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Design of Acquisition and Control System of Granary Supervisory Control and Data Acquisition System

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Abstract

Grain stored in granary is easily spoiled due to accumulated hear or humidity if not monitored and maintained properly. Supervisory control and data acquisition (SCADA) system is commonly used in granary to provide real-time storage information. Major functionalities in the granary SCADA system is usually provided by an acquisition and control system based on single chip computer installed inside or near the granary. Based on theoretical and commissioning data, the design of the acquisition and control system was introduced in this paper. The acquisition and control system is able to acquire real-time data of temperature, humidity and concentration of CO_2 inside the granary. It also provides the functionalities of open/shut the granary windows, as well as turning on/off the high-power roller shutter doors and blowers. Users are able to obtain real-time monitored data and control the system accordingly.

Keywords: *Temperature and humidity acquisition; Automatic control of ventilation; Supervisory control and data acquisition (SCADA); Granary*

1. Introduction

Grain is not only daily food but also imterminalant strategic materials. To provide smart operation and management of granaries, SCADA systems are frequently used. Most SCADA systems designed for granaries in China employed DS18x20 series temperature sensor [1-3]. However, the major influence affecting the storage of grain is the humidity and temperature inside the granary. An SHT10 digital temperature and humidity sensor was used in this paper based on a multiple-location measuring method. Temperature and humidity data at different locations inside the granary can be acquired at the same time. Alarms will be activated automatically if abnormal data is collected. Users are able to open window remotely via computer or smart phones to ensure safe storage of grain.

2. Generation

The acquisition and control system structure diagram is shown in Figure 1. The acquisition and control system is made up of CDMA wireless communication module, the main control and processor part, the multi-channel temperature and humidity acquisition part and the ventilation controlling part. The data was acquired by the multi-channel temperature and humidity acquisition part and the ventilation controlling part is transmitted to the main control and processor part through the RS485 bus [4].

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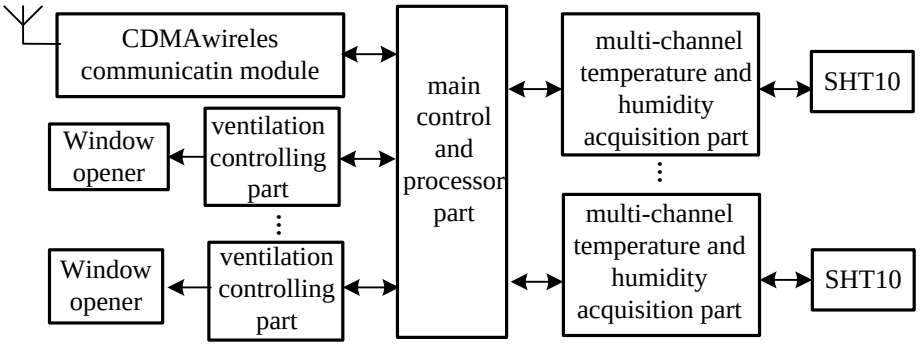

Figure 1. The Acquisition and Control System Structure Diagram

The main control and processor part can complete receiving and executing the commands which are sent by users [5].The multi-channel temperature and humidity acquisition part is polled by the main control and processor part timely. The part includes the function of key input, displaying output, audible alarm, control and feedback function of devices as well.

In order to realize the wireless communication, the set of the system and correct transmission of data should be completed by the CDMA wireless communication module [6-7].

Driving the SHT10 and sending the collected temperature and humidity data to the main control and processor part through the RS485 bus can be completed by the multi-channel temperature and humidity acquisition part [8-9].

Remote controlling the windows can be completed by the ventilation controlling part [10].

3. The Design of the Acquisition and Control System

3.1. The Hardware Design of the Multi-Channel Temperature and Humidity Acquisition Part

The functional block diagram of the multi-channel temperature and humidity acquisition part is shown in Figure 2.

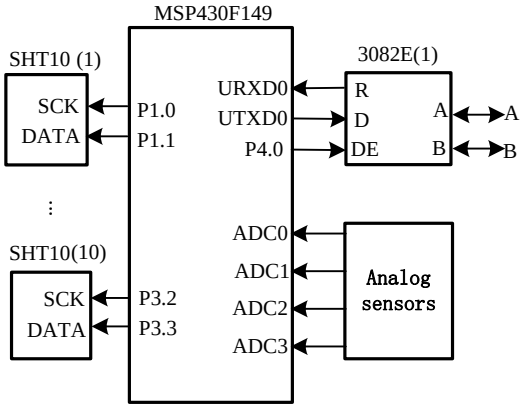

Figure 2. The Functional Block Diagram of the Multi-Channel Temperature and Humidity Acquisition Part

There are multiple points' temperature and humidity values of granaries which need to be acquired. To save the cost, a circuit of acquiring the multi-channel temperature and

humidity values was designed in this paper. The SHT10 sensors were selected because of simultaneous measurement and having certain compression capability. There is a I^2C bus in the SHT10 sensor, 20 free I/O port of SCM were choosed to simulate I^2C bus and drive ten SHT10 sensor. This way can achieve the maximum utilization of resources. Every multi-channel temperature and humidity acquisition part can measure 10 points' temperature and humidity values. It can realize multipoints' measurement of temperature and humidity values through a number of the multi-channel temperature and humidity acquisition part in granary. The acquired temperature and humidity values would be transferred to the main control and processor part through the RS485 bus.

The granaries need to be measured environmental parameters, such as CO_2 concentration in granary and suitable enzyme concentration of grain storage. A acquisition circuit of analog sensor was designed. The 0-20mA or 0-5V input signal is converted into digital signals by the AD chip, the digital signals is transferred to the main control and processor part through the RS485 bus.

Using the SN65HVD3082E as a transmitter of RS485 bus, its terminals A and B respectively connect with SN5HVD3080E（2）of the main control and processor part of Figure 3.

3.2. The Hardware Design of the Main Control and Processor Part

According to the power requirement of chips, in this paper the conversion from DC24V to DC5V was completed by LM2576-5 which is a step-down switching regulator and the conversion from DC5V to DC3.3V was completed by NCP1117ST33.

The functional block principle diagram of the main control and processor part is shown in Figure 3.

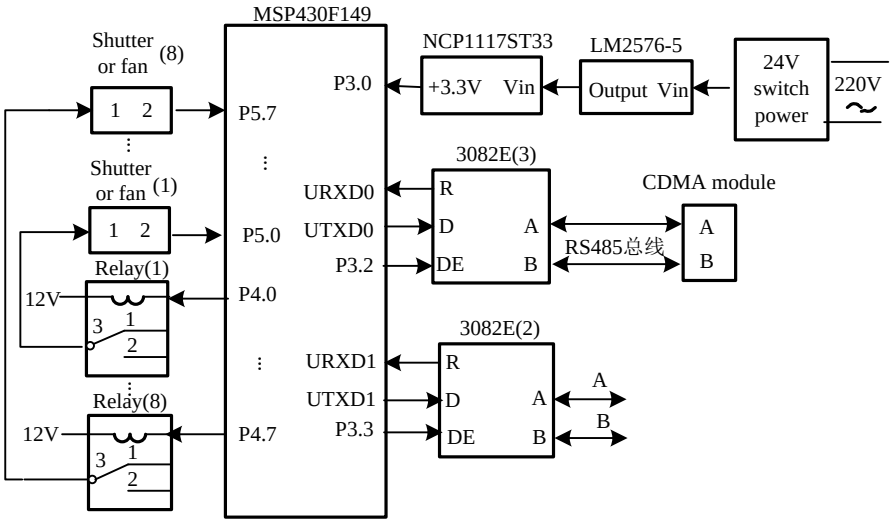

Figure 3. The Functional Block Principle Diagram ofthe Main Control and Processor Part

The acquired temperature and humidity value was received by the main control and processor part's MCU through the SN65HVD3082E (2). A circuit of 8 channel relay was designed and controlled high-power device such as shutter and fan. One side of the relay coil respectively connects to the P4.0--P4.7 of SCM. If the port 4 of SCM outputs high level, terminal 3 and terminal 2 of the relay will pick up, then the shutter will roll up and the fan will start. Otherwise, If the port 4 of SCM outputs low level, the shutter will fall and the fan will stop. Users can read the working state by the 8 channel feedback circuit of shutter or fan, terminal 2 of the shutter or fan respectively connects to the P5.0—P5.7

of SCM, when the shutter rolls up or fan starts, it will output high level form the corresponding port 5 of SCM, Otherwise, it will output low level.

3.3. The Hardware Design of the Ventilation Control Part

In order to adjust the environmental parameters such as temperature and humidity timely, the ventilation control part was designed in this paper. The control system is made up of the SCM and DS2Y-S-DC5V relay. The functional block principle diagram of the ventilation control part is shown in Figure 4.

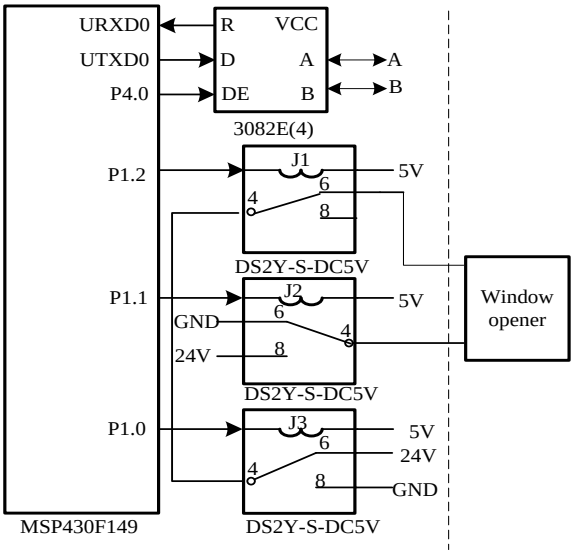

Figure 4. The Functional Block Principle Diagram of the Ventilation Control Part

The DS2Y-S-DC5V relay's the terminal 4 is Common, the terminal 6 is Normal Connected, the terminal 8 is Normal Open. The terminal 8 of J2 relay and the terminal 6 of J3 relay connect with the voltage of 24V. The terminal 4 of J1 connects with the terminal 4 of J3.When users choose to open the window, the open window command will be received by the acquisition and control system，then the P1.2 will be changed to high level and the voltage between the terminal 8 of J1 relay and the terminal 6 of J2 relay will be changed to DC24V. So between the cathode and the anode of window opener are applied the DC24V which is opened the window by the motor positive rotation and the chain extending. In order to close the window, the P1.0, P1.1and P1.2 will be changed to high level and the voltage between the terminal 8 of J1 relay and the terminal 6 of J2 relay will be changed to reverse DC24V.So between the cathode and the anode of window opener are applied the reverse DC24V which is closed the window by the motor reverse rotation and the chain withdrawing.

In order to realize the data transmission, the terminals A and B of SN65HVD3082E （4）of the ventilation control part respectively connect with SN5HVD3080E（2）of the main control and processor part.

3.4. The Software Design of the Acquisition and Control System

The frame format of communication command is shown in Table 1. The X means uncertain number of bytes. The length is the number of total bytes which includes the destination address, the source address, the command type, the command and the data.

Table 1. The Frame Format

name	head	length	destination address	source address	command type	command	data	verification
Byte	1	1	1	1	1	1	X	1

3.4.1 The Software Design of the Main Control and Processor Part

The software design's flow chart of the main control and processor part is shown in Figure 5.The initialization includes the initialization of hardware registers, timer, serial port communication, IO port and the initialization of arrays and structures in the software.

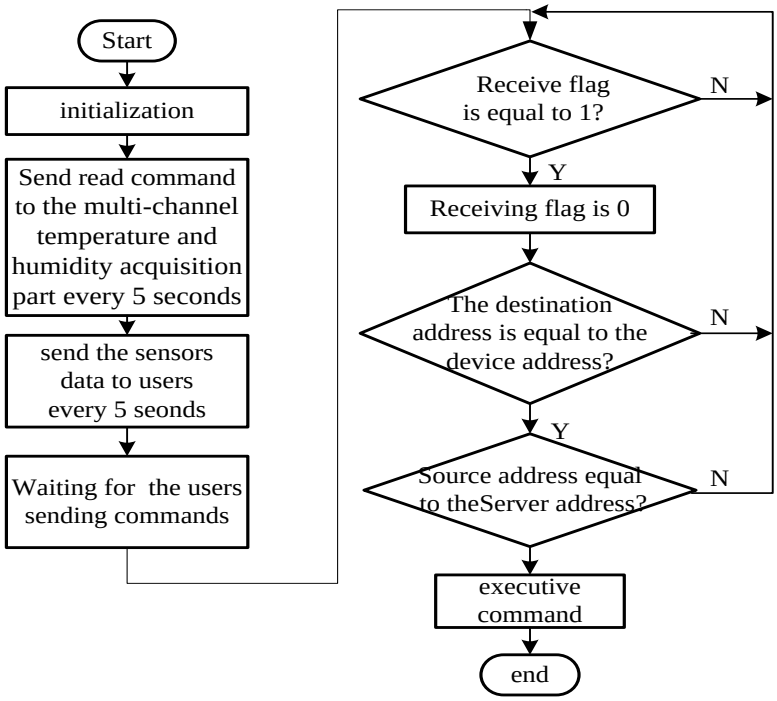

Figure 5. The Software Design's Flow Chart of the Main Control and Processor Part

Executing command includes uploading real-time data, reading the shutter or fan state command, controlling the shutter or fan command, reading parameters command, setting parameters command, demarcating acquisition part types command and controlling windows command.

3.4.2 The Software Design of the Multi-Channel Temperature and Humidity Acquisition Part

The software design's flow chart of the multi-channel temperature and humidity acquisition part is shown in Figure 6. Voltage values of sensors were acquired and the data was saved to the corresponding data structure every 5 seconds after the hardware and software debugging. If the received command is sending voltage command, the multi-channel temperature and humidity acquisition part will send the data which in the corresponding structure to the main control and processor part. The multi-channel temperature and humidity acquisition part tests whether the purpose of command address is consistent or not with itself when the users send command, if they are the consistent it will receive and execute the command.

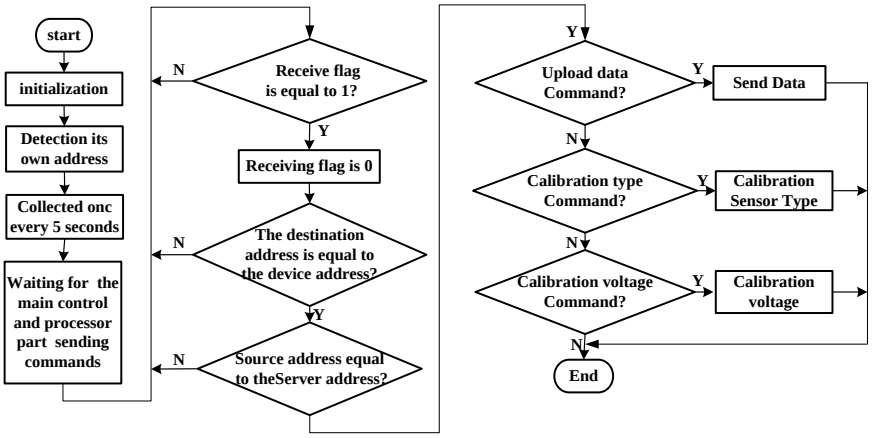

Figure6 .The Software Design's Flow Chart of the Multi-Channel Temperature and Humidity Acquisition Part

3.4.3 The Software Design of the Ventilation Control Part

The software design's flow chart of the ventilation control part is shown in Figure 7.

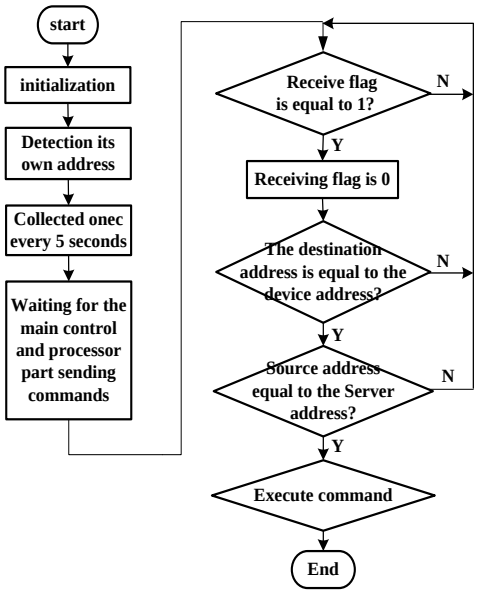

Figure 7. The Software Design's Flow Chart of the Ventilation Control Part

The ventilation control part tests whether the purpose of command address is consistent or not with itself when the users send command, if they are the consistent it will receive and execute the command. The commands include opening the window and closing the window.

4. Conclusion

The design of an acquisition and control system was elaborated in this paper. According to several times of each part was separated tested and overall system was debugged, test results indicate that the SCADA system can meet the requirements of the

design of performance index, realize the automation control of the granary, reduce the loss of grain and improve the work efficiency.

5. System Operation

The uploaded data through the acquisition and control system was displayed on the monitor of SCADA system .The monitor display interface is shown in Table 2.

Table 2 The Monitor Display Interface of the Acquisition and Control System

Equipment Information(G001)						
Coding	Device	UpdateTime	Working state	Value 1	Working state	Value 2
e001	Fan or shutter	141019 13:35:58	LOW	0	LOW	0
e002	SHT10	141019 13:35:58	HIGH	23	HIGH	72%
e003	SHT10	141019 13:35:58	NORMAL	16	NORMAL	53%
e004	Fan or shutter	141019 13:35:58	HIGH	1	HIGH	1

Acknowledgements

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