Design and Development of IOT Monitoring Equipment for Open Livestock Environment

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***Abstract* - In this paper, livestock and poultry breeding environment has a great effect on animal growth, prevention and cure of animal diseases, and improvement of animal products. Acquisition of animal breeding environment information is the key of livestock and poultry breeding. Schematic diagrams and PCB drawings of a 16-channel wireless monitoring device for livestock and poultry breeding environment were designed. The MCU program used to acquire breeding environment information, the heartbeat mechanism program and the program of reading sensing data in a loop was written. The structure diagram of the environmental monitoring devices was designed. Open-field livestock and poultry breeding environment monitoring devices based on Internet of Things (IOT) were developed by using system integration technology. The devices were put on a trial application in 11 livestock and poultry farms. Stability and adaptability of the devices were tested. The design and development of this device can provide technical support for information, automation, and modern management of livestock and poultry farming.**

Keywords - Livestock; Environmental monitoring; Open breed; IOT; Equipment development

I. INTRODUCTION

Livestock and poultry living environment are very important for the quantity and quality of animal products [1]. Sensing of livestock and poultry living environment mainly include sensing of harmful gases which were produced during the livestock and poultry farming processes, like ammonia, hydrogen sulfide, carbon monoxide, carbon dioxide and methane. The environmental parameters around livestock and poultry houses, such as temperature, humidity, light intensity, wind speed, wind direction, rain, barometric pressure etc. should also be monitored[2-5]. Harmful gases produced by livestock and poultry farming are the main source of air pollution in agriculture. Excessive harmful gases and change of breeding environment would cause multiple stresses in livestock and poultry, a decline of animal health and immunity [6,7]. It will greatly affect animal health, growth, reproduction and final animal products [8].

Currently, most of livestock and poultry farms cannot precisely control the breeding environment in China, thus it is difficult to improve the quantity and quality of livestock and poultry products. However, IOT technology can provide a solution for automatic control and precise simulation of animal breeding environment [9,10]. Environment information was acquired by light intensity, temperature, humidity, gas sensors. The information was transmitted to the server by wireless sensing network (WSN) and mobile communication technology, such as Bluetooth, Wi-Fi, ZigBee, 3G, and so on[11,12,13]. Applications will compare the gathered data with standard data in the database. By combining expert system and livestock and poultry growth model, the application will generate the environmental data of livestock and poultry environment. It can realize precise monitoring and early warning of livestock and poultry living environment. It will provide a favorable environment for livestock and poultry [14,15]. The quality and quantity of animal products will be improved.

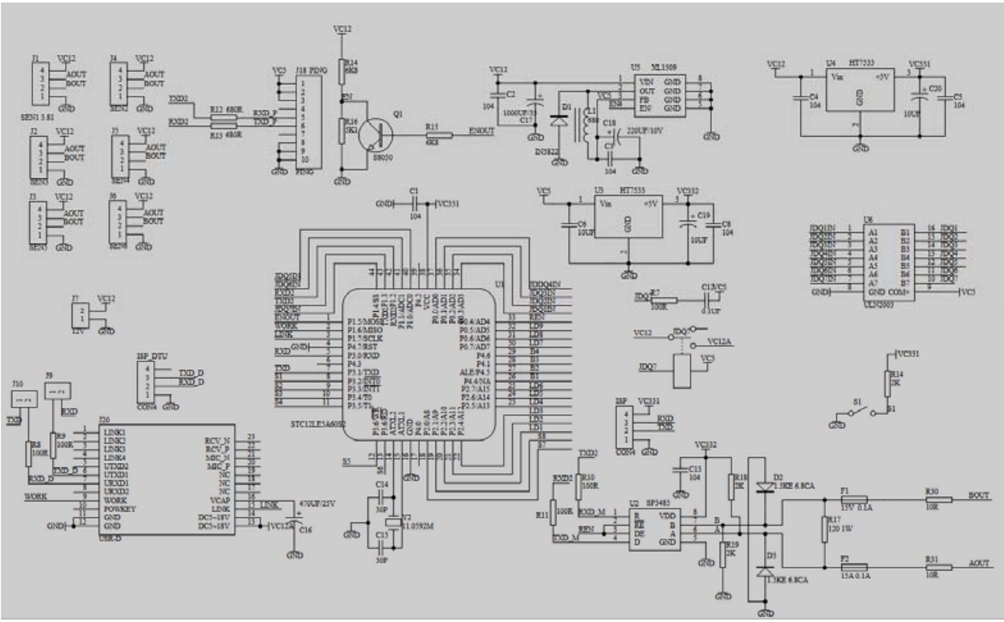
Therefore, based on the investigation of livestock farming, we designed a 16-channel wireless monitoring device for livestock and poultry breeding environment by using STC MCU. The interface program and function program, which were used to acquire breeding environmental information, were written. Open-field livestock and poultry breeding environment monitoring devices based on Internet of Things (IOT) were developed by using system integration technology. The trial application of the device was also conducted.

II. CIRCUIT DESIGN FOR LIVESTOCK ENVIRONMENTAL MONITORING

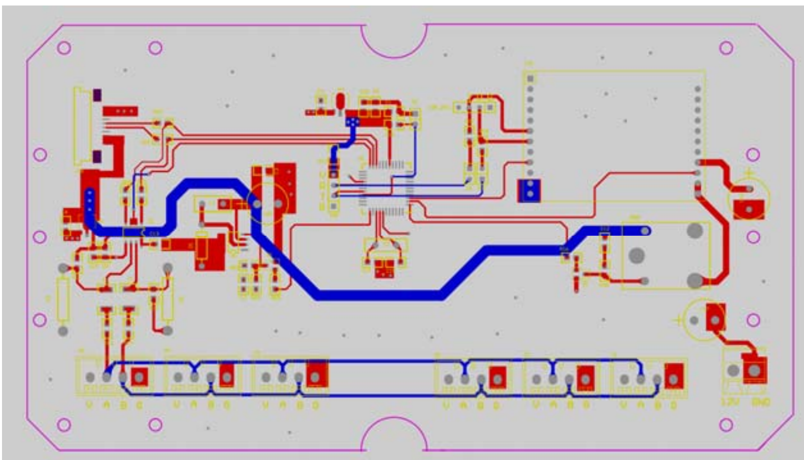
With the software of Protel, the circuit principle diagram and PCB diagram were designed in (Fig.1), including data transmission circuit, power module circuit, signal amplification circuit, filter circuit, liquid crystal display module, data acquisition interface, interface extension circuit, etc. Power module circuit, the system main controller STC12LE5A60S2 and RS-485 interface chip SP3485 need 3.3V power supply; Liquid crystal display module requires 5V power supply. DTU data transmission module and sensor module need 12V power supply [16]. Solar energy storage battery could provide 12V voltage, and then the 12V voltage was stepped down to 5V through DC/DC buck module composed by XL1509 to liquid crystal display module. 5V voltage supplied power to system master controller and RS-485 interface chip through 2 HT7533 linear voltage regulator chips.

Secondly, system function circuit. Data transmission module, liquid crystal display module and RS-485 sensor communication module were included. The main controller contains two serial port, serial port 1 and serial port 2. The pins of serial port 1, TXD and RXD, are respectively connected to the UTXD1 and URXD1 of the DTU data transmission module. The GPRS data transmission module, USR-GM1, was selected as DTU data transmission module. TCP/IP protocol stack was built in the module, and it was set simple and easy to use. The module can configure heartbeat packet data format, transmission interval, and the server stay connected, dropped support reconnection, realize data wireless transmission.

The pins of serial port 2, TXD2 and RXD2, were connected with LCD module communication pins RXD_P and TXD_P. An industrial serial LCD touch screen, DMT48270M043, was selected as the LCD module, which has the advantages of easily developing, low power consumption and backlight automatic standby. The pins, of serial port 2, TXD2 and RXD2, were simultaneously connected with RS-485 interface chip SP3485. SP3485 is a low power half duplex transceiver, meeting the requirements of the RS-485 serial protocol [17]. The TTL level of the main controller is converted to RS-485 level, which can realize the data acquisition of sensor module.



a. Circuit Principle Diagram



b. PCB Diagram

Fig. 1. Circuit Diagram of Livestock Environmental Monitoring Equipment

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III. PROGRAM DESIGN FOR LIVESTOCK BREEDING ENVIRONMENT MONITOR

The corresponding program and work program were designed to the livestock breeding environment wireless monitor system, shown in (Fig.2). After the system is started, the system is initialized, and the serial port parameters and the timer are set. open timer, check whether the timer time is up. If the time is not up, continue to wait; if it is, send the read sensor instruction to the sensor module, read the sensor data, Do cyclic redundancy check to the data, if it does not pass the verification, re read sensor data. If the check passes, sensor data on the LCD display and data through the Ethernet port is uploaded to the server.

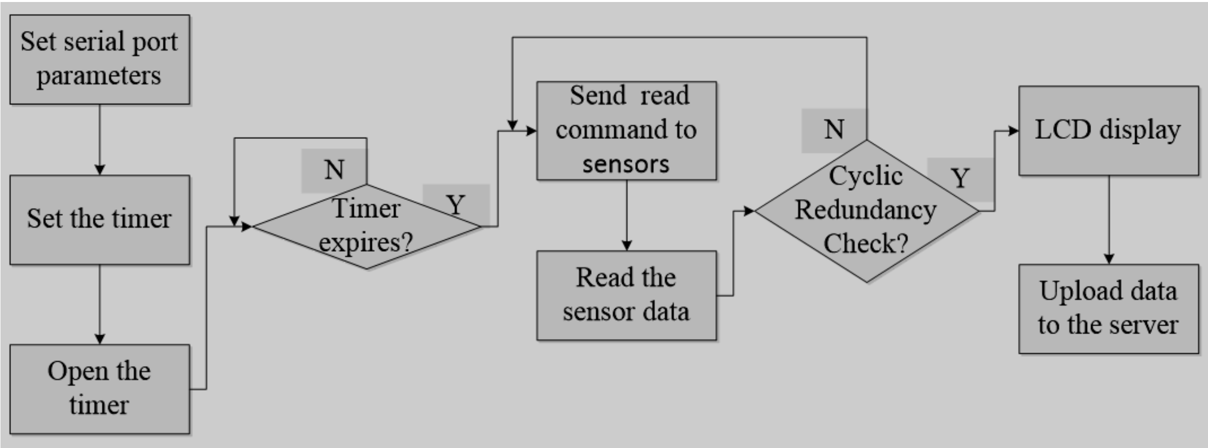

Fig. 2. System Workflow Flowchart

The monitor work program includes heartbeat mechanism design and Cyclic reading mechanism design. Heartbeat mechanism workflow is shown in (Fig. 3). Monitoring station through the socket uploads data to the server. When the socket is disconnected, if the monitoring station could not be aware of the broken link, it will send data as usual, but at this time the server could not receive data, so it is necessary to establish a heartbeat mechanism. The server sends the data to the monitoring station every 4 seconds. If the monitoring station receives the data, 5 seconds heartbeat timer is restarted, which proves that the link is valid. If did not receive the data after more than 5 seconds, the station will disconnect the link with the server, and re-establish the link.

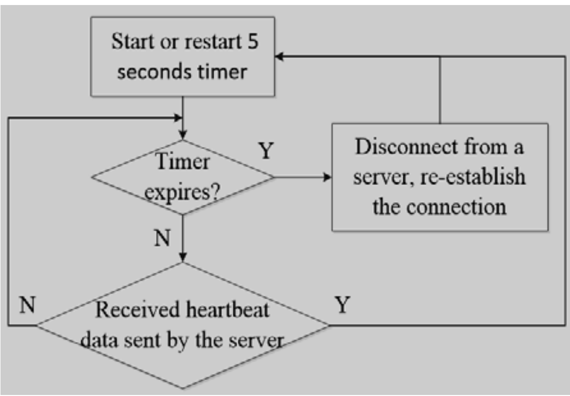

Fig. 3. Flowchart of Heartbeat Mechanism

Cycle reading mechanism working process is shown in (Fig.4). When the sensor data is abnormal, it is required to read the sensor data, until the data is checked by cyclic redundancy check or timer timeout. The timer is set to read data, preventing the program fall into dead cycle.

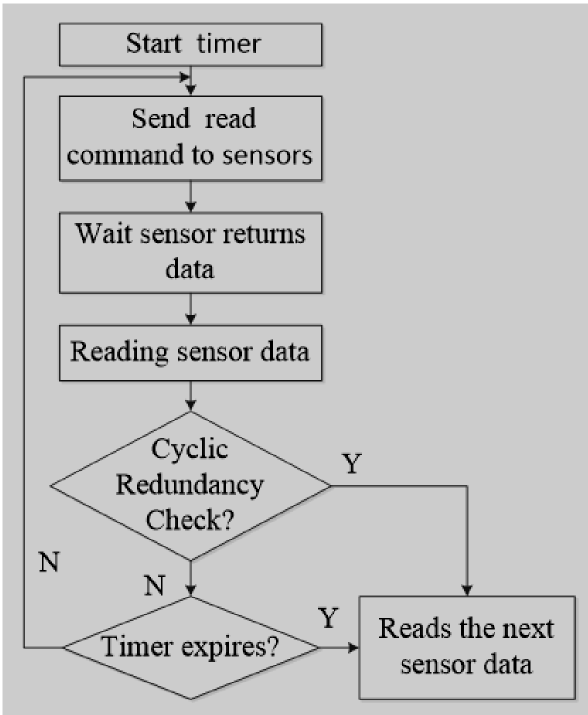

Fig. 4. Flowchart of Reading Sensor

IV. DEVELOPMENT AND APPLICATION OF EQUIPMENT

Farm environment meteorological and gas stations wireless transmission, and cable transmission function is the same, for real-time acquisition of breeding environment information, and through the wireless data transmission module will be collected sensor data uploaded to the server[18]. In order to meet the demand of monitoring station of field work power supply, monitoring stations equipped with solar power supply system. At present, the monitoring of the aquaculture environmental information including temperature, humidity, light intensity, wind direction, wind speed, precipitation, concentration of carbon monoxide concentration, ammonia, oxygen concentration, concentration of carbon dioxide, hydrogen sulfide concentration and 12 indicators such as methane concentrations. Sensor module are susceptible to severe damage to the natural environment, such as: the sun, rain, high temperature, high humidity, condensation, frost, ice, fog, dust, etc[19]. At the same time, the joint of destruction of wild animals, the sensor probe damage things also happen from time to time[20]. In order to solve the sensor module is easy to damage, and the problem need to be replaced on a regular basis, all sensor modules select the sensor module supports standard MODBUS communication protocol.

By 2015, Livestock and poultry breeding environmental monitoring equipment has been carried out experiment applications in various provinces and cities， such as Beijing, Shandong, Hebei and other field. The equipment developed that has been in 11 livestock and poultry farms field monitoring, as shown in Fig.5. Livestock and poultry breeding environmental monitoring equipment have collecting data 1 times per 10 minutes. the amount of data collected as of March 2016 has reached 1.20 GB.

Fig. 5. Application of Environmental Monitoring Equipment for Livestock and Poultry

Beef cattle farms in Yangxin County of Shandong Province taken as an example, monitoring the time from March 22, 2016 to April 5, 2016, total of 15 days, the data acquisition frequency of 10 minutes/time, monitoring beef environment information including temperature, humidity, light intensity, wind speed, ammonia, hydrogen sulphide, carbon dioxide and methane. Meteorological Monitoring Information cattle farms shown in Fig.6, the temperature of beef cattle farms and humidity variation width larger every day, a change in temperature between 9-18 degrees Celsius, humidity between 25 to 85RH, light intensity from 1 to between 3kLux, wind speed 0.5m/s to between 6m/s, because the farms are open architecture, the venue of the temperature and humidity will change as the weather changes, but the location for the morning and evening temperature difference between the North and the humidity difference relatively large, adequate light, moderate wind speed, such an environment for beef cattle breeding is more appropriate.

Gas monitoring data of correction for beef cattle farm are shown in (Fig.7). The daily changes of carbon dioxide in beef cattle farms are relatively large, between 410 to 760pmm. However the changes of ammonia, hydrogen sulphide and methane concentration are slightly, between 0 and 1.5pmm. Since cattle farms as open-ended structure, the gas concentration variation width of the field is not large.

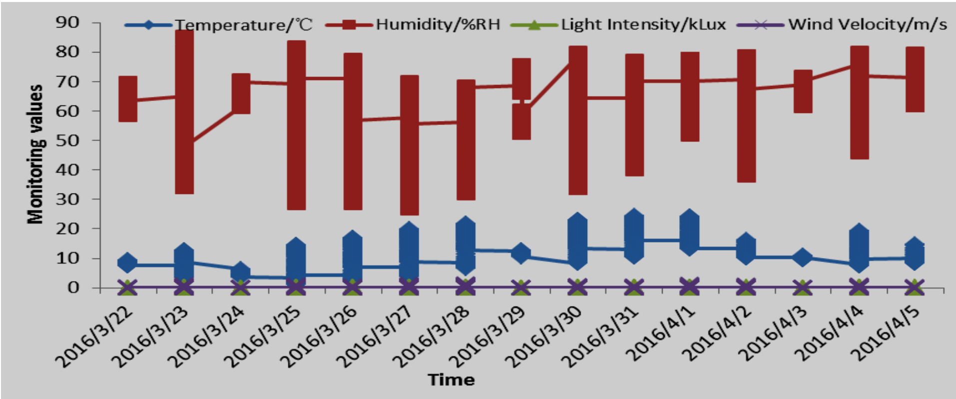

Fig. 6. Meteorological Monitoring Data of Beef Cattle Farm

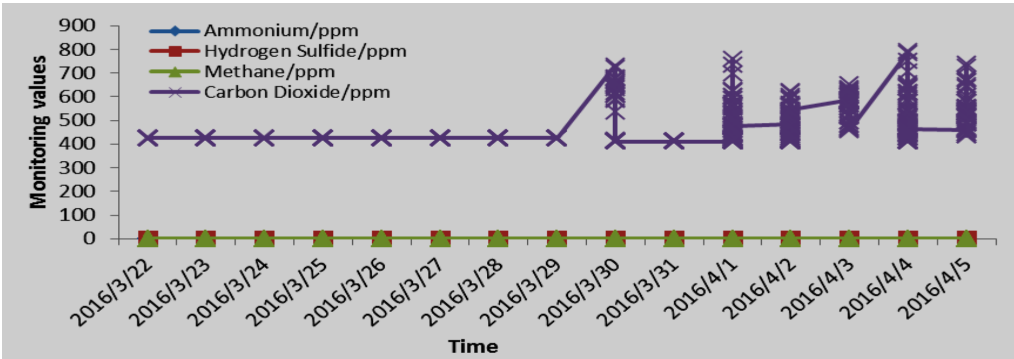

Fig. 7. Gas Monitoring Data of Beef Cattle Farm

V. CONCLUSION

With the increasing requirements for number and quality of livestock and poultry products, application requirements for IOT technology is expand quickly. Importance of open livestock environmental monitoring will be further highlighted. In this study, Schematic diagrams and PCB drawings of a 16-channel wireless monitoring device for livestock and poultry breeding environment were designed. The MCU program used to acquire breeding environment information, the heartbeat mechanism program and the program of reading sensing data in a loop was written. The structure diagram of the environmental monitoring devices was designed. Open-field livestock and poultry breeding environment monitoring devices based on Internet of Things (IOT) were developed by using system integration technology. The devices were put on a trial application in 11 livestock and poultry farms. Stability and adaptability of the devices were tested. The design and development of this device can provide technical support for automation, and modern management of livestock and poultry farming.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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