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Design of a mobile hydrological data measurement system

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Abstract. The current hydrological data acquisition is mainly used in the instrument measurement. Instrument measurement equipment is mainly fixed in a certain water area and the device is easy to be lost. In view of a series of problems, the dynamic measurement system is established by the method of unmanned surface vessel and embedded technology, which can realize any positions measurement of a lake. This method has many advantages, such as mobile convenience, saving money and so on.

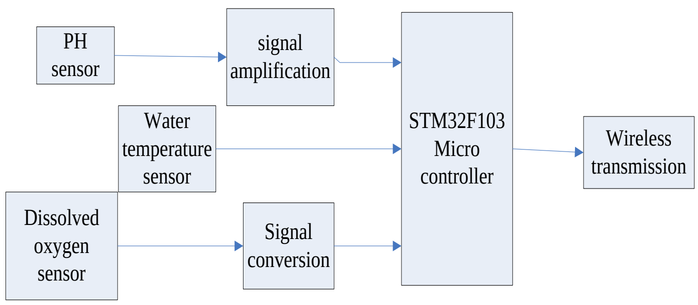
1 Introduction

Water is one of the important composed of elements in the relationship between human existence and nature. With the development of human society, the nature changed and destructed by people is growing more and more. But these destruction lead to soil erosion, water quality and other harsh environmental crisis occurred. Hydrological data collection can help people better learn the water quality and use of water than before. These technologies can provide the basic information services to the constructions design of water conservancy and hydropower, bridge, port and other engineering, and better service to human life [1].

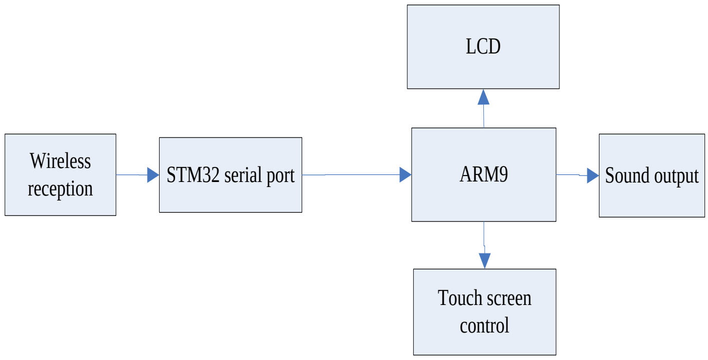
Now, the data were usually measured from single position by the fixed device. But the single location data cannot be used to describe the whole water region, which often bring great trouble to the actual production. In order to improve the situation and avoid the huge property loss caused by the unrealistic data, a monitor method of wireless hydrological data based on ARM technology is applied on the mobile vessels. the data of different locations for data fusion makes the authenticity of the data greatly improved. The data is transmitted from sensors to the ground terminal by wirelessly technology of NRF24101. And the data will be analyzed and displayed on the LCD [2-4].

2 Hardware Design

2.1 System composition



a. transmitting device



b. receiving device

Fig1 Design block diagram

The system is composed of by vessel, sensors, and the data transmitting device (see Fig.1 a) and data receiving device (Fig.1 b). The vessel is equipped with a PH test probe, a temperature sensor, a water pressure sensor, and other elements. These sensors can measure the hydrological data of a large range waters by the moving vessel. The wireless signal begins to be transmitted by the wireless module after the corresponding power and the receiving address is consistent with the parameters of the receiving module. The wireless transmission module based on the 2.4G communication principle includes the internal power amplifier, crystal oscillator and other devices. The data accordance with PH value, water temperature, water pressure is transmitted from serial port after the definitions by the single chip controller. A touch screen interface is developed with a cross compiler by platform of Qt Creator in the ARM system. The start of interface will give a voice warning by sound card [5-6]. The data will be displayed in the corresponding box, when the corresponding serial number and transmission rate is open in the test.

2.2 Circuit design

PH value measure

The core of system's test electrode of PH sensor is made up of glass electrode and the reference electrode, which is used to measure the aqueous solution of hydrogen ion concentration, that PH value. The component measurement signal can be recognized by the microcontroller with a certain signal conditioning because the signal is relatively weak. The amplification gain of the signal conditioning module can be adjusted by the potentiometer to meet different needs. The gain circuit is shown in the fig.2. Amplifier module using two-stage amplification, the first level of the larger input impedance of the FET CA3140AMZ, to reduce the loss of the signal, the second level is a common operational amplifier TL081BCDG4, the signal to enlarge the magnification [7].

The amplified signal is an analog signal that requires an analog-to-digital conversion to get the correct data. STM32F103VET6 embedded three 12-bit ADC, can achieve a single or multiple scans, ADC results can be left or just right-aligned stored in the register, and then read the memory through the command. PH value is more reliable at about 25 °C. It is necessary to test the offset value before the formal experiment. PH electrode is inserted into the PH value of 7.00 standard solutions, through the serial monitor to print out the PH value at this time. Then the offset value is calculated by the average value of ten times compared with 7.0. The last results need to subtract this offset value.

Wireless transmits

The wireless transmission module and receiver module of NRF24L01can communicate to meet the three conditions: (1) The same channel (2) Each send and receive has the same number of bytes (3) Receive and send the same address. The data communicate between the chip and single microcontroller by the SPI bus. This chip contains a number of registers, which is divided into control registers and data registers, and the register is set by command. The system uses the controller to configure the port as a hardware SPI way, to avoid the lack of analog SPI mode. Data is transmitted on the bus to complete the setup of the chip. Four lines only need to be connected for the SPI bus: serial clock line (SCK), host input/slave output (MISO), host output/slave input (MOSI), slave output (CS). After the data has been transmitted through the bus, it is not necessary to clear the register, and the state can be judged directly.

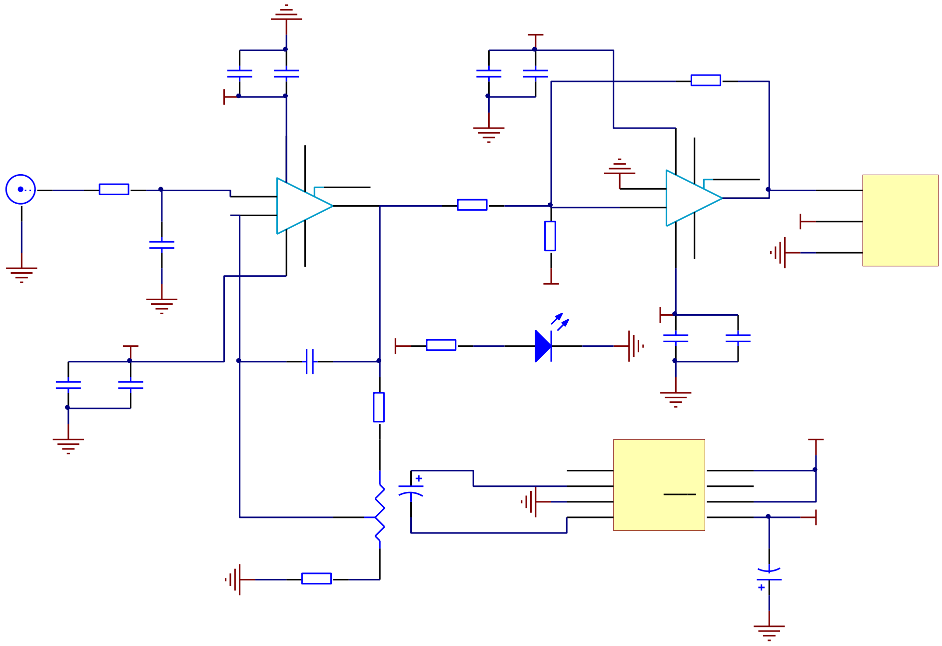


Fig2 PH measure circui

Audio codec

Audio codec chip of Philips UDA1341 (see Fig.3) uses the standard IIS bus to control its registers. The separation of data signal and clock signal can effectively reducing the audio jitter and the overhead. The standard IIS bus consists of three serial lines: a serial clock line (SCLK), a frame clock line (WS), and a serial data line (SDATA). The microprocessor of Samsung's ARM9 is built-in IIS bus interface, which is directly connected with the interface of audio chip IIS [8]. Due to avoid the emergence of audio playback load phenomenon, this design uses a direct memory DMA way, in the memory to establish a buffer. The controller through the L3 to complete the volume, status and other registers control, and use the IIS bus will be stored in the memory of the data transmitted to the audio codec chip, sent to the amplifier for sound playback. L3 bus is also composed of three lines, namely the model line (MODE), clock line (CLK), data line (DATA). The data transmission is completed by interaction between DATA and CLK with the transmission order from low to high.

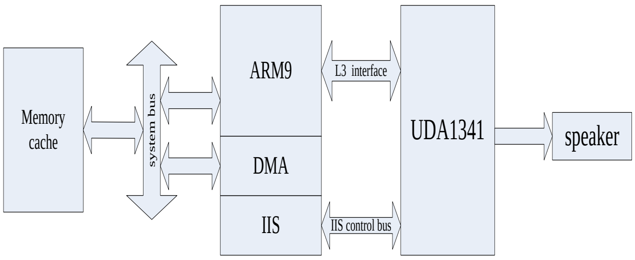


Fig.3 Audio bus block diagram

3 Software Design

3.1 Acquisition node software design

The design of the collection node is the core of the whole system, which will lead to the correct transmitting. The modular design ideas are applied into the development platform based on uvision5, which includes the compile and debug. The system include: ADC conversion, transmission function, temperature acquisition and other parts, the flow chart as shown in Fig.4.

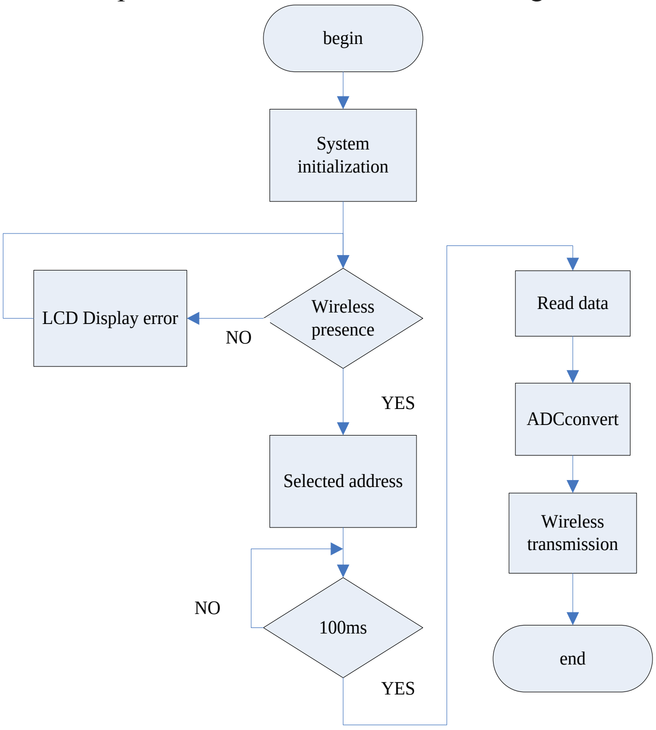


Fig4 Flow chart

3.2 Terminal software design

Terminal software design is the first use of bare metal STM32 to receive wireless data, and then send out the data by the serial port in accordance with the previously scheduled data format. Terminal interface program is running on the ARM development system, ARM development system is based on the Linux kernel, and the boot code uboot, Linux kernel and yaffs file system are set up by the transplant of actual onboard device respectively. After the three parts of the transplant, the kernel has been able to start the normal operation. A Qt graphical interface will be start successfully by running the binary file through the nfs file system to the development system. The operator selects the appropriate serial port cording to the actual situation. The data open in the serial port can be displayed correctly in the corresponding box.

3.3 Experimental analyses

In the experiment, the prototype was sailing in a certain water area at the speed of 0.25m/s. the Physical model as shown in Fig.5. The test data record for 15 times is analyzed. Analysis chart as shown in Fig.6, Fig.7, Fig.8. By comparing the data of a certain time is shown in Table 1.

Fig 5 Physical model

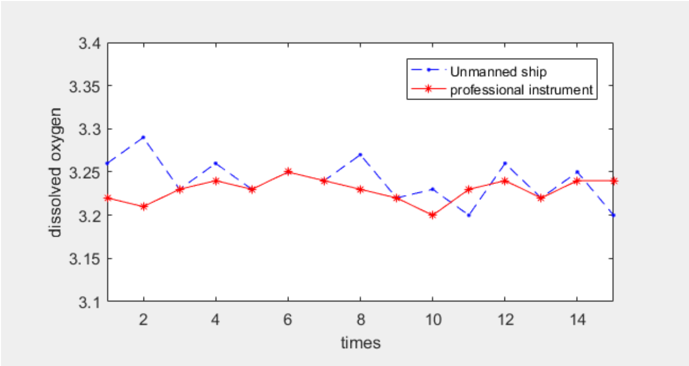


Fig 6 Dissolved oxygen

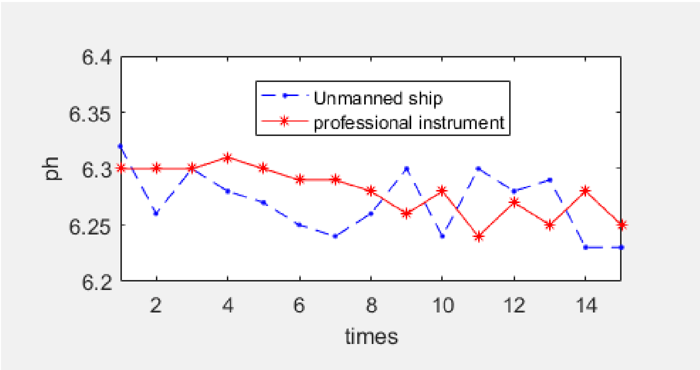


Fig 7 PH

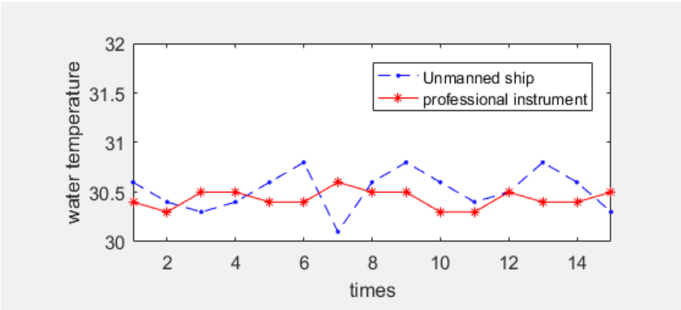


Fig 8 Water temperature

Table 1 Data comparison table

mode	0.5m water temperature	Dissolved oxygen	PH
Professional instrument	30.5	3.3	6.7
Unmanned ship	30.3	3.2	6.6

From the graph and table it can be seen that there are some errors in the acquisition of water quality data of unmanned ship compared and professional instruments, but they are all in the allowable range. The errors in the sensor conditioning circuit and data processing, which can be further reduced by optimizing the hardware and software design.

After a rigorous test, the data measured in the absence of obstacles can be achieved in the case of 1000 meters, in the building it can also achieve intensive communication distance of 600 meters. The experimental results basically meet the functional needs.

Acknowledgements

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