

Design of Intelligent Water Quality Detection System Based on STM32

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Abstract: This paper designs a water quality detection system which takes the STM32 single - chip microcomputer as the core control board, GSM as the data transmission platform, and is composed of various sensors. The water sample information is collected by three detection modules, namely resistance, PH, and temperature. The water quality information is transmitted to the STM32 single - chip microcomputer. After analyzing the water quality information, the processed information is respectively transmitted to the liquid crystal display screen and the management personnel, so as to realize the detection of water quality.

Keywords: STM32 single - chip microcomputer; GSM;

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I. Introduction

At present, against the backdrop of the national economy's vigorous and rapid development, people's material and cultural living standards have been rising by leaps and bounds—from the popularization of daily necessities to the pursuit of high-quality consumption, the quality of life has undergone a fundamental transformation. However, this magnificent development journey has also been accompanied by increasingly prominent environmental challenges, among which water resource pollution has become a pressing issue that cannot be ignored. Industrial wastewater containing harmful chemicals, untreated domestic sewage discharged randomly, and agricultural runoff carrying pesticides and fertilizers continue to erode water bodies such as rivers, lakes, and reservoirs. This not only destroys the ecological balance of water environments, leading to the death of aquatic organisms and the degradation of water ecosystems, but also directly disturbs people's daily lives. For example, it affects the normal supply of domestic water, endangers the safety of agricultural irrigation water, and even poses hidden threats to people's health. Consequently, the awareness of water resource protection has gradually penetrated into all sectors of society and attracted unprecedented attention. In recent years, discussions around protecting water resources have never faded from public view, becoming a core topic in social welfare, environmental protection forums, and even government work conferences. According to the latest authoritative statistical data released, nearly half of the urban drinking water sources in the country fail to meet the national drinking water quality standards, which sounds the alarm for the safety of urban residents' drinking water. In the entire water quality protection system, water quality detection is undoubtedly a crucial link and an important indicator to measure the effectiveness of water resource protection. Unfortunately, the current water quality detection work is plagued by multiple bottlenecks. On one hand, some inspectors lack a strong sense of environmental responsibility and professional ethics—some are perfunctory in the detection process, neglecting key detection steps, while others even falsify data to cope with inspections, making it impossible to reflect the real water quality situation. On the other hand, most of the existing water quality detection equipment is backward and lacks intelligent functions. These equipment often require manual operation for sampling and testing, with low detection efficiency and a narrow range of detectable parameters. Moreover, they cannot transmit data in real time, resulting in delays in information feedback, which makes it difficult for detection instruments to play their due supervisory and early warning roles. To address these prominent problems, we have specially designed an intelligent water quality monitoring system. Its core purpose is to achieve simple, efficient, and comprehensive monitoring of most key parameters of water quality in surrounding rivers, lakes, and other water bodies. Specifically, it can accurately and quickly detect important indicators such as water temperature, pH value, and conductivity—water temperature affects the activity of aquatic organisms and the decomposition rate of pollutants; pH value determines whether the water body is acidic or alkaline, which is closely related to the survival of organisms and the safety of drinking water; conductivity reflects the content of dissolved salts in the water, which can indirectly indicate the degree of water pollution. Once the system detects that the water quality pollution reaches a preset dangerous threshold, it will immediately trigger an automatic alarm mechanism, issuing a sharp alarm sound or flashing warning lights to attract the attention of on-site personnel. At the same time, the

system will transmit the detected real-time data to relevant management staff through short message services. After receiving the information, the staff will promptly sort out and verify the data, and then disseminate it to the surrounding residents through community announcements, WeChat groups, and other channels. This whole-process intelligent monitoring and information transmission mechanism not only enables the public to timely grasp the quality status of nearby water resources, but also effectively enhances people's awareness of water resource protection, making them deeply realize the urgency and importance of water protection. Furthermore, it can encourage more people to take practical actions—such as saving water in daily life, refusing to discharge sewage arbitrarily, participating in voluntary water cleaning activities, and supervising illegal pollution behaviors. In the long run, this will help form a good social atmosphere of joint participation in water protection, continuously improve the ecological environment of water resources, and ultimately better safeguard people's quality of life and health, laying a solid foundation for the sustainable development of society.

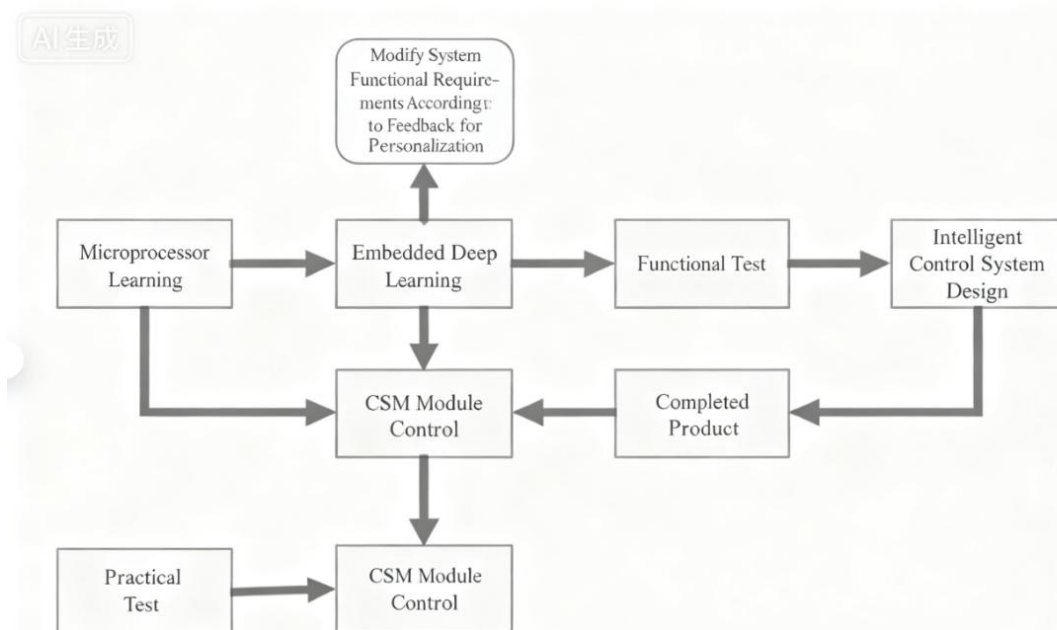


Figure 2

II. Overall Design Scheme of Intelligent Water Quality Detection System Based on STM32

This intelligent water quality monitoring project adopts a sophisticated and integrated hardware architecture, with the STM32 single-chip microcomputer development board serving as the core main control unit that undertakes the crucial task of coordinating and managing the entire system's operations. Complementing this core component are several essential functional modules, including a stable and reliable power supply module, a high-performance GSM communication module, and a multi-functional sensor module, each playing an indispensable role in ensuring the system's smooth operation. Among these, the sensor module is specifically tailored for water quality detection, integrating a diverse range of high-precision sensors such as temperature sensors, PH sensors, and conductivity sensors. These specialized sensors are meticulously selected to target the key parameters that directly reflect water quality conditions, enabling comprehensive and accurate data collection. In the actual operation process, the various sensors embedded in the sensor module continuously and real-time detect corresponding water quality data of the monitored water body—temperature sensors capture the dynamic changes in water temperature, which is closely related to the activity of aquatic organisms and the decomposition rate of pollutants; PH sensors accurately measure the acidity and alkalinity of the water, a critical indicator affecting the safety of drinking water and the survival of aquatic ecosystems; conductivity sensors monitor the electrical conductivity of the water, which indirectly reflects the content of dissolved salts and pollutants in the water body. Once these sensors complete the data collection, they promptly transmit the raw data to the STM32 single-chip microcomputer through pre-set data transmission channels. The single-chip microcomputer, as the "brain" of the system, processes the received raw data through built-in algorithms—including data filtering, calibration, and analysis—to convert it into standardized and interpretable water quality information. Subsequently, this processed information is displayed in a clear and intuitive manner on the supporting liquid crystal display screen, allowing on-site personnel to quickly grasp the real-time quality status of the monitored water body at a glance. Beyond on-site viewing, the system also achieves remote monitoring functionality through

the GSM module: the single-chip microcomputer sends the processed water quality data to the GSM module, which then transmits the information to designated mobile devices via wireless communication technology. This enables relevant management personnel and concerned individuals to access the water quality data anytime and anywhere, breaking the limitations of on-site monitoring and ensuring timely awareness of any changes in the water body's condition, thus providing strong technical support for efficient water quality management and early pollution warning.

III. Hardware Design Circuit

The hardware design circuit of this intelligent water quality monitoring system constitutes a sophisticated and interconnected functional framework, among which the power supply module, sensor module, and GSM module stand out as core components that are indispensable for the stable operation and full realization of the system's functions. Each module undertakes unique and critical responsibilities, and their coordinated operation forms the foundation of the entire hardware system's efficient performance. To provide a comprehensive and in-depth understanding of the system's hardware architecture, we will elaborate on the design principles, component configurations, functional characteristics, and operational mechanisms of each of these key modules separately in the subsequent content, shedding light on how they synergistically support the system's water quality detection, data processing, and remote transmission capabilities.

3.1 Power Supply Module Circuit

The power supply system of the entire STM32 development board, which serves as the core control unit of the intelligent water quality monitoring system, relies on an external 12V power source to meet the overall power demand of the hardware circuit. However, there is a mismatch between the voltage provided by this external power supply and the operating voltage requirements of key functional components in the system. Specifically, the STM32 single-chip microcomputer, the "brain" responsible for data processing and module coordination, requires a stable 5V power supply to ensure its precise operation and reliable execution of control instructions. Meanwhile, the sensor module, which undertakes the critical task of collecting water quality parameters such as temperature, pH value, and conductivity, has a more stringent voltage demand, requiring a 3.3V power supply to maintain the accuracy of its detection data and avoid component damage caused by voltage mismatches. Therefore, voltage step-down and stabilization processing become essential links in the power supply module design. To address this voltage adaptation problem, we have adopted a two-stage voltage regulation solution. First, the LM7805 voltage regulator chip is employed to convert the input 12V voltage into a stable 5V output, which is specifically supplied to the STM32 single-chip microcomputer to meet its operating power needs. Subsequently, the AMS1117 voltage regulator chip is used to further step down and stabilize the 5V voltage to 3.3V, providing a dedicated and stable power source for the sensor module. This multi-stage voltage regulation design effectively resolves the voltage mismatch issue between the external power supply and each core component, ensuring that every part of the system can operate within its rated voltage range, thereby laying a solid foundation for the stable and reliable operation of the entire intelligent water quality monitoring system.

3.2 Sensor Module Circuit

To fully fulfill the core functions of water quality monitoring and remote information transmission, the intelligent water quality monitoring system is equipped with a set of targeted hardware modules, including temperature sensor modules, PH sensor modules, resistance sensor modules, and GSM communication modules. Each of these modules undertakes specific tasks and is closely connected to the core STM32 single-chip microcomputer to form an efficient collaborative working mechanism. Specifically, the temperature sensor, PH sensor, and resistance sensor, which are responsible for collecting key water quality parameters, need to be directly connected to the designated IO ports of the STM32 single-chip microcomputer through corresponding circuit wiring. This hardware connection method ensures that the raw water quality data detected by the sensors can be quickly and stably transmitted to the single-chip microcomputer for subsequent processing and analysis. The GSM module, as the communication core of the system, undertakes two important tasks: on the one hand, it realizes the data communication between the system and external devices, and on the other hand, it supports the mobile phone control function, enabling administrators to interact with the system remotely. After the single-chip microcomputer completes the processing of the collected water quality data, it will rely on the GSM module to transmit the organized and analyzed monitoring information to the designated administrator in a timely manner, so that the administrator can grasp the real-time water quality status anytime and anywhere. To further clarify the hardware connection details of the system, the following will present partial circuit diagrams. The first one is the circuit diagram of the PH sensor, as shown in Figure 1: PH Sensor Circuit Diagram. This circuit diagram will visually display the connection mode between the PH sensor and other related components, providing a clear reference for understanding the system's hardware circuit design.

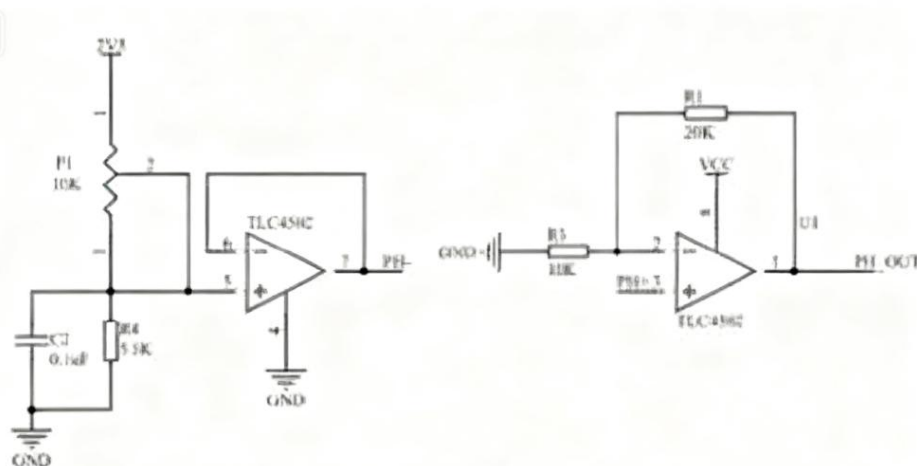


Figure 1 PH Sensor Circuit Diagram

IV. Software Code Debugging

When the intelligent water quality monitoring system is activated and starts its operational process, it first initiates the initialization procedures for the UART serial port and external interrupts. These two initializations are crucial foundational steps for the subsequent stable operation of the system: the UART serial port serves as a key communication channel for data transmission between the STM32 single-chip microcomputer and various functional modules, and its proper initialization ensures the accuracy and efficiency of data exchange; the initialization of external interrupts enables the system to promptly respond to external trigger signals, laying the groundwork for real-time processing of abnormal conditions and emergency events. After the completion of these two core initialization steps, the system formally enters a continuous cyclic working mode. Within each cycle, the system first focuses on the initialization of the GSM module—a critical link for realizing remote communication and control functions. During the GSM module initialization process, the system will detect the module's connection status and network registration situation. Only after the GSM module successfully completes network registration and establishes a stable communication link can the STM32 single-chip microcomputer proceed to the subsequent data processing phase. Next, the single-chip microcomputer, as the core control unit, begins to process the water quality data collected by each sensor (including temperature, PH value, conductivity, etc.). It performs a series of operations such as filtering, calibration, and analysis on the raw data to convert it into standardized and interpretable water quality information. Subsequently, the processed and organized sensor information is transmitted to the liquid crystal display screen connected to the single-chip microcomputer, which displays the data in a clear and intuitive manner. This allows on-site personnel to directly observe the real-time quality status of the monitored water body. Finally, relying on the previously initialized and stably registered GSM module, the system realizes the interaction between the water quality data and the mobile terminal. Relevant management personnel or designated users can obtain the real-time water quality information transmitted by the system through their mobile phones at any time and anywhere, breaking the limitations of on-site monitoring. At the same time, they can also issue corresponding control instructions to the system through the mobile phone, and the GSM module receives these instructions and transmits them to the single-chip microcomputer, which then executes the corresponding operational commands, thereby achieving remote control of the intelligent water quality monitoring system. This entire cyclic workflow ensures the continuous, stable, and efficient operation of the system, as well as the timely transmission and effective management of water quality information.

V. Conclusion

This intelligent water quality monitoring system innovatively integrates GSM communication technology into the field of water quality detection, realizing real-time, efficient, and remote monitoring of water quality parameters. By leveraging the wide coverage and stable transmission capabilities of GSM technology, the system can promptly send the collected and processed water quality data to users in the form of mobile phone messages, enabling users to grasp the current water quality status anytime and anywhere without being restricted by geographical locations. The application scenarios of this system are extensive and diverse, spanning from daily family life to large-scale water conservancy management. In the family context, installing this system allows residents to monitor the quality of their domestic water in real time, effectively avoiding potential health risks caused by substandard drinking water and providing a solid guarantee for family drinking water safety. In the field of water conservancy management, the system can be deployed beside reservoirs and other key water bodies. On

one hand, it can timely release water quality information to remind the general public of the importance of water resource protection, thereby enhancing public participation in water conservation and pollution prevention. On the other hand, it can continuously provide accurate and up-to-date water quality data to the staff of the Water Conservancy Bureau, laying a data foundation for scientific water resource regulation and pollution control decisions. Looking forward to the post-completion phase of the project, we plan to first launch demonstration and promotion work in small reservoirs across the province. Specifically, the system will be installed in various small reservoirs within the province to focus on monitoring core water quality indicators such as pH value and water temperature. During the demonstration period, the general public will be encouraged to access and check the real-time monitoring data at any time. This not only enables the public to keep abreast of the water quality of local reservoirs but also helps collect extensive practical feedback to verify and evaluate the accuracy of the system's detection data and its durability in long-term outdoor operation. Based on the results of the demonstration and promotion, we will further optimize and improve the system, laying the groundwork for its wider application in more regions and fields in the future, and making greater contributions to comprehensive water resource protection and intelligent water quality management.

Annotation

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