF8591 and MCU is carried out through I2C protocol. According to the program written, the connection rule between the AD module and the microcontroller is that the SCL pin joins to the P2.0 port while the SDA pin joins to the P2.1 port.

Figure 4. Gas sensor - AD conversion - MCU connection diagram
3.5.2. Connection of Bluetooth Module with Single Chip Microcomputer. The connection diagram between Bluetooth module and MCU is shown in Fig. 5. The TXD port of Bluetooth is connected with the P3.0 signal receiving port of MCU, and the RXD port is connected with the P3.1 signal sending port. At the same time, the 5V voltage pin of MCU is used to power Bluetooth (5V is included in the power range of HC-05 Bluetooth).

![Bluetooth and MCU connection diagram](image)

**Figure 5.** Bluetooth and MCU connection diagram

3.6. Power circuit
The main power supply of this system is lithium battery, which is converted to 5V voltage by voltage stabilization module to supply power to single chip computer, and then to provide power for the whole system. The power consumption rate of the system is very low and the disconnection from the user's home grid system can avoid the unavailable monitoring problems caused by power outages at home.

4. System implementation
The system is programmed in C language, including concentration signal acquisition module, serial communication program, Bluetooth transmission program, sound and light alarm program. After power-on, the system is initialized first. When entering the normal working state, the gas sensor collects the concentration signal and transmits it to the single-chip microcomputer I through the AD module. On the one hand, MCU I starts the Bluetooth transmission program and transmits the information to MCU II in the bedroom. On the other hand, the data are processed and compared in MCU I. If the concentration exceeds the set warning value, the sound and light alarm program is launched, and different instructions are made to the OLED display and the buzzer according to the danger level. Otherwise, system continue to collect concentration data and MCU I give out command to make OLED display "Normal concentration". In the meantime, MCU II also executes the same contrast program as MCU I. If taking the remote warning of mobile phone into consideration, it is needful to increase the program for communication with the mobile phone. The flow chart of the whole system is shown in Figure 6.
5. Conclusion
Focusing on the issue that most widely used gas alarm in the market can only alarm in the kitchen, this design proposes a gas alarm scheme based on Bluetooth communication and single-chip computer control, which can solve the problem of not receiving alarm information in time in the bedroom. HC-05 Bluetooth communication is adopted with low power consumption, small volume and fast transmission speed, and MQ-9 gas sensor is selected with high sensitivity and long service time. The combination of sound and light alarm can eliminate noise interference and has strong alarm capacity. In general, the system not only enhances the alarm function, but also reduces the power consumption. Therefore, the system has a good application prospect in this energy-saving era. On this basis, if the module of communication with mobile phone is added, the function will be more perfect.

At the same time, this monitoring method based on Bluetooth short-range communication can also be applied to the development of other similar intelligent alarms, such as the design of smart meters, humidity monitors, etc.

References
[1]Ying Luo. Home gas leakage detection, alarm and control device [D]. Fujian Agricultural and Forestry University, 2012.
[2] http://wiki.seeedstudio.com/cn/Grove-Gas_Sensor-MQ9/#_3
[3] Fan Wu, Xiaoyu Li, Yi Liu, Jingyi Wang, Xiaoxuan Jin. Design of vehicle interior environment monitoring system based on STC89C52 [J]. Automotive practical technology, 2019 (14): 73-75.
[4] Zhong Chen, Daizhong Zhu. Design of control system based on STC89C52 single chip computer [M]. Beijing: Tsinghua University Press, 2015.
[5] Yonghui Wei. Passive buzzer sound under embedded STM32 [J]. Prospects for science and technology, 2016, 26 (24): 163.
[6] Xiamen Xinyang Science and Technology Co., Ltd. A control circuit of passive buzzer: China, CN201820444753.5 [P]. 2018-11-20.
[7] Shen Jia, Ning Jiang. Analysis of competition status in display panel market [J]. Competition policy research, 2019 (02): 74-84.