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Integrated Water Quality Monitoring System Using STM32F103 and Wireless Technologies

Emma Johnson[1],Michael Brown[2]

University of Texas-Rio Grande Valley[1],University of Texas-Rio Grande Valley[2]

Emmaj@gmail.com[1],Michaelb9@gmail.com[2]

Abstract:

Water is essential for life, and its safety is crucial for human well-being. This water body monitoring system utilizes the STM32F103 microcontroller as its core control unit. It achieves temperature detection via the DS18B20 sensor, malodorous H2S gas detection using an H2S sensor, and turbidity measurement through the TSW-30 sensor. Should any of these parameters exceed predefined thresholds, an alarm is triggered by a buzzer. The system's parameters are displayed locally on an LCD and transmitted to a mobile app via a WiFi module based on the ESP8266. This allows users to monitor water conditions through their mobile devices. The development of this system involved schematic design, programming, physical assembly, and functional testing, successfully meeting the intended functional objectives.

Keywords:

Water temperature, H2S gas, turbidity, WiFi communication.

1. Introduction

In the context of rapid social and economic development, it is inseparable from the massive consumption of water resources, while the problem of water pollution is becoming increasingly serious. Water resources are one of the most important resources in nature. Water pollution will not only cause serious damage to the natural ecological environment, but also bring potential harm to people's daily life and industrial production development. In order to solve the safety problems caused by water pollution and the shortage of water resources, it is necessary to protect water resources scientifically, avoid the continuous deterioration of water resources problems, and protect water resources scientifically and effectively[1-3].

In recent years, with the rapid development of electronic information technology, sensor detection technology and wireless communication technology, China's environmental protection department has gradually carried out scientific research on the water body detection system. Through the application of water resources monitoring equipment, it can timely grasp various data of water resources and do a good job in the scientific prevention and control of water environment. At the earliest time, the water resources in important river basins were monitored by water conservancy departments in China by traditional manual sampling and extraction, and scientific instruments were tested in special laboratories. The actual situation of water resources was actually reflected by scientific detection data. Although this detection form can improve the actual detection accuracy, the overall detection cycle is long, and the detection cycle of each link is long, which affects the timeliness of the detection data. With the rapid development of detection technology and communication technology, relevant detection technology has been continuously innovated, and the effectiveness of detection equipment has been gradually improved. Through the use of wireless sensor networks, the detection data can be integrated at the first time. The R&D personnel can accurately evaluate the water resources environment based on the detection data, reflect its actual indicators in real time, and improve the water resources governance ability[3-5].

The progress of industrial society has accelerated the application of water resources. In order to minimize the serious impact of industrial production water supply resources, it is necessary to improve the design requirements of the water body online monitoring system, improve the practicability of the system functions, select the control system with the single chip computer as the main control core, improve the stability of the system operation, and improve the scientificity of the water resources online monitoring with the selection of sensors, This also provides an important theoretical guarantee for the design of online water monitoring system.

Water resources are not only an important resource for people's daily life, but also a necessary condition for industrial production. Real-time monitoring of water resources and ensuring the scientific use of water resources are directly related to the normal operation of industry, natural ecological protection, and people's daily life at home. It can be said that water detection has important practical significance. Foreign researchers have carried out systematic research on water protection.

In developed countries such as Europe and the United States, the development of scientific research technology has led to the rapid development of relevant computer science and technology and automatic control technology, which has made the water body detection technology realize the improvement of electronic and intelligent, and the detection products are gradually systematized. In the 1970s, researchers in Europe and America used analog instruments to detect various microbial data in water resources and measure and store the monitored data. By the 1980s, the relevant monitoring technology has gradually matured, and it can realize fully automatic and intelligent collection of water resources, and basically realize unmanned operation. In Japan, due to the rapid development of aquaculture technology, researchers have applied computer control technology to the application of relevant occasions, which can scientifically detect the temperature, PH value and turbidity of water body, so as to adjust the water quality in time. In Denmark, the relevant water detection technology has developed rapidly, which can automatically adjust the water environment according to the actual situation and improve the living environment of aquatic organisms[6].

In China, the research on water body detection technology started relatively late, which began in the 1990s. According to the geographical environment and climate conditions of China, the systematic research on water body monitoring was carried out, and the design requirements of multi-point detection and cross-region detection could be achieved. At the same time, on the basis of learning from foreign advanced technologies, it can realize the detection task of various parameters in water resources, and adjust them in time to achieve the design requirements of water resources protection. In the future, researchers will focus on enhancing the accuracy and comprehensiveness of water body detection.

This water body monitoring system based on single chip computer is integrated with single chip computer control technology, sensor detection technology and wireless communication technology to improve the accuracy and timeliness of water body detection from the perspective of practical application. In the overall design, STM32 single chip computer is used as the main control core of the system, combined with sensor detection module and WiFi transmission module, to monitor the water temperature, H2S gas, turbidity and other data. When the detection data exceeds the threshold level, the buzzer will give an alarm prompt to improve the function of the system design in practical application. At the same time, the schematic diagram of the system circuit, program compilation and physical production will be carried out.

2. Scheme design and component introduction

The water body monitoring system based on single-chip microcomputer is shown in Figure 1 as a whole, including the minimum system of single-chip microcomputer, water temperature detection module, HS2 detection module, turbidity detection, LCD display, WiFi communication, buzzer alarm and other modules. Here, STM32F103 single chip microcomputer is used as the core control unit to realize the temperature detection of water body through DS18B20, the detection of malodorous H2S gas in water body through H2S sensor, and the detection of turbidity in water body through TSW-30 sensor. If these parameters are arbitrarily out of standard, an alarm will be given through buzzer, and

its parameters can not only be displayed on the local LCD, It can also be sent to mobile APP through the WiFi wireless communication module composed of ESP8266, and users can monitor the water body status through mobile APP.

STM32 single chip computer is selected as the main control module of the system. STM32 single chip computer has mature research and development technology and is often used in embedded system design. STM32 single chip computer has outstanding reading and writing ability, and the number of peripheral devices is instigated after the festival. Users can write relevant library files according to the actual design requirements.

The DS18B20 temperature sensor is selected for temperature monitoring. The detection range of the DS18B20 temperature sensor is - 55 ℃ to 125 ℃, which is applicable to most detection requirements. In practical applications, the control mode of the sensor is relatively simple. It can be connected with the main controller only by using the data line to obtain accurate temperature data. This detection form has low cost and stable overall function.

Select OLED12864 LCD display to display various detection data of water body. OLED displays have low power consumption in practical applications, rich data information can be displayed, small application size and strong applicability. In practical applications, users only need to write corresponding programs according to IIC protocol to complete the display design requirements of the system, which is not only convenient and fast, but also can improve the efficiency of system design.

TS-300B turbidity sensor is selected to meet the design requirements of water turbidity. This type of sensor is composed of infrared emitting and receiving diodes. In the actual detection process, infrared is used to simulate the detection requirements of turbidity. The turbidity range actually detected is 0-1000NTU. Support 3-5 V power supply requirements in circuit design. In the process of turbidity monitoring, analog quantity is used to transmit the monitoring data. The main controller only needs to detect the actual output voltage in the circuit to complete the turbidity detection requirements.

EPS-01 module is used to realize data transmission of wireless communication, which is a practical application form of WiFi communication. At present, WiFi data communication is widely used. It can not only achieve the point-to-point communication requirements, but also support multiple devices to transmit data at the same time. After the software program is written, the actual data transmission communication design requirements of the system can be completed.

3. System hardware design

This water body monitoring system uses STM32F103 single chip microcomputer as the main control module of the system. STM32 single chip microcomputer uses ARM core, which can use the reduced instruction set for general control operation. STM32 single chip microcomputer supports multi-platform programming, as well as assembly language and C language programming. At the same time, STM32 single chip computer can increase the function of system design by enriching the operating system. The STM32 single-chip microcomputer has fast actual operation speed, and its working frequency can reach 72MHZ. The working form of 32-bit bus can improve the overall operating efficiency of the system to a certain extent. There are two independent analog-to-digital converters inside the single chip computer, which support various working modes, such as PWM output mode, input capture, etc. STM32 single chip microcomputer has two IIC communication interfaces, three USART serial communication interfaces and 16 external interrupt inputs. The I/O pin withstand voltage can reach 5V, which is convenient for data communication between single chip microcomputer and external components. The main control circuit of this system design is shown in Figure 1. The STM32 single-chip microcomputer has 48 pins in total, mainly including power interface, reset interface, crystal oscillator interface and general I/O pins. At the same time, although the STM32 single-chip microcomputer has its own RTC oscillator, the overall frequency is low, so it is necessary to use external crystal oscillator and use internal PLL to double the frequency to complete the design of crystal oscillator circuit in the main control module. In order to improve the stability of crystal oscillator circuit, two small capacitors are added to filter out the interference.

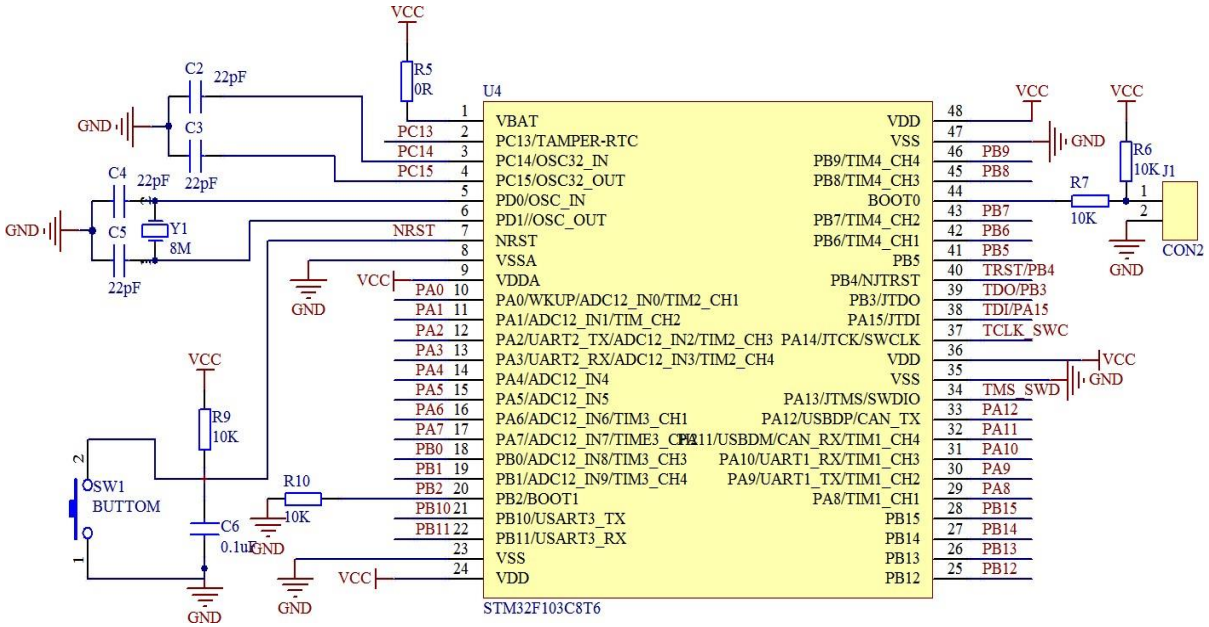

Figure 1 Minimum system diagram of single chip computer

In water body monitoring, it is necessary to complete the detection requirements for water body temperature, because the abnormal water temperature will lead to a large number of aquatic organisms breeding and directly affect the water quality, so it is necessary to monitor the water temperature in real time. The DS18B20 temperature sensor is selected in this design. The peripheral circuit of the chip includes power supply pin and DATA data line. The DS18B20 supports a variety of packaging forms, and the detectable temperature range is - 55 ℃ to 125 ℃. The time of monitoring temperature will increase with the number of bits of resolution. The sensor chip contains 64-bit ROM, alarm trigger TH and TL, configuration register and other functional modules. The module supports 3-5 V power supply. As shown in Figure 2, the actual circuit diagram of hydrological detection is shown. During the system circuit connection, the PB12 pin of the single chip computer is connected with the DATA data pin of the temperature sensor.

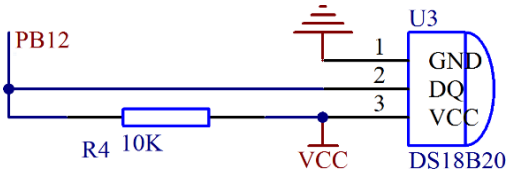

Figure 2 Water temperature detection circuit diagram

In the design of water body monitoring system, it is necessary to detect the concentration of H2S gas in the water body, and the H_2S gas sensor is used. This type of sensor is mainly composed of metal synthetic oxides, with high detection sensitivity. When the concentration of H2S gas detected by the sensor exceeds the threshold set by the system, the conductivity of the sensor will change accordingly. The conductivity will change correspondingly with the concentration of H2S gas, directly leading to the change of voltage in the H_2S detection circuit.

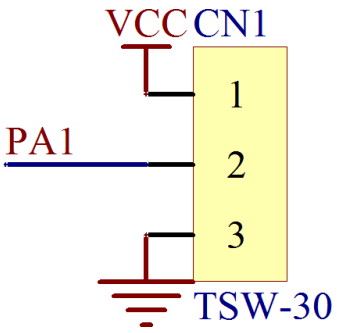

Figure 3 Turbidity detection circuit diagram

In this water body monitoring, it is necessary to detect the turbidity of the water in order to further monitor the water quality to a certain extent. Turbidity of water refers to the amount of particles in water per unit volume. The more particles, the higher the turbidity. To this end, we first need to select the corresponding sensor. Here we select the TSW-30 turbidity sensor after comparison. Its price is relatively cheap and the circuit is relatively simple. It uses the principle of photoelectric detection to detect the particles in water. When in use, its internal LED diode will emit infrared light and receive it at the other end. In the process of light transmission, if there are more particles in the water, The more light loss, the less light received, and the less voltage converted from the photosensitive part. Therefore, the microcontroller controller only needs to detect its output voltage to complete the detection of turbidity in water. However, in order to improve the detection accuracy in the process of use, it is necessary to pay attention to the impact of water temperature and external light, and make software correction according to the actual test results to better obtain the test accuracy. The circuit is shown in Figure 3, which is connected to it through the PA1 pin of the single chip computer.

As shown in Figure 4, the realization of wireless communication is an important part of the design of the water body monitoring system. It needs to be responsible for transmitting the data detected by the single-chip computer to the APP in the form of WiFi communication. The implementation of WiFi communication is based on the ESP8266 communication module, which has the UART-WiFi transmission function, that is, the single-chip computer controller UART sends instructions to the ESP8266 module, The ESP8266 module then automatically sends the received instructions in the form of WiFi, which greatly saves the user's workload and greatly reduces the software programming workload of the network communication part. In terms of function, it mainly includes AP and STA modes. In AP mode, it is generally used as a server server, while STA mode is used as a client, but no matter which mode is used, Its control is not complicated, because it is realized by sending AT instructions through UART during control, and it has built-in 32-bit processor, cache memory, etc., which can provide sufficient data processing capability when the ESP8266 module is online. The whole system has strong processing capability, high integration, and very low power consumption, so it is widely used in the Internet of Things and other fields. In addition to the processor and other key devices, It is also equipped with PCB antenna, filter, calibration circuit, Flash, etc. Its signal transmission distance can reach 100m effective distance and has strong anti-interference ability.

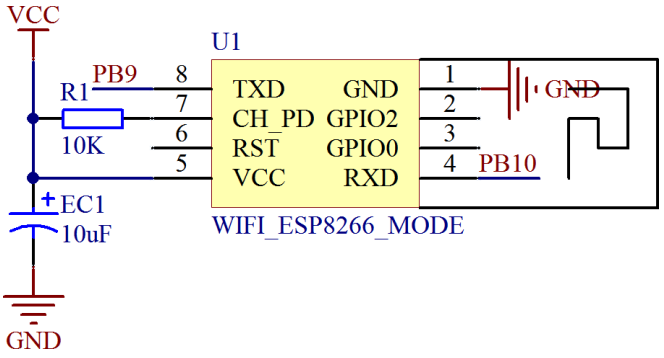

Figure 4 WiFi communication circuit diagram

The OLED12864 liquid crystal display is selected as the display module of the water body monitoring system design to display the detected data information in real time. The display module is made up of the principle that OLED emits different light colors under different conditions. OLED12864 has the advantages of fast display speed, stable operation and high resolution in practical applications, and can provide users with intuitive and clear data information. OLED12864 liquid crystal display module has the working property of self- illumination. It has simple overall structure, low design cost, wide operating temperature range, and can display the system in a large area. OLED12864 liquid crystal has 8 internal storage addresses, which can be used for the storage of Chinese characters, and has important application value in practical applications. The OLED display module provides users with four interface modes, which can be set through BS1/BS2 of the display module. The interface modes of the module include 6800 and 8080 parallel interface modes and SPI and IIC bus interface modes. The circuit diagram of OLED display module is shown in Figure 5.

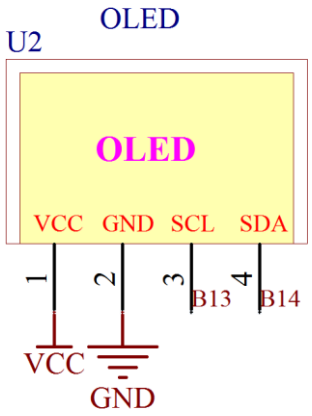

Figure 5 the circuit diagram

In this design, when the temperature, turbidity and H2S gas detected in the water body exceed the safety threshold range set by the system, the buzzer alarm circuit shall be used to give an alarm prompt, so as to realize the design requirements of water body safety management. This alarm circuit uses an active buzzer for alarm safety prompt. Because the buzzer needs a large current to drive during the drive design process, and the IO port of the single-chip microcomputer outputs high and low levels, it is necessary to design the corresponding drive circuit for alarm circuit design. The PNP control form of triode is adopted in the design of alarm circuit. When the output of the single chip computer is low level, the triode in the circuit will go through the same process, and the buzzer will make a sound, on the contrary, it will be in a quiet state.

4. Conclusion

This water body monitoring system based on single chip microcomputer, with STM32F103 single chip microcomputer as the core control unit, realizes the temperature detection of water body through DS18B20, the detection of malodorous H2S gas in water body through H2S sensor, and the detection of turbidity in water body through TSW-30 sensor. If these parameters arbitrarily exceed the standard, it will alarm through buzzer, and its parameters can not only be displayed on the local LCD, It can also be sent to mobile APP through the WiFi wireless communication module composed of ESP8266, and users can monitor the water body status through mobile APP. Although the design has made physical objects and verified the feasibility of the design through functional tests, due to the limited personal ability, its overall function is still relatively simple, and there are many areas that can be improved, such as adding cloud platforms to improve communication distance, improve detection accuracy, etc., so that the whole water body monitoring system can be better applied in life.

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