

Design of Intelligent Household Gas Alarm System

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Abstract

A set of intelligent household gas alarm system based on STM32F103 single chip microcomputer is designed by using Bluetooth Communication Technology with low power consumption and low cost, and GPRS Remote Communication Technology with high transmission rate and fast login. This system realizes the sound and light alarm of kitchen and bedroom as well as remote SMS / APP alarm, so as to fully cover all kinds of situations. Compared with the current popular gas alarm in the market, it has the advantages of high security and comprehensive functions, which meets the requirements of Smart Home.

Keywords

GPRS technology, STM32F103 microcontroller, Intelligent Gas Early Warning System.

1. Introduction

The family gas explosion accident has troubled people for many years. So far, the most effective measure is to use gas alarm system for early warning. Although there are many gas alarm manufacturers in our country at present, there still exists many problems such as single function, small alarm range and poor warning effect. The gas alarm system based on Bluetooth technology and single chip microcomputer puts forward a double early warning method for kitchen and bedroom, which effectively improves the safety of early warning [1]. However, it can not reduce the risk of gas leakage when the residents are not at home. Therefore, it is necessary to introduce remote communication technology to realize mobile phone warning.

In this paper, on the basis of Bluetooth technology and single-chip alarm system, the system adds GPRS module to complete the task of remote communication. At the same time, a memory storage unit is added to record the monitoring data of a certain period of time. By analyzing the data curve, the performance of gas system can be evaluated, and the trouble can be prevented in advance.

With the development of intelligent and automatic high-tech, Smart Home gradually permeates into people's life. The gas early warning system proposed in this paper is a link of smart home and has a good application and development prospect.

2. Overall Design of Early Warning System

The system is a "four-in-one" gas alarm system, which is mainly used in the early warning of household gas leakage. The "four-in-one" system integrates the four core technical functions of monitoring, alarm, control and evaluation (as shown in Figure 1). It adopts the methods of multi-location warning, multi-level warning and regular assessment to greatly enhance the effectiveness of early warning and improve residents' home safety index.

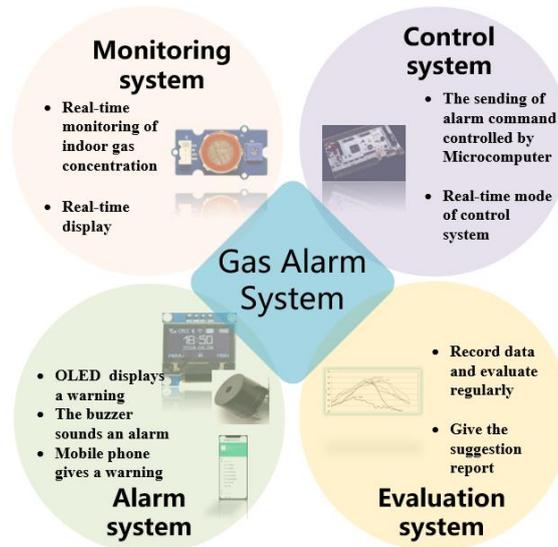


Fig 1. System function module

Figure 2 shows the overall design of the system. The system is mainly composed of gas sensor, MCU master-slave, Bluetooth transmission module, sound and light alarm module, GPRS module and SD card. Among them, the gas-sensitive sensor, the single-chip slave and its attached sound-light alarm are located in the kitchen [1]. While the single-chip host and its attached sound-light alarm, SD and GPRS modules are located in the bedroom. The communication between the master and slave of the single chip microcomputer adopts Bluetooth technology, while the communication between the host of the single chip microcomputer and the mobile phone takes GPRS remote communication technology. The concentration detection module monitors the concentration of gas in the kitchen in real time and transmits the results to two MCU in time. The MCU slave machine processes and compares the concentration information, and sends different alarm commands [1]. And on the one hand, the MCU host gives out the alarm command in the light of the concentration information received. On the other hand, it stores the data in the SD card and selects the GPRS working mode according to the alarm level to send the alarm information to the user's mobile phone in time.

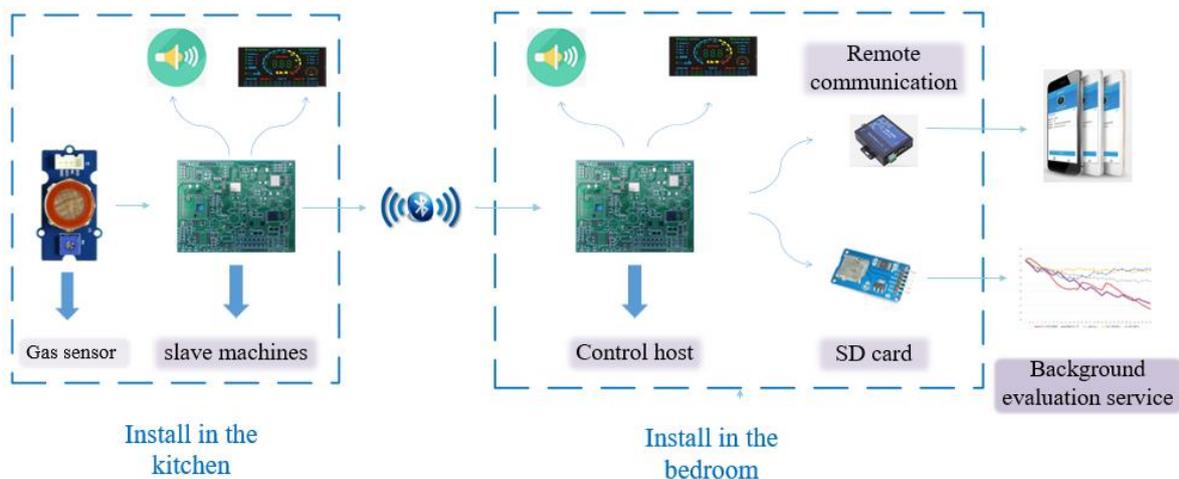


Fig 2. Overall system design drawing

3. Four Functional Systems

3.1. Monitoring System

The monitoring module of the system is mainly gas sensor, which is placed in the kitchen. At present, the commonly used types of gas are natural gas, gas, methane and so on. Different types of sensors, such as MQ-5, MQ-9 and SGP30 gas sensors, can be selected according to the main composition ratio of gas. All of them have high sensitivity, good stability and high integrability. At the same time, the power consumption is low, which is suitable for the real-time monitoring system.

3.2. Control System

The control part of this early warning system is composed of two single chip microcomputer. The slave is placed in the kitchen and the host is placed in the bedroom. The data is exchanged through Bluetooth protocol. The control system is equipped with four monitoring states: normal, first-level alarm, second-level alarm and third-level alarm. And the concentration threshold for each state is set in the program. After receiving the information, the MCU compares the collected concentration with the threshold value and makes corresponding alarm instructions, as shown in Figure 3. The difference between the two MCU instructions is that the host machine will start the remote communication module to send alarm information to the mobile phone under the second and third alarm state.

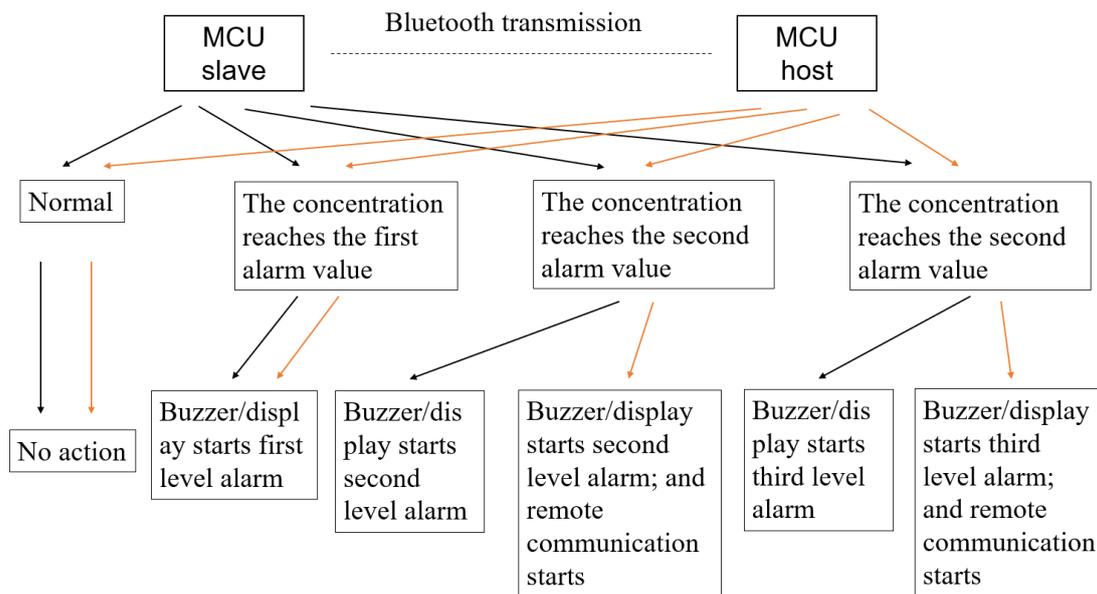


Fig 3. Diagram of MCU control system

In this design, STM32F103 microcontroller is selected. STM32F series is a 32-bit ARM microcontroller with low cost, and STM32's powerful performance makes the external circuit relatively simple. Its internal integration includes SPI, IIC, USART, A/D conversion, etc.. It also has very low power consumption and has three modes of standby, stop and sleep [2]. The host STM32F103 communicates with bluetooth module and GPRS module respectively through serial port 0 and serial port 1. Meanwhile, an SD card is inserted on the development board of STM32F103 to record the monitoring data for a period of time for further evaluation and analysis.

3.3. Alarm System

The alarm device of this system is mainly divided into three parts: buzzer, OLED display screen and SMS/APP. There is an audible and visual alarm system in the kitchen and bedroom, each consisting of a buzzer and OLED display. There are two types of remote alarm information: SMS prompt and the detection app loaded on the phone pop up. According to different alarm levels, the three alarm devices have different alarm modes. Its working status is shown in Figure 4.

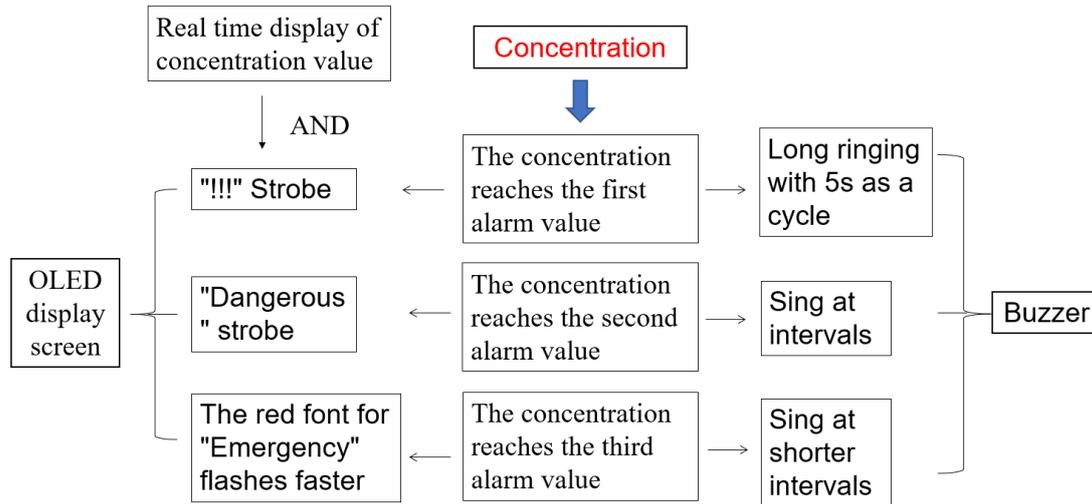


Fig 4. Alarm status diagram

The OLED screen displays the gas concentration value in real time for people to view. At normal concentration, OLED displays the word "normal" and the buzzer does not act. When the concentration reaches the first level threshold, the OLED screen displays the concentration value and flashes "!!!", and the buzzer gives out a long ring with 5s as a cycle. When the concentration reaches the secondary threshold, the OLED screen shows the concentration value as well as "Dangerous" flashing. The buzzer beeps at short intervals. At the same time, the remote alarm is activated, indicating that the secondary alarm has been reached. When the concentration reaches the third level threshold, in addition to displaying the concentration value, the OLED screen also displays the red font "Emergency" which flashes rapidly. The buzzer beeps at a shorter time interval and the remote alarm indicates that the third level alarm has been reached.

3.4. Evaluation System

The SD card is connected on the host MCU to record the indoor gas concentration information. It can be used to keep track of the recent gas concentration changes by reading the data on SD card regularly. On this basis, residents can analyzes whether there is potential leakage, so as to take measures such as inspecting the aging of pipelines to further improve the safety of early warning.

4. Information Transmission Technology of the System

The system adopts the combination of remote and near communication. It achieves the close range alarm in the kitchen and bedroom through Bluetooth protocol while realizes the alarm on the mobile phone of residents by GPRS remote communication module.

The working frequency band of Bluetooth communication technology is 2.4GHz, and its transmission rate is 1Mbps. The communication distance is generally within 10 meters. When using spread spectrum technology, it can reach 100 meters. Additionally, it can be transmitted

through walls and briefcases [3]. Due to the close distance between each room in the residential house, the communication between the kitchen and the bedroom can be realized by using bluetooth protocol. Meanwhile, compared with other short-distance communication methods, Bluetooth communication has low power consumption and stable data transmission.

GPRS technology is used to transmit the information to the user's associated mobile phone terminal to realize the alarm function of SMS and app. GPRS technology, based on packet switching technology, is suitable for sudden data transmission. GPRS communication is charged according to the flow rate, and only charged when the flow is generated, so the communication cost is lower [4]. In addition, GPRS technology also has the characteristics of short access time and high transmission rate, which is suitable for remote monitoring and alarm [5]. GPRS communication module supports a variety of data transmission modes, such as low power consumption mode, network mode, SMS mode, etc., which are set by AT command [6]. In order to save electric energy, GPRS module is set to be in low power consumption mode under normal concentration or level-1 alarm state. When the concentration alarm level reaches level 2 or above, GPRS module is set to be in SMS transparent transmission mode or network transparent transmission mode, as shown in Figure 5. It can reduce power consumption and save power cost on the premise of reliable transmission of alarm information.

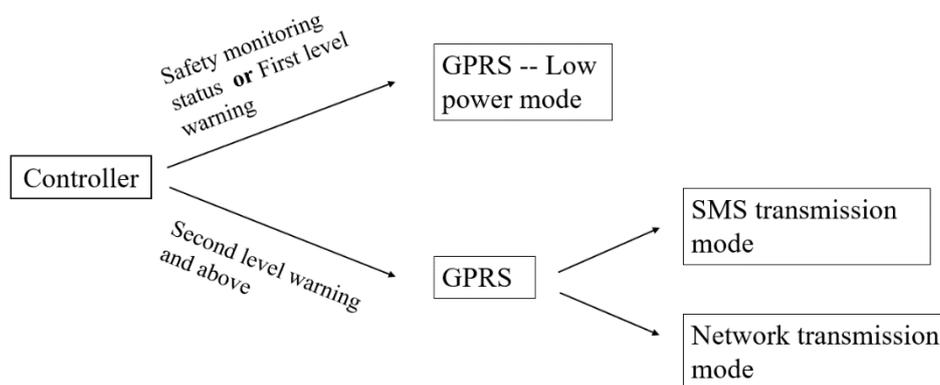


Fig 5. GPRS mode setting

5. Conclusion

This Intelligent Gas Alarm System develops the traditional single-terminal alarm into multi-terminal early-warning -- the kitchen, bedroom and mobile phone, which improves the coverage of the early-warning system so that people can receive the alarm information wherever they are and take corresponding measures in time to protect the personal and property safety. The system has four functional modules: monitoring, alarm, control and evaluation. The sensor is used for real-time monitoring. The alarm part includes OLED display, buzzer and mobile phone, which are mainly controlled by two STM32F103 microcontrollers. By reading the data of SD card regularly, the sealing performance of gas system can be evaluated. In addition, the whole system adopts a combination of short-distance and long-distance communication. Low energy bluetooth module is used for short distance real-time communication. And when the warning degree is high, the remote module is started, otherwise it is in the low-power module, which greatly reduces the power consumption.

References

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