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Design of Fishpond Water Quality Monitoring and Control System Based on ZigBee

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Abstract: LPC2131 is the main controller of the monitoring system to realize the monitoring and regulation for water quality parameters in fishpond water quality monitoring system. The main parameters include temperature, dissolved oxygen, PH value and the water level. ZigBee wireless communication technology is used in the system, which will transmit monitored information to the monitoring and control center in a host computer. The host computer can real-time display the historical data of fish pond water quality parameters of each terminal and the history data are stored in Access database for later data analysis. Simultaneously, lower computer terminals can be controlled by the PC's control panel, which can make it realized that the water quality parameters will be automatically adjusted according to the set threshold in lower computer terminals. In the end, the goal to reduce labor burden and to improve the yield and quality is achieved.

Keywords Water quality monitoring; LPC2131; ZigBee; Fish farming

INTRODUCTION

With the constant improvement of the people on aquatic products quality, aquaculture will gradually change from the traditional way to the large-scale, intensive, diversified farming, breeding technology level will also increase rapidly.

It's known from biological knowledge that pond water temperature, illumination, dissolved oxygen, ammonia nitrogen and PH are very important for the growth of fish, but it is difficult for people to accurately and timely adjust these factors[Li,2007]. Now most of the fisheries management is guided by the breeding experience, it is difficult for people to secure the yield and quality of the fish ponds. In view of the characteristics for aquaculture environment, which are of diversity, dynamics and dispersion, the pond water quality monitoring system based on ZigBee can save a lot of manual operation and electricity consumption for the fish farmers, and can prevent control the loss caused by fish diseases effectively, and reduce the death rate. Through long-term continuous monitoring, adjustment and control of water quality, the breeding production and aquatic product quality can be obviously increased and improved[Huang *et al.*, 2013].

POND WATER QUALITY MONITORING AND CONTROL SYSTEM DESIGN

The basic principle of pond water quality monitoring system

Pond water quality monitoring system is based on people's needs for fish pond aquaculture, the key water quality parameters in the aquaculture process will be sampled and controlled in real-time by all kinds of sensors acquisition. Firstly, the sensors are needed to sample water quality parameters, including temperature, water level, PH and dissolved oxygen, etc., which are processed through the signal conditioning circuit and are input to LPC2131 AD converter so as to convert analog to digital quantity. Secondly the converted results will be sent to the ZigBee wireless module via a serial port in LPC2131 controller, and then transmitted to the PC monitoring system[Zhou,2012]. In the PC monitoring system, the received data are processed into actual unit values, and the results are displayed real-time in the PC interface.

PC monitoring system can not only display water quality information from various fishpond terminals real-time, but also send control command to the monitoring terminals (LPC2131 controller) via ZigBee wireless network. Then the monitoring terminal compares the current values and real-time control values after receiving the control command, correspondingly, it will send control signal to actuator so as to maintain the water quality parameters in the control range. In addition, the PC will also collect data and store them in the database regularly, for later use in data analysis.

The overall scheme design

According to the basic principle of pond water quality monitoring system, the final overall scheme design of the system is shown in Fig.1.

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The whole pond water quality monitoring system is based on LPC2131, which works as the main controller. The system includes power supply module, the infrared distance measurement module, PH detection module, temperature and air pressure module, alarm module, water pump control module, Nokia5110 LCD module, ZigBee wireless transmission module, etc. The interaction of these modules constructs the hardware of the pond water quality monitoring system.

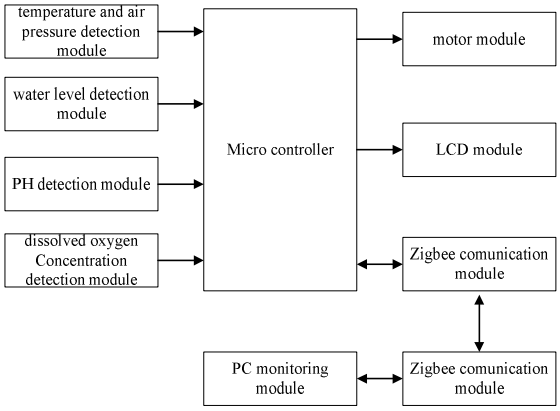

Fig.1 The overall hardware design block diagram

THE REALIZATION OF THE SYSTEM MAIN FUNCTION MODULES

Temperature and air pressure detection module design

The integrated sensor module GY-68 BMP180 is selected in temperature and air pressure acquisition module, which can be directly connected to a variety of microprocessors through the I2C bus.GY-68 BMP180 module circuit principle diagram is shown in Fig.2.

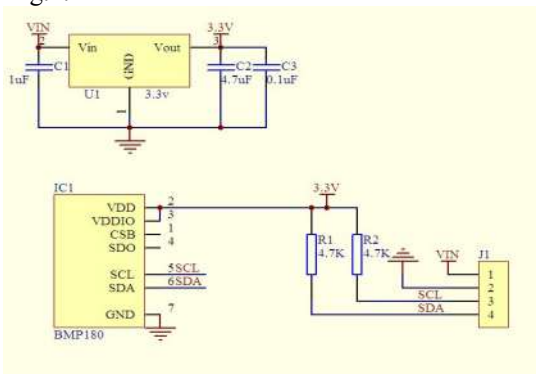

Fig.2 The circuit principle diagram of GY-68 BMP180 module

The water level detection module design

SHARP GP2Y0A21YK0F is a distance measuring sensor unit, which are integrated with PSD (position sensitive detector), IRED (infrared emitting diode) and signal processing circuit. Because triangulation method is used in this sensor, it is less susceptible to reflectivity of the object, environment temperature and duration of the operation, the output voltage directly represents the distance.

The output voltage of SHARP GP2Y0A21YK0F can be divided into two parts respectively. When the distance is from 0 to 7 cm, sensor output voltage is proportional to the distance, and the slope is very big, the sensitivity is high. When the distance is in 7 ~ 80 cm, the output voltage is inversely proportional to the distance. So the distance calculation formulas can be got as follows:

$$U = \frac{23}{L} \qquad (7\text{cm} \le L < 80\text{cm}) \quad (1)$$

$$U = \frac{2}{3}L \qquad (0\text{cm} < L < 7\text{cm}) \quad (2)$$

Where, U is the output voltage, the unit is V .L is the distance. The AD Conversion digit is 10 in LPC2131, so in formula (1) and (2),

$$U = \frac{AD \times 3.3}{(2^{10} - 1)} \qquad (3)$$

Where, AD is the AD conversion result.

PH acquisition module design

PH acquisition module consists of PH probe(sensor), and signal conditioning circuit.E201-C-9 electrode is used for PH probe. E201-C-9 electrode is the composite electrode which is made of glass electrode and reference electrode together, it is a PH detection sensor. Measuring range is 0-14, measuring temperature is 0-80℃. The PH sensor conditioning circuit is shown in Fig.3.

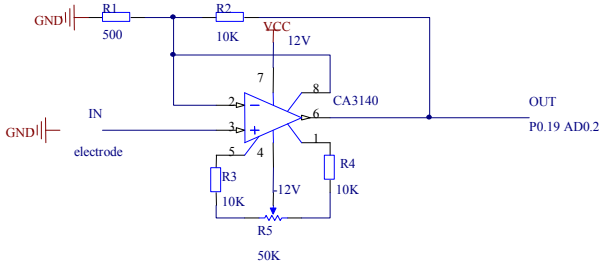

Fig.3 PH sensor conditioning circuit

The high input impedance operational amplifier CA3140 is applied to the design, because the PH probe resistance is very big, the input resistance of the conditioning circuit needs to be greater than 106 MΩ for effective measurement. And CA3140 input impedance is high, the typical value is 1.5 TΩ, which can satisfy the demand and the price is relatively cheap.

Through the conditioning circuit, PH sensor probe measurement signal is amplified and then is input into AD converter. According to relevant information available[Yang,2009] ,E201-C-9 nernst equation is as follows:

$$E = 0.1984 \times (T + 273.16) \times (7 - PH) \quad (4)$$

Where, E is output electromotive force, the unit is mV. T is the tested solution temperature, the unit is K.PH is the tested solution PH value.

Through the conditioning circuit, galvanic cell output electromotive force is amplified 21 times , the zero is regulated to 1.5 V. therefore, PH calculation formula is shown in formula(5)and(6).

$$E = 0.1984 \times (T + 273.16) \times (7 - PH) \times 21 + 1500 = \frac{3.3 \times 1000}{2^{10} - 1} \times AD \quad (5)$$

So,

$$PH = 7 - \frac{\frac{3300}{1023} \times AD - 1500}{0.1984 \times (T + 273.16) \times 21} \quad (6)$$

The design of the ZigBee wireless transmission module

ZigBee technology is a kind of wireless communication technology based on the IEEE 802.15.4,which is concerned with network building, security and software[Sheng *et al.*,2011]. The ZigBee technology characteristic is close and is of low complexity, self-organization, low power consumption, low data rate.The on-chip system CC2530 module produced by TI Company is selected as the system network node in the design[Li,2010]. The hardware principle diagram is shown in Fig.4.

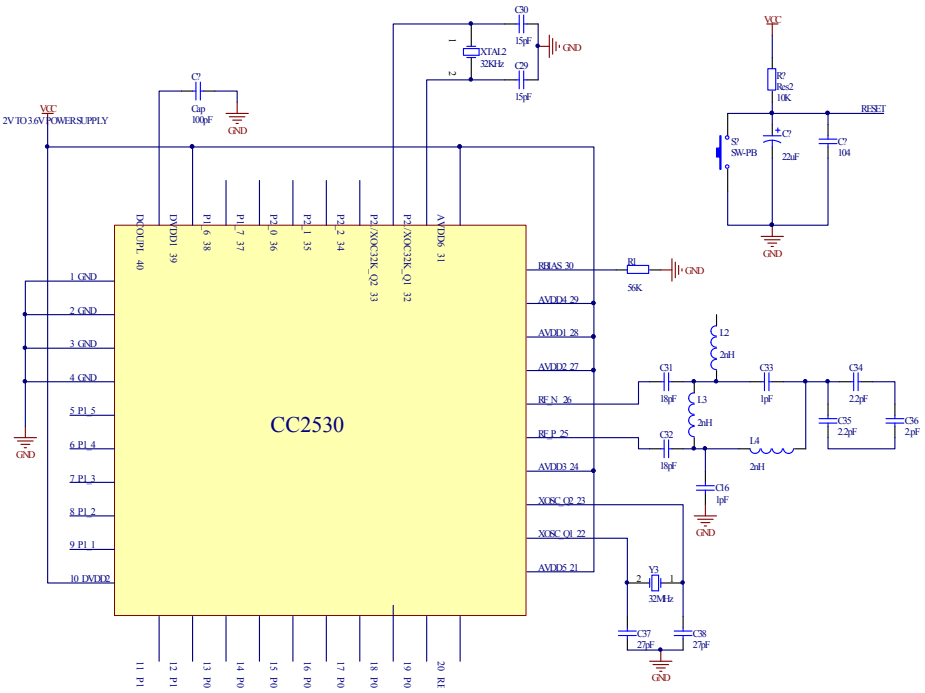

Fig.4 The hardware principle diagram

SOFTWARE DESIGN

LPC2131 from ARM7 series works as the main controller in system, through which the real-time monitoring of some important parameters in the pond aquaculture is implemented. The first thing to do in the main program is to initialize the UART0, SPI, I2C, AD and GPIO. After the completion of all the initialization, command from the host computer is monitored real-time, its corresponding function is achieved by testing each command characters. This system contains multiple modules: temperature monitoring module, water level monitoring module, PH monitoring module, the oxygen concentration monitoring module[Zhou,2012].

ZigBee wireless communication technology is used to realize the communication between host computer and lower computer. monitoring software. Wireless passthrough mode is adopted in Zigbee, each terminal is worked as the router, host computer links with the coordinator[Wang,2011]. Zigbee builds star network automatically, that is, host computer is able to receive data from each node and each node can receive monitoring commands from host computer.

The main program flow chart is shown in Fig.5.

In Fig.5, “ s ” stands for the start of communication. Terminal number stands for each lower terminal number and is used to distinguish each terminal. Symbol ”1” shows the transferred data is temperature data . Symbol ”2” shows the transferred data is water level data . Symbol ”3” shows the transferred data is pressure data . Symbol ”4” shows the transferred data is oxygen concentration data .

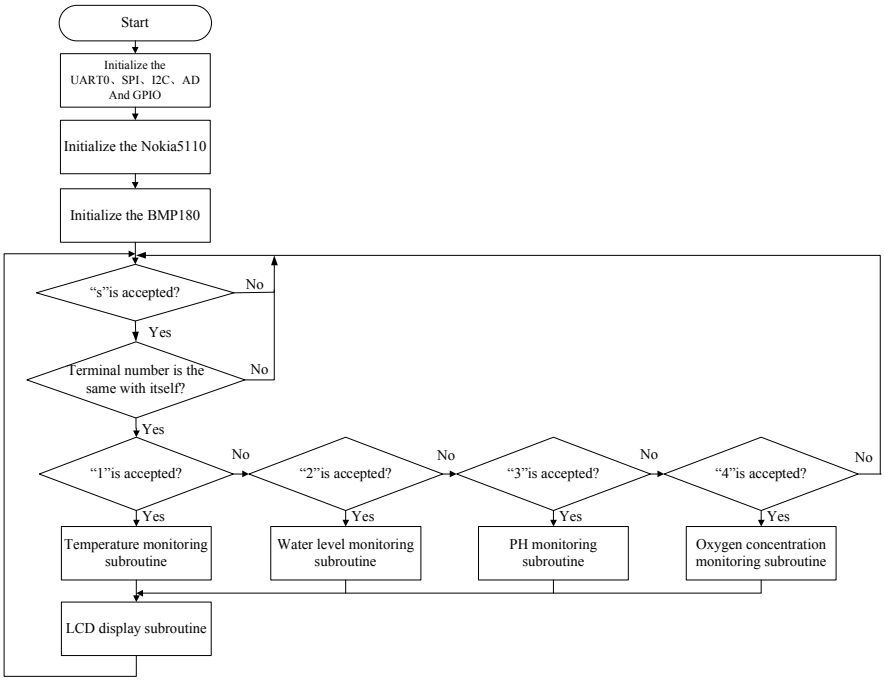

Fig.5 The main program flow chart

CONCLUSION

Through software and hardware joint debugging, the results show that the function of pond water quality monitoring system is implemented, and the real-time monitoring of important water quality parameters in the process of pond aquaculture is completed, and is of good stability and real-time performance. ZigBee wireless network technology is applied in the system, which can realize distributed complex environment monitoring requirements and has a broad market prospects.

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