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Automatic Measurement and Reporting System of Water Quality Based on GSM

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***Abstract*—The traditional method of water quality testing is to collect samples manually and then send them to laboratory for analysis. However, it has been unable to meet the demands of water quality monitoring today. So a set of automatic measurement and reporting system of water quality has been developed. The system consists of multiple sensors of water quality testing, single-chip microcontroller data acquisition module, information transmission module, monitoring center and other accessories. Various parameters of water quality are automatically detected under the control of single chip microcontroller all day. The single chip gets the data, and then processes and analyzes them. After that, the data are instantaneously sent to monitoring center by GSM network in the form of SMS. If the water quality is abnormal, the data will be sent to monitoring center and management's mobile in the same way at the same time. It is convenient for management to take corresponding measures timely and be able to detect real-time situation of water quality remotely. The system has realized the automation of water quality monitoring, intelligence of data analyzing and networking of information transferring. It is characterized by advantages of shortcut, accuracy and using manpower and material resources sparingly. The system has widespread application value and can be extended and transplanted to other fields of automatic monitoring where needed.**

Keywords-Water Quality Monitoring; Measurement and Reporting; Sensors;* SMS*; Remote

Ⅰ. ITRODUCTION

With the rapid development of the economy, more and more serious problems of environment arise. Water pollution is one of these problems. Routinely monitored parameters of water quality are temperature, pH, turbidity, conductivity, dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonia nitrogen, nitrate, nitrite, phosphate, various metal ions and so on. The most common method to detect these parameters is to collect samples manually and then send them to laboratory for detecting and analyzing. This method wastes too much manpower and material resource, and has the limitations of the samples collecting, long-time analyzing, the aging of experiment equipment and other issues. Sensor is an ideal detecting device to solve these problems. It can convert non-power information into electrical signals. It can easily transfer, process, transform and control signals, and has many special advantages such as good selectivity, high sensitivity, fast response speed and so on. According to these characteristics and advantages of sensors, automatic measurement and reporting system of water quality is designed and developed. It bases on SMS (Short Messaging Service) in the GSM (Global System for Mobile Communications) network to instantaneously transfer the collected data. It also can remotely monitor the water quality on line. The system implements automation, intelligence and network of water quality monitoring, and uses manpower, material and financial resources sparingly.

Ⅱ. SYSTEM HARDWARE ARCHITECTURE

A. Overall Design of the System

As figure 1 shows, the system consists of multiple water detection sensors, single-chip microcontroller data acquisition module, information transmission module, monitoring center and other accessories. Temperature sensor used in this system directly converts the temperature signal into digital signal. Other water quality sensors transform the detected chemical signals into electrical signals, amplified by the signal conditioning circuit. The multiplexers select one road signal and send to A/D converter. Then it is converted into a digital signal. Single-chip reads and processes the digital information. It also controls the GSM module sending the collected data to the monitoring center in the form of SMS by GSM network instantaneously. Monitoring center receives the data and then analyzes, classifies, saves them and draws corresponding graphs. That can instantaneously monitor and alarm the situation of water quality. If the water quality is abnormal, single-chip will control the GSM module to send data to the monitoring center in the form of short message. The alarm in the monitoring center is activated. At the same time, the data are sent to management mobile phone in this way. It is easy for management to take corresponding measures immediately. When needed, management can also send orders in the form of SMS to GSM module of data collection terminal. GSM module communicates with the single chip. Then the single chip gets the data, and controls the GSM module to send the data to the manger's phones. The system can do all-weather real-time monitor to water temperature, pH, conductivity, turbidity, dissolved oxygen and other water-quality guideline. The design is

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beneficial for management to know the real-time water quality information, and make man-machine interaction with the system by mobile.

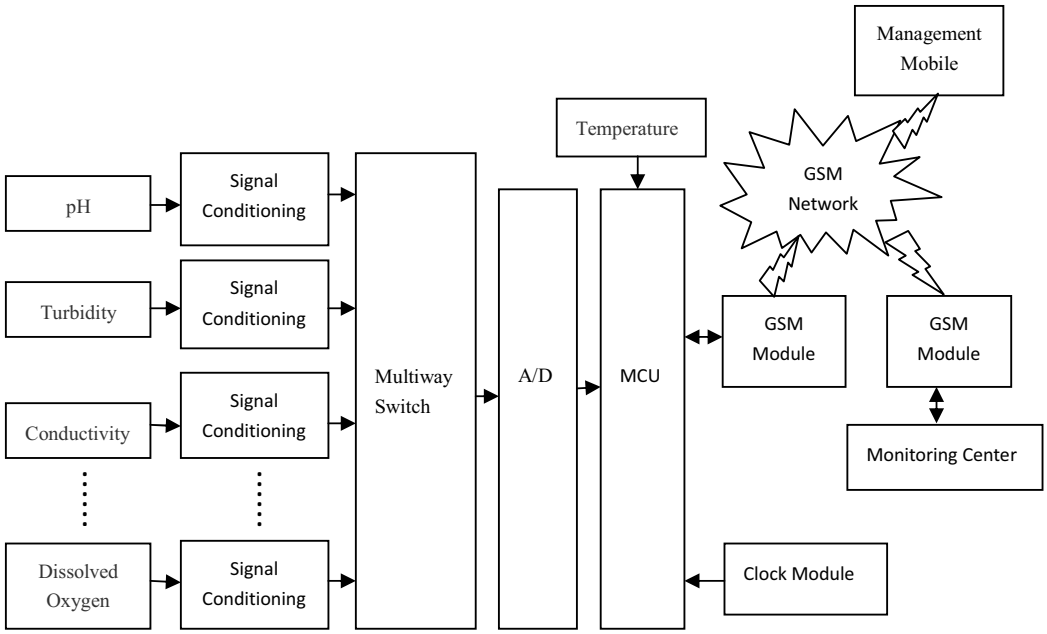

Figure 1. The framework of the system structure

B. Water Detection Sensors

Water detection sensors determine the system's accuracy and cost. Generally, they are very expensive on the market. In order to reduce the cost, we choose DS18B20, make conductivity sensors, turbidity sensors and pH sensors by ourselves, and purchase dissolved oxygen sensor of U.S. Global Water.

Temperature is one of the five common water quality parameters. Thermoelectric power temperature sensors and heat resistance temperature sensor are commonly used to detect water temperature. But thermoelectric power temperature sensors require temperature compensation, and the output of the heat resistance temperature sensor is not conducive to signal testing. DS18B20 is produced by U.S. DALLAS Semiconductor Company. It is a digital temperature sensor, using single-bus protocol. The testing temperature range is -55 ° C-+125 ° C, and the accuracy between -10 ° C~+85 ° C is ± 0.5 °. Therefore, the DS18B20 temperature sensor is chosen.

Conductivity sensors are generally divided into two types: two electrodes or multiple electrodes. Conductivity of two electrodes is commonly used interiorly. Generally, two conductivity electrodes in laboratory can be made by using two platinized platinum to sinter on two parallel glass, or inner wall of the round glass tube. Changing the size of platinum pieces and adjusting the distance between them can make different constant value of two conductivity electrodes.

Turbidity is caused by suspended particles in water. Suspended particles block a lot of incident light and scattered light. It also diffuses the incident light. Therefore, photoelectricity sensor is used to detect turbidity.

pH value is tested by the method of electric potential. Primary cell made by a constant potential reference electrode and measuring electrode is used in the method. A pH glass probe, which is sensitive to pH, is on measurement electrode. It is made of a special glass that can conduct electricity and permeate hydrogen ion. The potential can be produced when the glass probe touch the hydrogen ion. Different pH in the water generates corresponding potential. It can be converted into 4~20mA output by the transmitter.

The amount of dissolved oxygen in water is a very important indicator of the water quality. The system uses WQ401 dissolved oxygen sensor produced by the U.S. Global Water Company. As physical map shown in Figure 2, it is three-electrode structure and three-wire configuration. If the electrolyte deteriorates, the sensor can diagnose itself. Temperature compensation of it can reach to 25 ° C; the output is 4-20mA; testing range is 0-8ppm; accuracy is ± 0.5% of full scale; operating temperature is -40 ° C-+55 ° C. It is removable, and easy to maintain.

Figure 2. WQ401 dissolved oxygen sensor

C. Design of Single-chip Microcontroller Data Acquisition Module

The construction of single chip data acquisition module is shown in Figure 3. The signals collected by sensors of water quality monitoring need to be amplified because the output of them is in millivolt or milliampere. Then CD4051 multiple-way switch selects and sends a signal to A/D converter. It converts analog signals into digital signals that the single chip can read. CD4051 is a single 8-channel digital control of analog electronic switch with low on-resistance and low cut-off leakage current. Single chip collects and sends the data to GSM module by serial communication interface. Meanwhile, it reads and processes the commands which feed back from monitoring center and administrators. Lithium cell and solar battery are combined as power supplier. So the system can continuously work about 100 hours on cloudy days and 30 days on sunny conditions. In order to ensure the time accuracy of collecting, sending data and saving SCM internal resources, and be easy to find out the appearing time of abnormal data, the single chip adds a DS1302 clock chip.

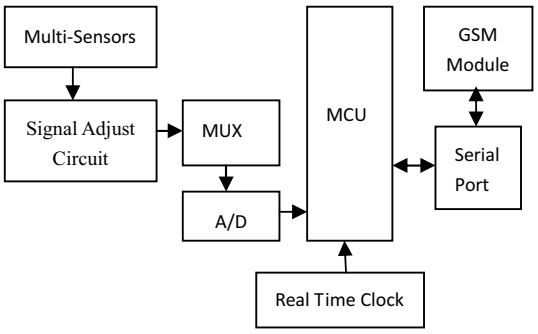

Figure 3. The framework of single chip data acquisition module

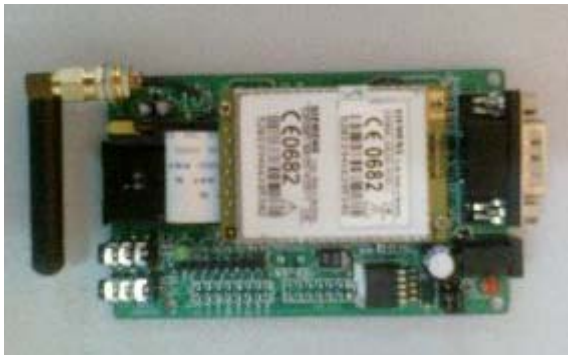

Figure 4. GSM module

D. Information Transmission Module

Information transmission module is a GSM module. GSM module uses SIMENS TC35, and its physical map is shown in Figure 4. GSM module mainly consists of GSM baseband processor, GSM RF, power, Flash, antennas and antenna jack. The module provides standard AT command interface for users, and its working voltage is between 3.3V and 5.5V and power consumption is lower. What is more, it can transfer data and voice safely and fast at frequency bandwidth of 900MHZ and 1800MHZ. There are three SMS modes that the GSM supports: Block Mode，Text Mode and PDU Mode. The Text Mode sustains numbers and characters. The system mainly transmits the digital messages, so Text Mode is chosen to be applied. GSM module uses standard AT commands, and communicates with the signal chip by UART. The commonly used AT commands are shown in Table 1.

Table 1 Common AT Commands menu

Instructions	Function
AT+CIMI	Detect SIM card
AT+CREG	Detect network registration information
AT+IPR	Set baud rate
AT+CMGF	Set SMS mode
AT+CSMP	Set text mode parameters
AT+CSCS	Set characters
AT+CSCA	SMS service center address
AT+CMGS	Send message
AT+CMGR	Read SMS
AT+CNMA	News confirmed
AT+CMGD	Delete one or more SMS

III. System Software constitution

A. Software Design of Microcontroller Data Acquisition Module

Software program of microcontroller data acquisition module mainly includes these functions: data collection, ADC, timing, comparison with standard

parameters that have been saved, SMS transmitting and receiving, etc. Different timing corresponds to different A/D sampling rate. Single chip reads the data after A/D converting. Then it uses AT commands to control GSM module which sends the data by GSM network in the form of SMS to GMS module in the monitoring center. Meanwhile, single-chip compares the read data with standard parameters. If the data is beyond the standard range of water quality parameters, single chip sends data to GSM module in monitoring center and management's mobile in the form of SMS. So it is convenient for management to take corresponding measures timely.

B. Software Design of Monitoring Center

Software program of monitoring center mainly includes such functions: MT mobile terminated, databank, alarm, data collation, mapping curve, etc. Monitoring center PC communicates with GSM module by UART. Upper machine reads SMS data received by GSM, and then sorts out and puts them into a database, so it is easy for managements to manage and perform a backup. Meanwhile, the data is plotted to curve and displayed on PC interface. As the SIM card in GSM module can store limited SMS data, it must delete the SMS timely after upper machine has read SMS. When the received data is abnormal, alarm indicator will be displayed on computer screen in the monitoring center, at the same time, the alarm of monitoring center will be switched on.

Ⅳ. Conclusion

Automatic measurement and reporting system of water quality based on GSM makes use of water detection sensor with unique advantage and existing GSM network. The system can monitor water quality automatically, and it is low in cost and does not require people on duty. So the water quality testing is likely to be more economical, convenient and fast. The system has good flexibility. Only by replacing the corresponding sensors and changing the relevant software programs, this system can be used to monitor other water quality parameters. The operation is simple. The system can be expanded to monitor hydrologic, air pollution, industrial and agricultural production and so on. It has widespread application and extension value.

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