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Research Article

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Design and implementation of wireless intelligent monitoring system for environment

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ABSTRACT

On the basis of experiments, using advanced measurement and control technology, a new type of wireless intelligent monitoring system for environment has been designed. The system is mainly consisted of data collection terminal and mobile monitoring terminal. Using 16-bit microcontroller SPCE061A as the processing core, in the data collection terminal, using the chip CD4067BE to connect temperature and humidity sensors, light intensity sensors, CO_2 sensors and PH value sensors, in this way, temperature, humidity, light and other parameters of environment can be collected. 10-bit ADC is selected to recode environmental sound, OV7670 webcam is used to for real-time monitoring. Collected data frames are transmitted to mobile monitoring terminal through the wireless transmission module NRF905, in the mobile monitoring terminal, data are received through NRF905. The processed parameters of environment are displayed. The received compressed codes are decoded by DAC of 10 byte, and then they are played. The display modes are selected by switching function keys, and the received parameters of environment are stored into the SD card. Repeated experiments and applications show that the design of overall system is compact, the system has a high degree of intelligence, cost-effective, high stability and high reliability, and it can meet the actual needs.

Key words: Wireless communication, Sensor, Environmental parameters, SPCE061A, HMI

INTRODUCTION

Currently, the monitoring systems for environment environmental monitoring system are in everywhere, but they are single mode of separation, and they are valuable, their power consumptions are high, the mobility is poor and they require higher hardware and software supports. The communication of collection terminal of data and monitoring terminal needs very long communication line, thus the stability of the system becomes very low, for many parameters of multi-point monitoring places, conventional devices can′t meet the requirements of its node number, their feasibilities are not high, and the rate of space occupancy is high.

Some traditional devices for sensor replacement are extremely inconvenient, the replaced sensors need to be renumbered and they are not easy to maintain [1]. In the view of the above deficiencies, we have studied and designed a set of wireless intelligent monitoring system for environment integrating with environmental parameters monitoring, voice and taking photographs.

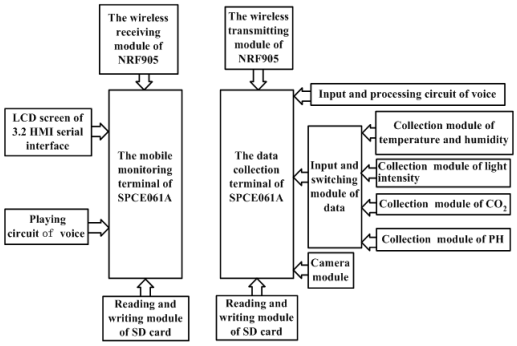
EXPERIMENTAL SECTION

OVERALL DESIGN OF THE SYSTEM

The wireless intelligent monitoring system for environment is mainly consisted of collection terminal of data and mobile monitoring terminal. The collection terminal of data includes SPCE061A core board, collection module of temperature and humidity, collection module of light intensity, collection module of CO_2, collection module of PH, data switching module CD4067, inputting and processing circuits of voice, taking photographs, reading and writing

module of SD card, wireless transmitting module of NRF905. The mobile monitoring terminal includes SPCE061A core board, reading and writing module of SD card, wireless transmitting module of NRF905, playing circuit of voice, 3.2-inch LCD screen of human-machine interface. The block diagram of the system is shown below.

The Block Diagram of the System



DESIGN OF THE MAIN MODULES

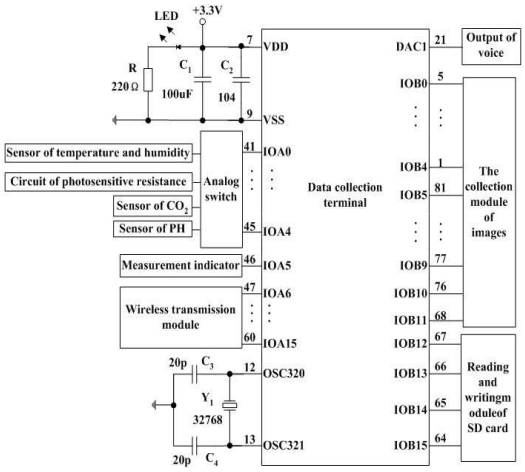
Power modules

We can get DC +7.4V by the series connection of two large-capacity polymer batteries, and then using IC LM7805, we can get DC +5V [2], it can provide power to the temperature and humidity collection circuit, the light intensity collection circuit, CO_2 collection circuit, PH value measurement circuit. Finally, DC +5V is input into the integrated chip SPY0029, the DC +3.3V is gotten, it provides power to SPCE061A processor.

Controller module

The controller is the core of the wireless intelligent monitoring system for environment, and its performance will directly affect the performance of the system. The data collection and processing speed, on-chip RAM capacity, on-chip ROM capacity as well as voice, video, pictures and other digital signal processing capability of common type 51 single chip microcomputer can't meet requirements of the system. Although the data processing speed of AVR microcontroller has a certain upgrade, but for voice, video, pictures and other digital signal processing is too much trouble, they are require more complex software programming support, and the development cycle is longer, they are not easy to maintain. SPCE061A MCU is the launch of a 16-bit microcontroller developed by Sunplus Technology, with fast processing speed, low power consumption, ease of debugging, etc., it is applied to the digital signal applications products [3], it is the most economical choice, so we use SPCE061A MCU as the controller. The controller circuits are mainly made of SPCE061A and its peripheral circuits. The connection of data collection controller and the other module is shown below.

Controller Circuit



The collection module of temperature and humidity

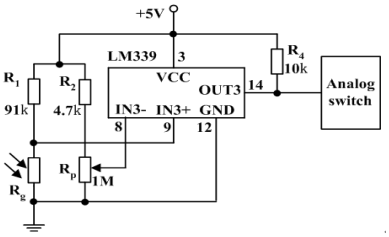
The value of thermistors and humidity resistances will vary according to the changes of environment, coupled with resistive divider circuit, and then we use AD converter in the microcontroller for collecting voltage, in this way, we can get temperature and humidity of environment. Input of sensors in this program are analog, when we collect

multi-channel data, the microcontroller need to take up too much of the IO port, but it is constrained by the linearity of the resistors and the manufacturing error of resistor, it is very difficult to obtain stable and relatively accurate data. DS18B20 is a high precision single-bus temperature sensor, on-chip comes with a unique serial number, but its price is relatively high. DHT21 is a type of digital sensor, it has an output for a single bus, integrating with the temperature and humidity, and it integrates on-chip 8-bit microcontroller, it doesn't need additional external circuits, and its conversion time and a single communication time is shorter [4]. So we use DHT21 to collect temperature and humidity.

The collection module of light intensity

If using a special light-sensitive chip, the light intensity can be accurately obtained, but the price is high, peripheral circuit of the chip is complex, and production process of PCB is high. Using photosensitive resistance, adding a comparator and a dividing adjustment potentiometer of voltage [5], adjustment potentiometer is set to the desired position, when the light intensity is greater than the set light intensity, the comparator output is low level, and on the contrary, the comparator output is high level. In practical applications, we do not need real-time measurement of light intensity, and we don't need exact value of light intensity, we just need a critical value to ensure that the light intensity can′t exceed the safe value. In the design process, we use the comparison circuit of photosensitive resistances to collected light intensity, the circuit is shown below.

The Collection Circuit of Light Intensity



The Collection module CO_2

Infrared absorption of CO_2 sensor has characteristics of high precision, good stability and high reliability, when it wants to detect CO_2, it must work with optical device, and this device has high cost, it is bulky and inconvenient to use. Although Electrochemical and thermal conduction sensor of CO_2 has small volume, but its stability, accuracy and reliability are all not ideal to detect CO_2. Solid electrolyte sensor has many virtues such as high sensitivity, little affected by temperature and humidity, good stability, good linearity and so on, but also it is easy to amplify the output voltage, it simplifies the measurement circuit greatly [5]. Summing up multi-disciplinary consideration, we chose the solid electrolyte sensor MS4100 to detect CO_2.

The Collection module of PH

One of the measurement methods is electric potential method. In this method, the pH glass electrode and calomel electrode are inserted into soil suspensions or lixivium, the EMF value is measured, and then is converted into the pH value. This method only applies to measure the PH value of soil, it is also difficult to operate, and it is not conducive to improve the intelligence of the system. The dedicated sensor of PH has a wide range of applications, it can be directly connected with the microcontroller, it can not only simplify the circuits, but also can do long-term online test, and prolong the life of the system. So it improves the intelligence of the system greatly. Therefore, we choose H311-AS002 sensor to measure PH.

The data input module of sensors

SPCE061A MCU only has 32 IO ports, if the parallel input mode is used, IO ports are not enough, the function of the system can′t be completed, so the program is undesirable. We use digitally controlled CMOS analog switch CD4067BE to detect data of sensors periodically by query mode.

The collection module of images

The data output speed OV7670 camera is higher, the data stream is large, if the OV7670 is directly connected with the single-chip, SPCE061A need free up more resources coordinate with OV7670 to complete the collection of image data, so that SPCE061A is difficult to match with OV7670, it increases the chip's power consumption and data error rate, and its stability is lower [6]. We add the FIFO memory chip AL422B to the data output port of OV7670, AL422B can store 3M-bit data, output data of OV7670 are stored temporarily into AL422B, AL422B plays a buffer role, and SPCE061A only needs to read the image data of AL422B from time to time, what's more the user is free to set the read speed, it reduces resource consumption of the microcontroller greatly.

The mode of data storage

If we use off-chip ROM chip, its storage space is small, it is expensive, and it has parallel operation, it uses many IO ports, and it is inconvenient to read and write, it is also inconvenient to copy data with external devices. Therefore, we use the SD card to read and write, its capacity is large, it is easy to use, it use SPI communication mode, it occupy less microcontroller IO port, the speed of reading and writing is fast, it can easily to operate the SD card coupling with the FAT file system.

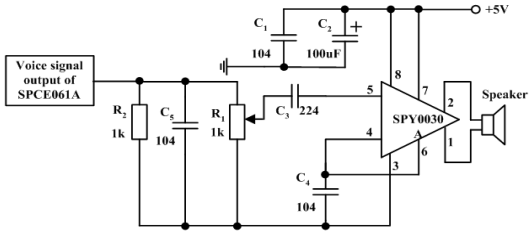
The mode of display

If we use pure TFT color LCD screen, the driver of MCU is complex, parallel operation occupies more IO ports, the speed of refreshing screen is slower, it is difficult to meet the instant display of images, the occupancy rate of MCU resources is large, and the ability of visualizing human-computer interaction is poor. We use the LCD screen with HMI serial port, it uses serial communication, its operation is easy, it only need two IO ports, its baud is rate up to 961200bps, it is integrated dedicated driver chip and graphics operated SPI function interface, it can store 255 pictures, the refresh rate of image is fast, it greatly reduces the share of resources of the microcontroller, it has a high interactive capability.

The playing circuit of voice

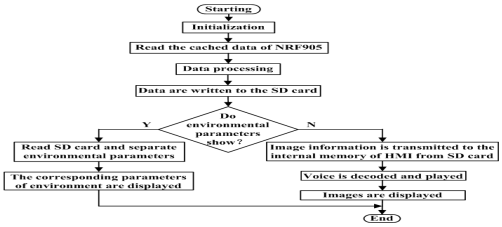
Voice signals are decoded by the voice library functions, and then they are encoded into analog voice signals by 10-bite DA which is in the processor, the analog voice signals are amplified by the voice signal amplification chip SPY0030, and finally analog voice signals are played. The playing circuit of voice is shown below.

The Playing Circuit of Voice



THE SOFTWARE DESIGN OF THE SYSTEM

The Main Program Flow Chart of the Mobile Monitoring Terminal



The software design of the system is programmed by C language and assembly language, the driver level is programmed by assembly language, functional level is programmed by C language. The overall software design uses modular programming, we set aside a corresponding communication interface, and finally through the API function to integrate, it is easy for overall debugging of the system, maintenance and upgrade of the software [7], the main program flow chart of the mobile monitoring terminal is shown above.

RESULTS AND DISCUSSION

Taking the square of Heze University as the measuring object, parameters of the square are measured by the standard instrument, the standard value of temperature is $13^{O}C$, the standard value of humidity is26%RH, the standard value of light intensity is 1200LX, the standard value of CO_2 is 410ppm, and the standard PH value of air is 7.7. The collection terminal of data of the wireless intelligent monitoring system for environment is placed at the right position, the power is turned on, and then the collection terminal of data begins to work. At the same time, the corresponding information is gained in the mobile monitoring terminal, part of the measured data are shown in table 1.

Table 1. Part of the Measured Data

No.	Temperature(°C)	Humidity(RH)	Light Intensity(LX)	Concentration of CO_2 (ppm)	PH
1	12.9	26%	1207	406	7.2
2	13.2	25%	1199	409	7.5
3	13.1	26%	1203	412	7.8
4	12.7	27%	1201	411	7.7
5	13.0	25%	1202	410	7.3
6	13.2	24%	1197	408	7.6

The repeated measured data show that the system can perform well in various environmental parameters, the measured object can be arbitrarily chosen, the mobile monitoring terminal can get real-time information, and the wireless intelligent monitoring system for environment can meet the actual needs well.

CONCLUSION

Using the sensor technology as the core, combining with single-chip microcomputer technology, control technology and other technologies, a kind of the wireless intelligent monitoring system for environment has been successfully designed. The overall design scheme of the system is feasible, it can process multi-node data of sensors, the system is able to fully take into account collection of temperature, humidity, light intensity and PH value, it can also record environmental sound recording and shoot scene photos. The external monitoring of environmental scene has been very conveniently achieved through the wireless transmission, and the system has very good mobile portability and practicality, so the wireless intelligent monitoring system for environment has broad application prospects.

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