REMOTE MONITORING SYSTEM OF pH DETECTION BASED ON SI4432

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Abstract. In order to improve the yield of aquaculture, there should be a guarantee of the normal water quality, and the pH value is the main reaction indicator of the water quality. Thus, a pH remote monitoring system used in aquaculture is proposed in this paper. The Si4432 RF module is adopted to design the pH acquisition node and terminal node, which can realize the remote transmission of the pH value of the monitoring point. At the same time, a communication scheme to achieve reliable data transmission is designed in this paper. Visual C++ is used to develop the monitoring software of the host computer to realize the storage and display of the pH value of all monitoring nodes. To ensure that the user deals with abnormal circumstances in time, the DTU module is used to realize SMS alarm about the abnormal monitoring point. The result shows that the relative error of pH detection is below 3.17%, and the average packet loss rate is 3.4%, which indicates that the designed remote monitoring system in this paper can realize the pH detection and has certain reliability and practicality.

Keywords: Si4432; pH value detection; remote monitoring.

References

[1] Ma, Daokun. Wireless Sensor Network for Continuous Monitoring Water Quality in Aquaculture Farm. Sensor Letters, 2010, no. 8, pp. 109–113.

[2] Uddin, Md. Hanif. Impacts of organophosphate pesticide, sumithion on water quality and benthic invertebrates in aquaculture ponds. Aquaculture Reports, 2016, no. 3, pp. 88–92.

[3] Yue-Ming, Hu. Design of pH value of water quality wireless monitoring system for aquaculture. Transducer & Microsystem Technologies, 2014.

[4] Qian, Liu. Design of a Smart pH Value Transducer for Measuring Aquaculture Water Quality. Transactions of the Chinese Society of Agricultural Engineering, 2008.

[5] Jing, Dawei, C. Wang, Q. Liang. Influence of Feedwater Conductivity and pH Value in RO Systems. Industrial Water Treatment, 2006, no. 26, pp. 62–64.

[6] Milka M. Vidović. The influence of pH on removal of H2S and natural organic matter by anion resin. Desalination & Water Treatment, 2010, no. 21, pp. 255–263.

[7] Jiang, Long. Based SI4432 on the 915 MHz Radio Frequency Reader Design. Equipment Manufacturing Technology, 2010.

[8] Ding, Shi Ming. An Authentication Protocol Based on USB-KEY. Microcomputer Development, 2005.

[9] Frausig, Jesper. Industrialisation of Polymer Solar Cells. Phase 2: Consolidation. Technical University of Denmark. Dtu Energy Conversion Dtu Risoe Campus Roskilde, 2013.

[10] Meng, Ling Zhi. Preparation and Response to Metal Ions of pH Glass Electrode Modified by Polysiloxane Composite Membranes. Wuhan University Journal, 2003, no. 49, pp. 171–174.

[11] Qiong, Wi. Design of Intelligent pH Analyzer Based on MSP430. Electronic Test, 2013.

[12] Aoki, K. Nernst Equation Complicated by Electric Random Percolation at Conducting Polymer-Coated Electrodes. Journal of Electroanalytical Chemistry, 1991, no. 310, pp. 1–12.

[13] Wang, Cai Hong. The Research and Implementation of USB Communication Interface Circuit Based on FPGA. Applied Mechanics & Materials, 2012, no. 220–223, pp. 2032–2035.

[14] Sakthi, P. A., Sukanesh R. A Reliable and Fast Routing Data Transmission Protocol for Wi-Fi Based Real-Time Patient Monitoring System. Proceedings of the International Conference on Electronics and Communication Systems, 2014, pp. 1–5.

[15] Zou, Z. An Approach of Reliable Data Transmission With Random Redundancy for Wireless Sensors in Structural Health Monitoring. IEEE Sensors Journal, 2014, no. 15, pp. 809–818.

[16] Khattak, Muazzam Ali Khan. Challenging Ad-Hoc Networks under Reliable & Unreliable Transport with Variable Node Density. Journal of Theoretical & Applied Information Technology, 2008, no. 4, pp. 309–318.

[17] Lin, Chun Ting. Simple 60-GHz Radio-over-Fiber System with Transmission Distance Improvement Employing Signal-to-Signal Beat Noise Compensation. IEEE Journal on Selected Areas in Communications, 2013, no. 31, pp. 773–779.

[18] Hornbuckle, Gary D. Method and Apparatus for Remotely Controlling and Monitoring the Use of Computer Software, 1995.

[19] Murphy, Joe. Determination of Phosphoric Acid in Cola Beverages: A Colorimetric and pH Titration Experiment for General Chemistry. J. Chem. Educ., 1983, no. 60, pp. 420–421.

[20] Bapat, S. Analyzing the Yield of ExScal, a Large-Scale Wireless Sensor Network Experiment. Proceedings of the IEEE International Conference on Network Protocols. IEEE Computer Society, 2005, pp. 53–62.

Problem statement. AThe increase of metabolites of aquatic products such as remnant and excrement in the process of aquaculture could cause deterioration in the water quality and result in slow growth of aquatic products, even their death. Therefore, it is necessary to monitor the quality of aquaculture water, which complies with [1, 2]. In particular, the pH value has the most direct impact on fish and other aquatic products [3]. In general, the alkaline environment (pH value is 7.5 ~ 8) is suitable for the growth of aquatic products. If the pH value is low, the sulfide in water will become H2S with toxic. Phosphate fertilizer will be permanently ineffective, the growth of some zooplankton is inhibited, most of algae photosynthesis is weakened, which leads to the decrease of the intensity of the water mass. If the pH value is too high, the proportion of ammonia in water increases, and the toxicity of water is enhanced. Thus, at the time of hatching eggs, the egg membrane and the embryo can be automatically dissolved, which directly leads to the decrease of the output of aquatic products.

THE ARTICLE AIM is to present a solution to this problem, which is design of a pH remote monitoring system by using the Si4432 radio frequency module [4] combined with the Visual C++ programming environment. Through the verification, the system can realize the online detection of pH value, and has low cost and high reliability.

Basic material. ***General System Design.*** The system mainly includes three parts: acquisition node, terminal node and PC monitoring software. The diagram of the whole system is shown in Fig. 1.

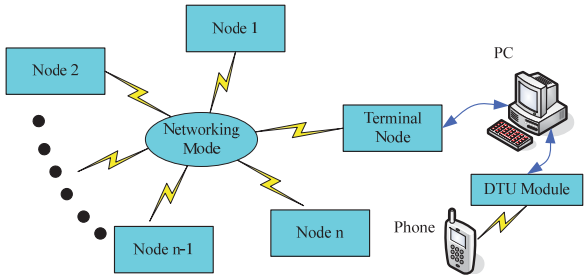

Fig. 1. Diagram of general system design

A number of acquisition nodes is respectively installed in the vicinity of the water area which needs to be monitored. After the completion of the pH value detection, the pH value is sent to the terminal node through the custom network, then the terminal node collects all the data sent by the acquisition nodes, and waits for the command of the host computer to upload data through the USB protocol. If pH value of some node is abnormal, or there is a node failure, the system will send a message to the user's mobile phone via the DTU module, which makes it convenient for users to handle it in time and avoid the economic loss effectively.

Design of pH Remote Monitoring System. Hardware of acquisition node. The hardware of the acquisition node consists of an MCU control module, a pH acquisition circuit, a Si4432 wireless module and a power-supply module. It is shown in Fig. 2.

The E-201-C-9 pH composite glass electrode produced by Shanghai Magnetic Electronic Technology Co., Ltd. is adopted in this paper to detect the pH value of aquaculture water. The range of output voltage is –420 ~ 420 mV, therefore, pH acquisition circuit is designed to process the output signal. The pH acquisition circuit is shown in Fig. 3. The LMP91200 chip [5] is selected to reduce the voltage error caused by the input bias current and the electrode impedance. Then the output signal is input to the internal AD converter of the microcomputer. In addition, based on Nernst equation [6], temperature compensation measure is adopted to improve the accuracy in the process of detection. Finally, the pH value is transmitted through the Si4432 wireless module. The power supply module is designed to provide the working voltage for the entire node.

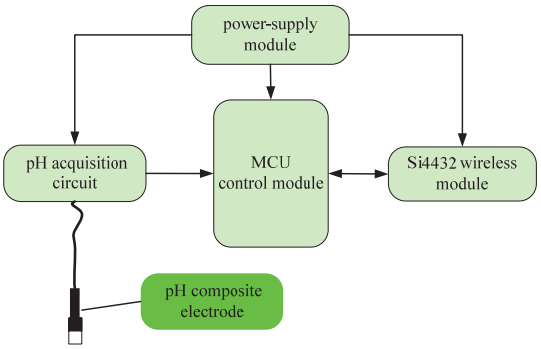

Fig. 2. Hardware of acquisition node

Hardware of terminal node. The hardware of the terminal node consists of an MCU control module, a USB power supply and communication circuit and a Si4432 wireless module. It is shown in Fig. 4. The USB power supply circuit provides the working voltage for the entire node; the MCU receives the data of all acquisition nodes through the Si4432 module, then uploads the data to PC for processing and displaying through the USB communication circuit.

Communication scheme design. Reliable data transmission is the core part of the whole monitoring system. In this paper, we design a scheme named variable transit node, where each acquisition node has the function of collecting and transferring the data of other nodes except its own data acquisition. The communication schematic is shown in Fig. 5. At first, acquisition node 1 is selected as a transit node, and it sends data collection instructions in the form of broadcast. Due to the influence of signal interference, transmission distance and other factors, each time the number of nodes that receive instruction is different. We assume that only node 2, node 3 and node 4 can receive the instruction from node 1. According to numbers from small to large, three nodes send data to node 1 in turn interval for a period of time which is $(ID-ID_{transit})\times t$. According to the data received, node 1 finds the maximum ID of nodes that is 4 in this case, then selects node 4 as the next transit node, and sends the data packet to node 4. If node 4 does not return "OK" signal within the prescribed time, node 3 will be selected as the next transit node, and so on, until the next appropriate transit node is found. When node 4 receives the data properly, it will continue to send data collection instructions in the form of broadcast, and only receive nodes whose ID number is larger than its own, such as node 5, node 6 and node 7. Then it repeats the above operation, until the data of all nodes is transferred to the terminal node.

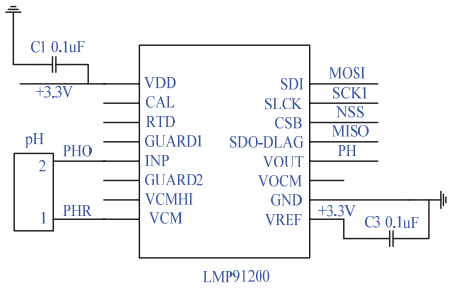

Fig. 3. pH acquisition circuit

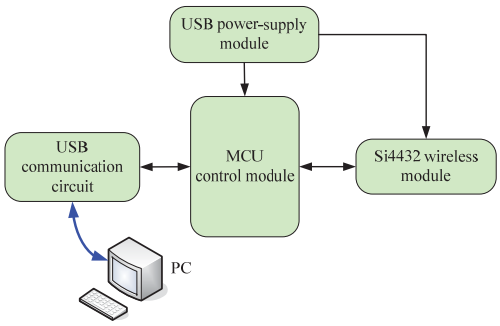

Fig. 4. Hardware of terminal node

Design of Monitor Software. The core part of the system is design of monitoring software based on Visual C++ [7]. In this paper, the monitoring software can communicate with the lower computer through the USB, so as to realize the data processing and display. The main functions of the software are as follows: 1) displaying the corresponding pH value and the running state according to the selected time and the node; 2) displaying the number of the abnormal node and the corresponding fault information; (3) setting the serial number and baud rate, and starting the DTU device to send text messages in abnormal conditions, so that users could deal with it in time. A part of the interface is shown in Fig. 6.

Experiment and Analysis. pH Detection Experiment. The pH detection equipment is composed of a beaker, a pH composite electrode, a supporting frame, a control box, a PC, and a base. The supporting frame used for fixing the pH composite electrode is mounted on the base. The beaker also is placed on the base, and it is filled with a water sample to be analyzed. The integrated circuit inside the control box is used to process the output signal of the pH electrode and transmit the corresponding result to the PC through the USB interface. At the same time, we can observe and save the pH value through the PC. Fig. 7 shows the structure of the experimental equipment.

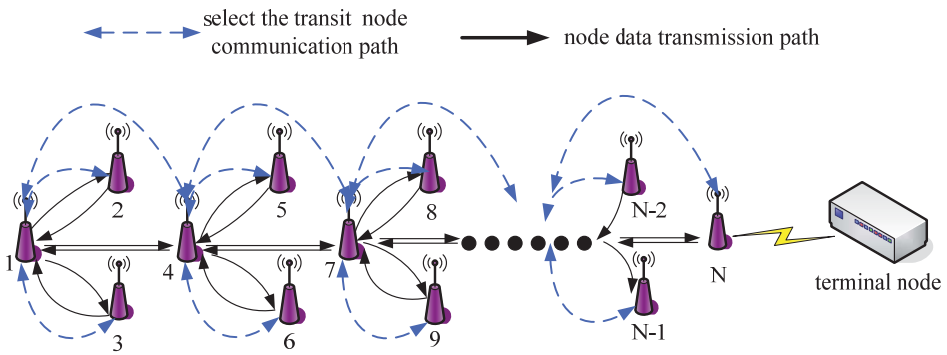

Fig. 5. Schematic of node communication

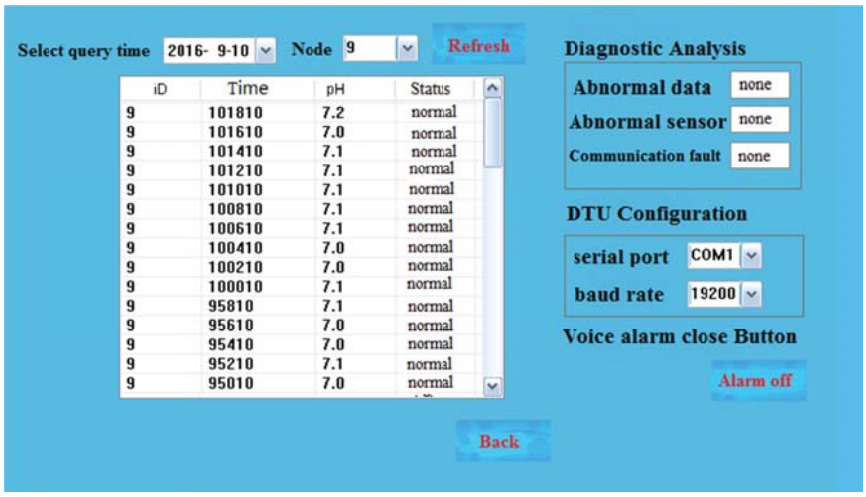

Fig. 6. Interface of monitoring software

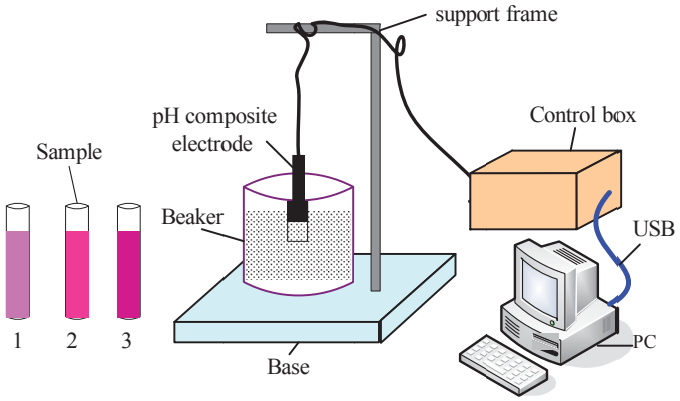

Fig. 7. Interface of monitoring software

For this paper, three kinds of liquid samples with different acid and alkali degree have been prepared. The pH value is detected by using pH detection equipment and compared with the real value. The specific results are shown in Table 1. The detection error of the designed acquisition node is low and equal to 3.17%; it can be put into use.

Network Reliability Experiment. The schematic of the network experiment is shown in Fig. 8. Six adjacent rooms of a story of a school building are selected for it. The specifications of each room are the same, and all of the rooms are 10×12 m. In this paper, 20 acquisition nodes and one terminal node are designed. Four acquisition nodes are placed in room 1 to room 5, respectively. The terminal node and the host computer are placed in room 6. All the acquisition nodes are placed in the four corners of the room and run continuously for five days. The PC communicates with a terminal node every two minutes, which means the PC should receive 720 packets one day. According to the communication scheme in-

Table 1. pH acquisition results

	NO.	Standard value	Detection value	Relative error
pH	1	7.5	7.3	2.67%
	2	8.1	7.9	2.47%
	3	6.3	6.5	3.17%

Table 2. Data packet loss rate

Day	1	2	3	4	5	Average
Number	23	26	15	31	29	24.8
Loss rate (%)	3.1	3.6	2.1	4.3	4.0	3.4

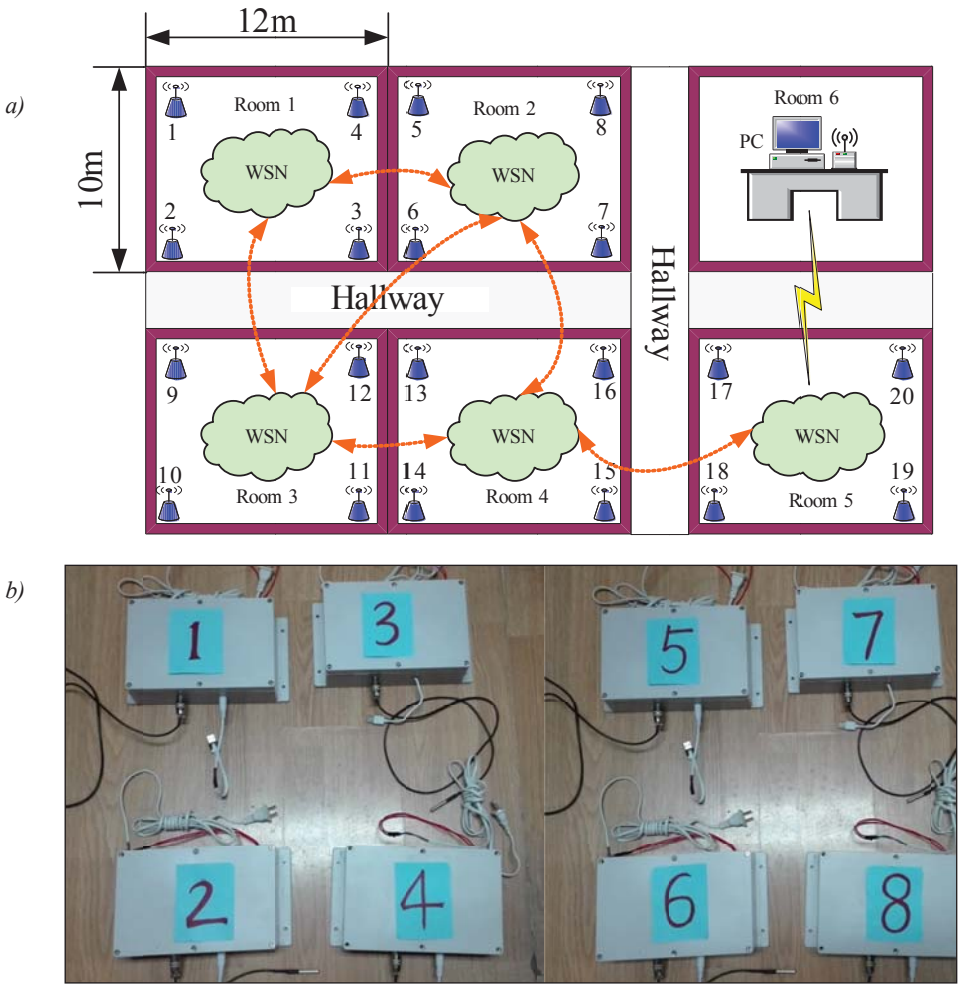

Fig. 8. Diagram of networking experiment:
a — sketch map; *b* — actual appearance

troduced earlier, node 1 wakes up the entire link. After multiple forwarding, the data collected will be finally sent to the terminal node via node 20, then the terminal node will transmit the data to PC software. We can obtain the data packet loss according to the statistics of the PC software.

The statistical results are shown in Table 2. The average packet loss rate is 3.4%, which indicated a high quality of communication in the communication scheme designed in this paper.

CONCLUSION. A pH remote monitoring system used in aquaculture is proposed in this paper. The Si4432 RF module is used to realize the remote transmission of the pH value. A new communication scheme is designed to achieve reliable data transmission. The monitoring software is designed to storage and display the pH value of all nodes. Besides, the DTU module is used to realize SMS alarm. The result shows that this system can realize the pH value detection online, and it is an effective and low-cost method in aquaculture.

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