

## Study on Multi-environment Factor Monitoring System of the Livestock Breeding

\* **Xiao Yu, Hai-Ye Yu**

School of Biological and Agricultural Engineering, Jilin University, 130012, China

\* Tel.: 13163680678, fax: 0451-55191333

\* E-mail: [neaufish@163.com](mailto:neaufish@163.com)

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**Abstract:** To aim at the characteristics of livestock environment in china, a livestock breeding multi-environment factor monitoring system was studied. In this paper, the design thought and main function of the system were introduced, and design methods of system hardware and software described too. To begin with, the hardware part of monitoring system is build. The detection equipments of temperature and humidity, carbon dioxide, ammonia, hydrogen sulfide, as well as light monitoring equipment are included in this hardware part, and the former four sensors are assembled together in order to establish the breeding environment parameter perception concentrator. Then the technology project based on RS485 and Zigbee is respectively devised according to the different situations, and the solution of hardware anti-jamming is also proposed accordingly. Secondly, the software part of environmental monitoring system is structured. The data acquisition system based on C/S structure is mainly responsible for the information collection and storage tasks of environmental parameters, and the acquisition system is capable of 24 hours of work. Furthermore, this acquisition system also includes perfect management mechanism and reliable detection mechanism, as well as the alarm information is recorded and the management personnel is timely informed when environmental information exceeds alarm value in poultry housing. The monitoring system is featured by high precise, appropriate price, powerful function, which is suitable for most environments of barn farming in China and provides us with important reference for future environment control. *Copyright © 2013 IFSA.*

**Keywords:** Animal house, Multi-environmental factors, Monitoring system.

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### 1. Introduction

With rapid economic development of our country and the continuous improvement of people's living standards, the demand for various types of livestock and poultry meat continues to increase, therefore, the need of safe, high-quality, non-polluting, and green food is increasingly strong, which comes up with very strict requirements for the current large-scale breeding. Especially after the emergence of the "foot-and-mouth disease", "mad-cow disease" and "avian-flu disease", the livestock and poultry plants are

forced to change the traditional farming methods, also the monitoring means of the modern breeding environment are put into practice. besides, the barn aquaculture environment of northeast cold region is focused in this thesis based on the status quo at home and abroad and combined with the actual situation of our country, meanwhile, the monitoring system of modern breeding environment, which has remote query function, is established corresponding to the detailed research objectives and contents.

All Livestock breeding environment directly affects animal growth, reproduction, health, and feed

utilization efficiency. Currently, many large-scale farms have been adopted the sealed way to feed in order to solve the complex and volatile of the culture environment factors, and a lot of environmental control technologies, but the overall level of automation is lower, and the regulation is less effective, as well as to adapt to large-scale farming needs is more difficult.

At the same time, environmental factors lack the necessary contacts during regulating animal house environment, and the most of regulating system of the animal building is still in the state of manually operation or semi-automatic operation by the feeding and management personnel, and it is difficult to adapt to the requirements of modern management [1-4].

It is an objective to realize the animal building environmental control system hardware and software design by combining the sensor technology, communication technology and computer

technology, as well as to control the animal house environmental factors by the means of fuzzy control technology so as to achieve better regulation.

## 2. System Component

Temperature, humidity, light, harmful gases, and the conditions of ventilation are the most important factors of the animal house environmental monitoring system, while it is the nonlinear, time-varying and complex dynamic characteristics between these environmental factors. Various environmental factors have respective sensor detects, how to measure these environmental factors accurately, and to control the system automatically is the focus of this study. The whole design of this system is following as Fig. 1.

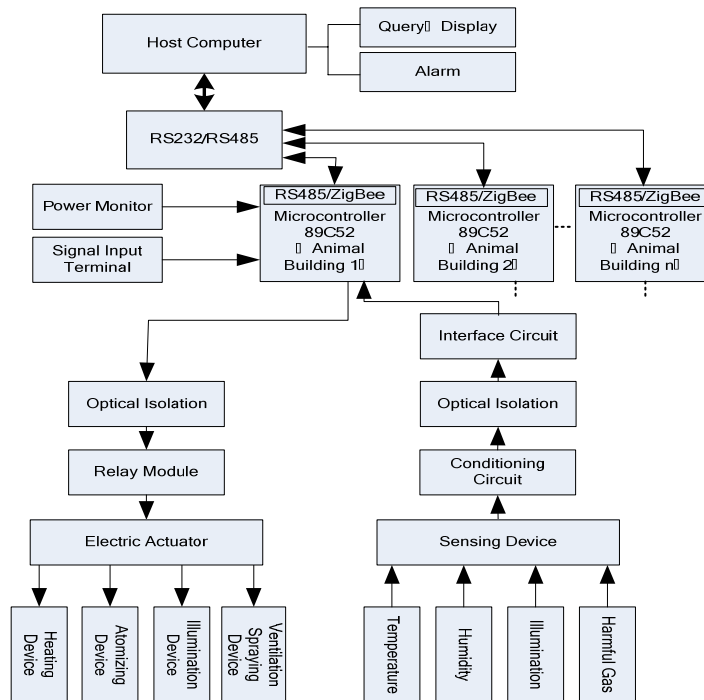


Fig. 1. Poultry breeding environment monitoring system structure.

As can be seen from the figure, animal house environmental monitoring system could collect or observe the temperature and humidity, light, and the concentration of harmful gases in the animal building as well as other environmental factors information by the multi-source information sensing equipment which is installed in the house. The most suitable environment is provided for the growth and development of the livestock and poultry, and the production of livestock and poultry production and quality is improved by the controlling device to control the drive actuator adjustment and controlling the local environment and climate to reach the needs of livestock and poultry [5-7].

Monitoring system is composed of four parts: sensing agencies, control agencies, executive agencies and auxiliary agencies. The four parts are an organic body, and ensure the normal operation of the system as a whole. Control agency is the core part of the whole system, which is used to deal with system control signals and to establish appropriate control rules [8-12].

Sense testing organization includes all kinds of sense testing equipments, and could achieve the immediate monitoring for the animal building of temperature and humidity, light and harmful gases specifically, and could send the result of the detection to the control organization. Signal by

analyzing and operation regulates animal house's temperature, humidity, light and harmful gases and other environmental factors by converted, enlarged, drive circuit driving the implementing agency of the temperature control system, humidity control system, light control system and ventilation system. In this control system, the fan is important equipment which regulates temperature, humidity and gas concentration of particles, and the intelligent control of these environmental factors is achieved by Inverter driving easy to rely on speed adjustment [13-16].

Auxiliary organization includes a display unit and an alarm unit. On the big screen or terminal animal house, the display unit can display dynamically the temperature, humidity, light and harmful gases, and switches status information for each device, and the key link of production, as well as the important circulation of audio and video information. The alarm unit makes an alarm by the buzzer alarm sound when the environmental indicators of the animal house reach the cordon [17-20].

### 3. Overall Structure of Hardware System

As the physical foundation of the whole monitoring system, hardware system can not only meet the demand of system functions, but also be considered technical index such as precision, resolution ratio, transmission distance and speed, etc. to carry on optimization design.

#### 3.1. Parameter Sensing Equipment in Breeding Environment

Sensing equipment on breeding environmental parameter includes temperature and humidity sensor, carbon dioxide sensor, ammonia sensor, hydrogen sulfide sensor and illumination sensor, which are the basis of setting up this monitoring system. Therefore, when choosing specific sensor, we should considered overall inside and outside environment, market supply, developing difficulty and economic condition to choose appropriate sensor according to the actual situation on spot.

##### 3.1.1. Measurement on Temperature and Humidity

In the system of environment monitoring, temperature and humidity measurement is one of the most basic variables in system input. Because humidity is high in winter in animal house and hazardous gas is full in the environment, temperature and humidity sensor owns ability of frosting prevention and could keep running stably in long term in the severe environment.

This system is selected SHT10 temperature and humidity sensor produced by Sensirion Company in Switzerland, full digital calibration relative humidity

and temperature sensor with single product of two-wire serial interface, which has the characteristics as without peripheral circuit, without demarcating, without debugging, digital output and full-interchange. Combining the technology of sensor with CMOS chip technology, this sensor provide solution for developing temperature and humidity monitoring system with high integration density, high reliability and high precision, as shown in Fig. 2.

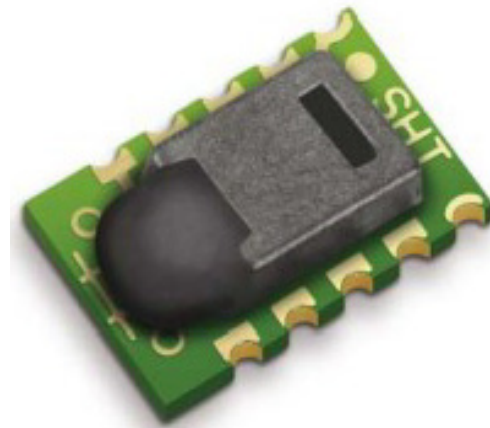


Fig. 2. Sensor appearance of temperature and humidity with SHT10.

The tolerant relative humidity and temperature measuring resolution ratio of SHT10 sensor is 12 bits and 14 bits separately, which could be fell to 8 bits and 12 bits through setting up the register. The range of temperature measurement is  $-40^{\circ}\text{C} - +123.8^{\circ}\text{C}$ , whose corresponding 14 bits resolution ratio is  $0.01^{\circ}\text{C}$ ; the range of humidity measurement is 0-100 % RH, whose corresponding 12 bits resolution ratio is 0.03 % RH. Both measurement range and resolution ratio should meet the project requirement.

##### 3.1.2. Measurement on Concentrations of Carbon Dioxide

The module of carbon dioxide sensor of this project is chosen B-530 carbon dioxide sensor module from Lanyue Technology, the configuration of sensor is as shown in Fig. 3. No matter on the volume, or on the quality, the module of B-530 carbon dioxide sensor is very small, which is widely used in agriculture, industry, life and livestock breeding industry, etc. The module has been reserved contact pin which is easy to insert and pull out and extremely convenient to be used for combining with other equipments. In addition, this output of this sensor module is various (I2C, analogy quantity), which is easy to transmit and read, is fit for installment and dismantlement on most occasions.

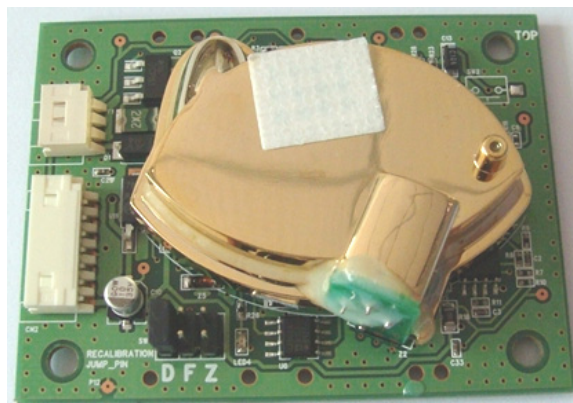


Fig. 3. Carbon dioxide sensor appearance of B-530.

### 3.1.3. Measurement on Ammonia Concentration

The ammonia sensor of this project is chose 4NH<sub>3</sub>-100 ammonia sensor from RAE Systems Company in America, as shown in Fig. 4. Possessing features such as simple drive circuit, favorable sensitivity and long service life, etc., 4NH<sub>3</sub>-100 ammonia sensor is widely used in agriculture, industry, life and livestock breeding industry, etc. This sensor module could output analog current signal, which is easy to transmit and read, is fit for installment and dismantlement on most occasions.



Fig. 4. Ammonia sensor appearance of 4NH<sub>3</sub>-100.

### 3.1.4. Measurement on Hydrogen Sulfide Concentration

The hydrogen sulfide sensor of this project is chose 4H<sub>2</sub>S-100 hydrogen sulfide sensor from RAE Systems Company in America, whose configuration is as shown in Fig. 5. Possessing features such as favorable sensitivity, simple drive circuit and long service life, etc., 4H<sub>2</sub>S-100 hydrogen sulfide sensor is widely used in life, agriculture, livestock breeding industry and industry, etc. This sensor module could output analog current signal, which is easy to transmit and read, is fit for demarcating, installment and debugging on most occasions.

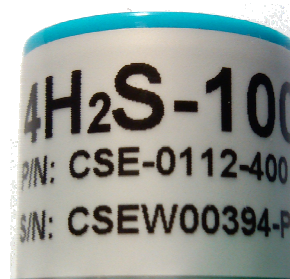


Fig. 5. Ammonia sensor appearance of 4H<sub>2</sub>S-100.

### 3.1.5. Measurement on Illumination Intensity

The collecting module of illumination intensity of this system is chosen GY-30 module of illumination sensor researched, developed and produced by Beijing Dihui Technology Co., Ltd. With much higher sensitivity photosensitive detector, this module is widely used with high measurement precision, wide application range, convenient installment and low price. The configuration of GY-30 illumination sensor is as shown in Fig. 6.

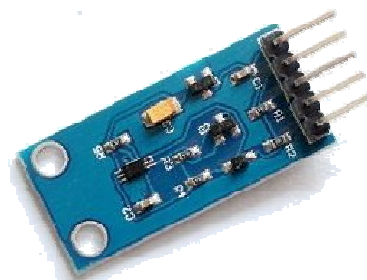


Fig. 6. Light sensor appearance of GY-30.

### 3.2. Parameter Sensing Concentrator in Breeding Environment

Combining temperature and humidity sensor, carbon dioxide sensor, ammonia sensor, hydrogen sulfide sensor, parameter sensing concentrator in breeding environment is not only allocated with RS485 and ZigBee interfaces to upload data easily, but also with LCD display and keyboard which is convenient for the workers on spot to see about true time and historic environmental data to realize multipurpose, microminiaturization and integration. It could be used on permanent breeding environmental monitoring and could be used as portable measurement instrument. The equipment structure of the parameter sensing concentrator in breeding environment is as shown in Fig. 7.

As the physical foundation of the whole monitoring system, hardware system can not only meet the demand of system functions, but also be considered technical index such as precision, resolution ratio, transmission speed and distance, etc. to carry on optimization design. Starting from the

whole design of system hardware and for the monitoring on parameter sensing in breeding environment of this chapter, we design temperature and humidity measurement, carbon dioxide measurement, ammonia measurement, hydrogen sulfide measurement and illumination measurement. And then we combined four sensors such as temperature and humidity measurement, carbon dioxide measurement, ammonia measurement, hydrogen sulfide sensor measurement according to the measured object to constitute parameter sensing concentrator in breeding environment, which realize integration and miniaturization to maximum extent.

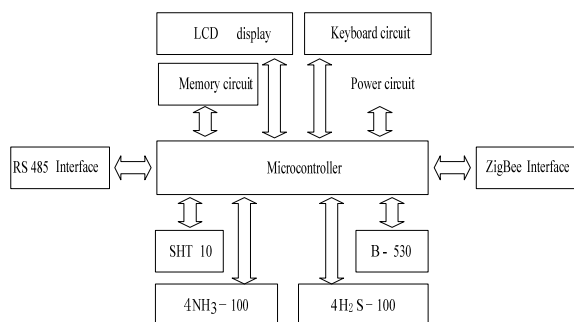


Fig. 7. Structure of parameter perception concentrator.

#### 4. Design and Realization of System Software

To realize real time ongoing and all-round monitoring in 24 hours for breeding environment of animal house and be convenient for the managers on daily management, we design data collection system based on C/S framework and remote data inquiry platform base on B/S framework. Data collection system could complete works such as definition, collection, alarm and storage, etc. of monitoring data for the whole breeding environment, which is convenient for the workers to make real-time monitoring on all environmental parameter information in breeding environment. Remote inquiry platform is a platform for external data dissemination, users can login the webpage according to their own limits of authority, see about related breeding environmental information, form visual data report and tendency chart combined with related historical data in order to reduce the workload of the managers to the maximum extent and improve work efficiency. Design and realization scheme of the software will be introduced in detail as below.

The software platform of monitoring system on breeding environment in animal house is developed based on Microsoft .NET Framework 3.5 technology and Microsoft .NET Framework 3.5 is a software framework which is issued in 2008 by Microsoft. It has many characteristics such as short development period, high security and perfect authority limits

certification system, etc., which is widely used in industry, agriculture, animal husbandry and real life. SQL Server 2008 data base we used is the strongest and the most comprehensive SQL Server version issued in 2008 by Microsoft, which is a dependable, efficient and intelligent data platform. It owns many features, for example, easy operation, high security, support large-scale concurrent access, etc. and it has excellent downward compatibility to provide convenience for system upgrade in the future.

The software platform of monitoring system on breeding environment in animal house is divided into data collection system based on C/S framework and remote data inquiry platform base on B/S framework. The former is mainly in charge of related information entering about breeding environment in animal house, data collection, out of limit alarming, data storage and local real-time data inquiry, etc. The latter is a platform on external platform to see about related breeding environmental information, provide related historical data and tendency chart. The overall software structure of monitoring system on breeding environment in animal house is as shown in Fig. 8.

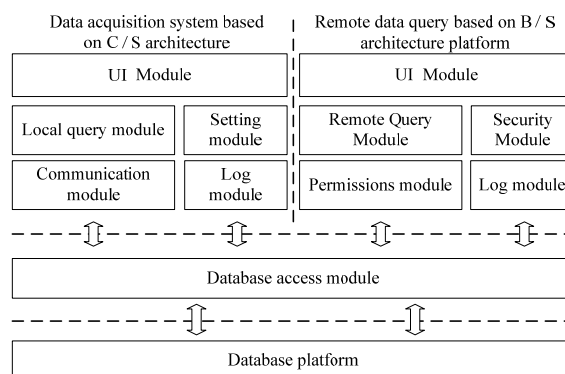


Fig. 8. Overall structure of software system.

Located at the bottom, from-bottom-to-top database platform is responsible for storing all setting information, log information, user permission information and environmental monitoring information, which is the base of collection system and remote inquiry system. SQL Server 2008 database used in this project ensure performance requirement of the system and future expandability to the maximum extent.

Located at the middle layer, database access module is the communication medium for collection system and remote inquiry system with database platform, whose design quality will directly influence the performance of collection system and remote inquiry system. Considered on the performance of database access module and database migratory probability, this module is developed by three assemblies as Spring.NET, Enterprise Library and ADO.NET with excellent data access performance and database portability. It is not only applied to SQL Server 2008 but also applied to Oracle and MySQL

etc. database to be convenient for the users to choose with different requirements.

Located at the top layer, collection system and remote inquiry platform use database platform and database access module together. The former includes local inquiry module, setting module, communication module, log module, etc. to be convenient for the workers on spot to monitor breeding environmental information in real time. The latter contains remote inquiry module, security module, authority limits module and log module, etc. to be convenient for the remote users to see about breeding environment information and abnormal condition, etc. at any time.

There will be electric field and magnetic field around development type electronic and electrical product, which are able to exist in any substance, one electronic product may produce interference for another electronic product, and such phenomenon is called electromagnetic interference. There are many hardware equipments in this system, for example, perception concentrator on breeding environmental parameter, illumination measurement sensor, RS485 change to RS232 module, ZigBee module, etc. In order to make hardware equipment to operate stably, we must carry on anti-interference design on hardware equipments to improve their anti-interference performance [21-23].

There are three requirements electromagnetic interference exist: the first is source of electromagnetic interference, the second is transmission route of electromagnetic interference, and the third is sensitive body of electromagnetic interference. Now we will conduct anti-interference design on the hardware in this system as the three points above.

Source of electromagnetic interference refers to produce the source of electromagnetic interference, whose represent interference characteristic has no obvious rule to follow in common, it fully lies on the interference source itself. The power maybe the interference source in this system, therefore, we make all our efforts to let the power far away from core chip and connect low pass filter at the input terminal of power. The higher harmonic of filtering improves power supply wave form, which not only restrain interference produced by the insert switching power supply report back to power grid, but also the equipment interference from power grid.

The route of transmission of electromagnetic interference is a transmission media which connect the source of electromagnetic interference with equipments. There are mainly two forms of route of transmission of electromagnetic interference, one is transmission through space and another is transmission through electric conductor (or wire). No matter in transmission way, electromagnetic interference always has certain coverage area, if it goes beyond this area, the interference will be weak so as to be neglected. We adopt block thinking when designing circuit board of hardware equipment in this system and make the hardware modularization, the

power line running of PCB board is in line with data transfer direction, make over striking about power line and ground lead of positive and negative current-carrying to the greatest extent and absorb high frequency energy by the way of cupreous coverage around the main devices, shown in Fig. 9.

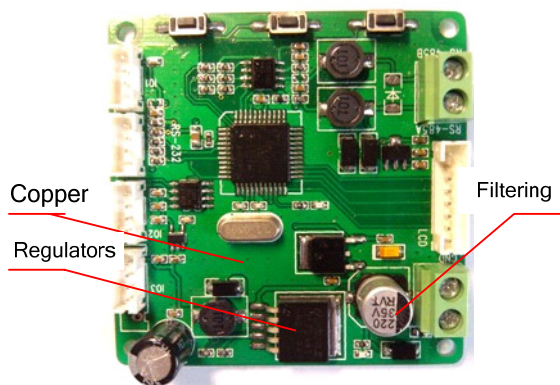


Fig. 9. Anti-jamming design of equipment.

Sensitive body of electromagnetic interference refers that there has response to the interference produced by the source of electromagnetic interference and the receptor which makes its working performance or motion energy declined. In general case, sensitive body owns certain frequency characteristic as well, which could response to the electromagnetic interference only in the sensitive bandwidth. There have many sensitive bodies in this system, for example, STC12C5A60S2 single chip microcomputer, IS24C256 storage, clock circuit of single chip microcomputer, etc. Aim at the sensitive bodies above, we try our best to make the distance between them with related devices much closer, connect with short and thick conductor jointing, the circuit which could be isolated adopted ground wire isolation, etc.

The hardware of this system is not only adopted with several kinds of hardware anti-interference measures above, but also adopted with software anti-interference design, such as improving redundancy command and starting using opening dog, etc. Interference is ubiquitous, although the ways can not eliminate the interference completely under some circumstances, they can weaken the interference to some extent to play role in restraining interference and improving availability and reliability of the system.

## 5. Conclusions

Established in much outdated current situation on integral level of monitoring system of animal house in small and medium size at the present stage in our nation and based on the investigation, consulted with various mature greenhouse control technology and

research result from forefathers, this thesis designed complete environmental monitoring system on animal house take the environment measurement and control on hog house as an example and carry on test run in Wondersun farm in Haerbin. Through running in laboratory and on the spot, this measurement and control system is stable, reliable, has long trouble-free time, good expandability and could meet the design requirement.

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