Inspection System of Food Storage Quality and Safety

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Keywords: Granary, Carbon dioxide, Wireless, Temperature and humidity, Stm32

Abstract: This paper designs a system for stock quality monitoring, uses MSP430 single-chip microcomputer to collect multi-point temperature and humidity of food pile, uses STM32F103 to control related pump valves, collects carbon dioxide, phosphine, oxygen and other gases, and collects gas content data. Delivered into an industrial computer touch screen based on Android. The human-computer interaction node of the upper computer displays the monitoring data, and analyzes the data through the relevant mathematical model to obtain the security level and the disaster type of the reserves.

1. Introduction

Food security is a global and strategic issue related to economic development, social stability and national security. The purchase and storage of food is a very important link in the process of food circulation, but for now, there are great losses and wastes that cannot be ignored during the period from food production to final consumption all over the world. In China, due to the simple and crude food storage equipment of households in most areas and the low level of storage technology, a large amount of food loss is caused by factors such as rats, insect pests and mildew. According to a sample survey conducted by the state grain administration, the average loss rate of food stored by rural households in China is about 8 percent, resulting in an annual loss of about 40 billion jin of food. Therefore, it is necessary to have an effective digital monitoring and management equipment for the granary storage environment.

At present, the newly-built national storage basically uses large-scale centralized inspection instrument. Although this instrument can realize the functions of food temperature detection, ventilation and refrigeration, and can continuously monitor the changes of food conditions. However, the requirements for granary scale are relatively high, the project is huge and the cost is high, as well asonce the temperature measuring equipment and wiring system are completed, it is difficult to change and the system flexibility is poor. The location of the granary is not fixed for a long time, and it often takesfood out of a granary and takes out the bale. The traditional data collection and control system based on wiring cannot meet the requirements well any more. In view of the complexity of food storage and many problems, this paper puts forward a new system design, which adds the measurement function of carbon dioxide, oxygen and phosphine gas concentration on the premise of realizing the detection function of temperature and humidity, it can comprehensively, systematically and accurately grasp the situation of food storage in the granary, and effectively guarantee the safety of the granary.

2. Overall Design Scheme of the System

Inspection System of Food Storage Quality and Safety is a set of monitoring and control equipment, which uses the single chip microcomputerSTM32 as the main control system, and equipped with fan and pump related gas and temperature and humidity sensors. It can measure the content of carbon dioxide, oxygen and phosphine in the granary, and control the on/off of the air valve through relay at the same time. Finally, the results are displayed on the Android screen, and the human-computer interaction is completed by touching. The granary monitoring system consists of terminal nodes and equipment in the cabinet. The workflow of the whole system is: the terminal

  DOI: 10.25236/iwass.2019.280

node collects the temperature and humidity parameters in the granary, and transmits the obtained data to the main controller of ARM. ARM master controller displays, summarizes, stores and backs up data, and performs corresponding operations. The administrator can set the alarm range of each terminal node.

The hardware equipment of Inspection System of Food Storage Quality and Safetymainly consists of embedded master control unit, serial port display touch screen, gas acquisition module, temperature and humidity acquisition module, gas control unit and pump control unit. The structure diagram ofthis systemis shown in Figure 1. The system carries out information interaction with the single chip microcomputer STM32F103ZE through the serial port display touch screen. The gas acquisition module carries out sampling detection for the gas in the granary and transmits the detection result to the single chip microcomputer. And the main control unit will also control the fan pump, and relay through the test results.

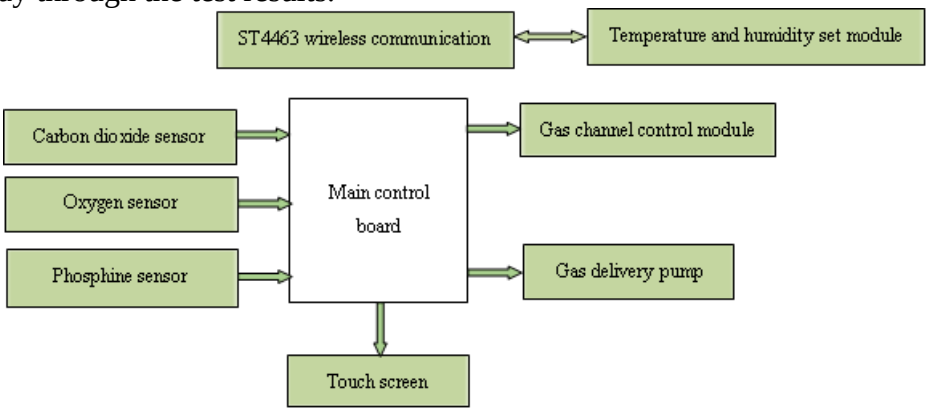

Fig.1the Structure Diagram of Design of System Checking Quality and Safety of Food Storage

3. The Design of Each Functional Module

3.1 Main Control Module

In the Inspection System of Food Storage Quality and Safety, the design of system controller plays an important role. This project chooses STM Company's single chip microcomputer STM32F103ZE, which is widely used in industrial control. It is a single chip microcomputer with high performance, low cost and low power consumption. Then, the mainboard based on STM32F103ZE is the main control unit of the system, and the carbon dioxide acquisition unit and pump drive unit are designed on the main control board. The topology of the main control board is shown in Figure 2. Six single-pole double-throw and six-pin ultra-small electromagnetic relay HK23F-DC5V are designed on the main control board to be used as the control unit of the whole system to control whether the external equipment of each part of the system works or not.

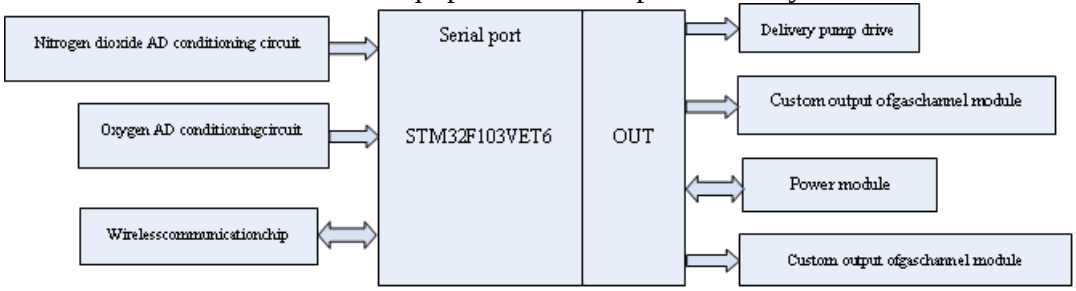

Fig.2 Topology Diagram of Main Control Board

3.2 Terminal Wireless Acquisition Module

This module is mainly composed of single chip microcomputerMSP430G2553, temperature and humidity sensor and wireless transmission module Si4463. Through the temperature and humidity sensor to detect the temperature and humidity of each monitoring point in the granary, and transmit the temperature and humidity data after data conversion to the main control system for data

processing through wireless.

The temperature sensor adopts the temperature and humidity sensor Swiss Sensirion CompanySHT11. The chip includes temperature and humidity sensitive elements, signal amplification processing, A/D conversion and I2C bus interface. The working voltage of sensor power supplySHT11 is 2.4-5.5 V, which adopts two-wire serial interface. The measuring range of temperature is-40-125 degrees, the measuring range of humidity is 0%-100% RH, and the maximum error of temperature measurement is 0.4 degrees. By outputting the two-wire digital interface of SHT11 to the single chip microcomputerMSP430G2553, the temperature and humidity data can be collected at the same time, which greatly saves the reaction time.

Considering the particularity of the using environment, the interior wall of the granary may be thicker than that of common buildings, so it is necessary to choose a wireless module with better penetrability and far transmission distance. ChipSi4463 produced by Silicon Laboratories is selected. The wireless moduleSI4463 has relatively high output power, which ensures a wide range and high link performance. The core frequency of the chip is 433 MHz, the power supply voltage is 1.8-3.6 V, the transmitting power is 20dBm; the maximum transmitting current is 92. 94mA, and the receiving current 13.915mA. The data transmission adopts the SPI mode, which realizes extremely low activity and dormant current consumption. The diversity of its built-in antenna and the support for frequency hopping can be used to further expand the scope and improve the performance, which is very suitable for the use of this system and is also beneficial to the later development. Figure 3 is the circuit diagram of wireless transmission module Si4463 and the connection interface between temperature and humidity acquisition module and single chip microcomputer circuit board.

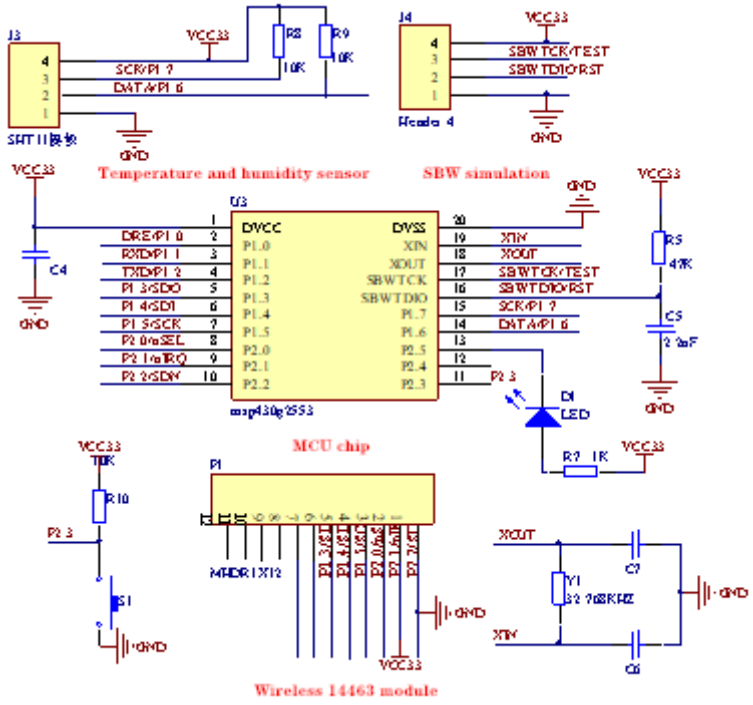

Fig.3 Interface Circuit Diagram of Wireless Acquisition Module and Main Control Circuit Board

3.3 Carbon Dioxide Concentration Acquisition Module

In order to control the interior environment of the granary more accurately, it must realize the most basic functions of temperatureas well as humidity monitoring, gas concentration sensors of oxygen, carbon dioxide and phosphine are also added.

Carbon dioxide sensor adopts T6615-50KF, infrared CO2 sensor and dual-channel suction circulation type. The power supply voltage is 5 V, and the measuring range is 0-50,000 ppm. The output signal is UART Porter digital mode or 0 ~ 4V analog output. The system chooses UART communication mode with strong anti-interference, and the RXD and TXD of the module are respectively connected with TXD and RXD of the main control board.

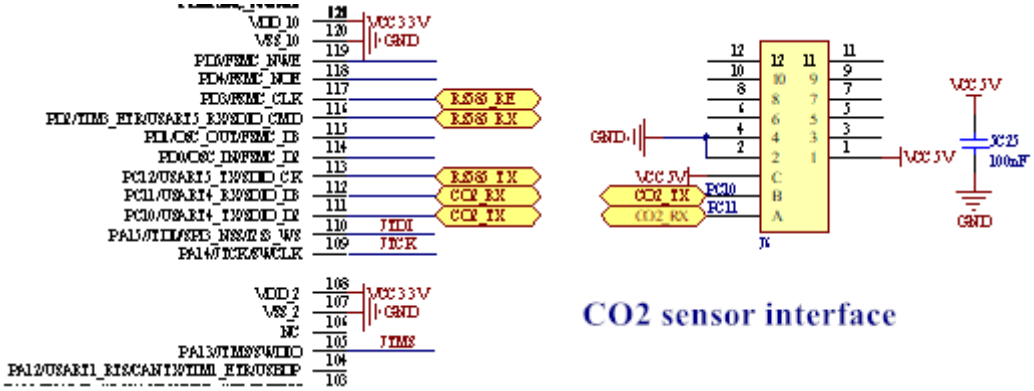

Fig.4 the Interface Circuit Diagram of Carbon Dioxide Module and Stm32

The system uses the gas sensor of galvanic cell in the electrochemical gas sensor for detection. Its basic principle is to use the degree of redox reaction with the electrochemical activity of oxygen to detect the gas concentration of oxygen. The infrared gas sensor is used to detect the concentration of carbon dioxide, because the infrared gas sensor has excellent selectivitywith strong anti-interference ability, good stability and fast response. It can be set to detect only fixed-wavelength gases, and the signal-to-noise ratio using infrared gas sensors is also high. The RXD and TXD of the nitrogen dioxide module are respectively connected with the 111 and 112 pins of serial port 4 of the single chip microcomputerSTM32F103ZET6, and the interface circuit is shown in Figure 4.

3.4 Gas Control Module Design

Gas control is mainly controlled by 16 solenoid valves, which solenoid valve is turned on, gas leads to that road. The drive of the solenoid valve is realized by designing 16 relay circuits separately, controlling the connection and disconnection of each granary air valve, so as to measure each granary in a specific way and achieve more effective control. The relay model selected on the control panel of relay is SRD-12VDC, which has the function of 10-contact switching, and has a set of normally open and a set of switching contact forms. Figure 5 is the topological structure diagram of gas control module.

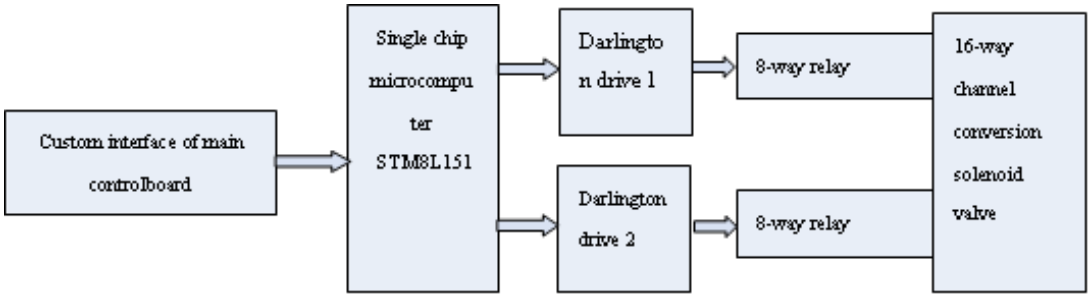

Fig.5 Topological Structure Diagram of Gas Control Module

The 12V and 5V power supplies from the switching power supply are connected to the drive circuit board, and the 5V power supply is powered by the voltage-down of AMS1117 voltage-stabilizing module to 3.3 Vto supply power tosingle chip microcomputerSTM8L151. A 12V power supply supplies the relay. Channel conversion solenoid valve is composed of 1 main channel and 16 branch channels. If a certain channel solenoid valve is powered on, this gas channel will be opened to collect the content of carbon dioxide or oxygen in this channel.

3.5 Fan and Pump Moduledesign

In the whole system, the drive of the micro fan and pump is directly controlled by the main control board. The single chip microcomputer realizes the control in the program, because it does not require high working voltage and current, and does not need high-power drive, so it is driven by the main control DCS and triode. The system encapsulates the micro fanpump and the main control board in the case. Notice that a large current will be generated when the fan and pump is started,

and pay attention to electromagnetic interference. The pump we choose is FKY8006, the power supply voltage is 5 V, the starting current is about 5.5A, and the duration is less than 30 ms, which is within the bearing range of the system circuit board.

3.6 Oxygen and Phosphine Acquisition Module Design

This design uses three different kinds of gas sensors on the system gas detection module to detect their concentrations respectively. Through the sampling pump inside the instrument and the external connection pipe, the gas samples of the detection points are collected and transported to the internal of the instrument for centralized measurement.Connectingto the single chip microcomputer, and performingthe transformation of ADC in the single chip microcomputer. The wiring is very simple. The single chip microcomputer only needs to capture the analog signal, and then convert it in the CPU, and then according to the data bits and reference voltage value of single chip microcomputer, the actual content of gas concentration can be calculated. The circuit diagram of oxygen acquisitionmodule is shown in Figure 6 below. The signal is amplified by high-precision operational amplifier LT6003, and the constant voltage source TL431 is used to output 1.6V datum source to supply power for the operational amplifier. The amplified signal carries out AD conversion through the 27 pins of STM32F103. The phosphine sensor adopts three-wire output of standard 4-20mA analog output, which is converted into voltage signal through 160 ohm resistance and input 28 pins collected by the AD of STM32.

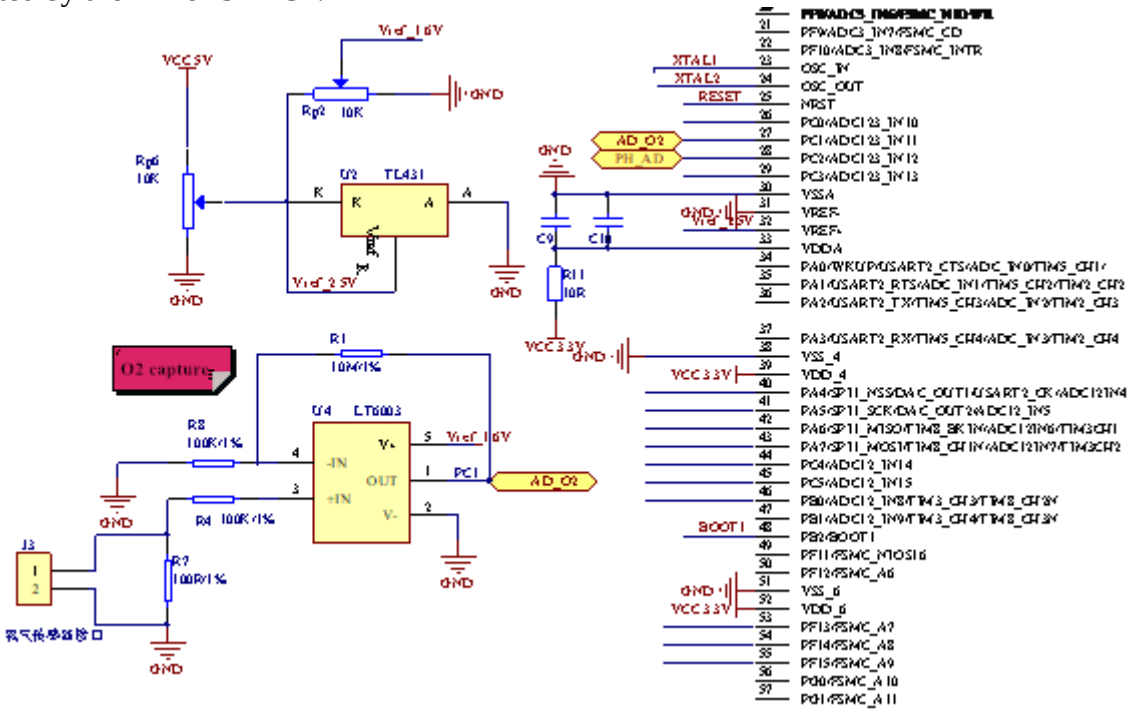

Fig.6 Circuit Diagram of Oxygen Acquisition Module

4. Detection Process Design

In the system, the single chip microcomputer uses STM32F103ZE, the applicable compiler is Keil5, and JTAG is used in hardware simulation. The main system flow is shown in Figure 7.

The lower computer part of this design mainly includes a series of on-line detection instruments, and the detection items include temperature, humidity, CO_2 and phosphine. The detection of CO_2 and phosphine is to collect the gas samples from the detection point and send them to the inside of the instrument for centralized measurement through the sampling pump inside the instrument and the external connecting pipe. There are two kinds of self-detection functions of the lower computer instrument. One is that it can pass regular detection, such as 10d ~ 30d. It can be freely set. The other is real-time monitoring, generally 1h or 24h. It can be set as needed. The detection sequence is: starts the detection program → detect the temperature and humidity values at each point → open

the sampling pump → conduct the detection of CO_2, oxygen and phosphine gas at each detection point.

Fig.7 System Flow Chart

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In terms of information communication and human-computer interaction, the lower computer is equipped with two kinds of interfaces: serial port and network port for communication with the upper computer, which can transmit information with the control center. The basic operation of the lower computer can be realized by pressing buttons and touch screens. Some basic operations of the screen can be set by some codes and sent to the single chip microcomputer to complete the dialogue between the two computers.

The reference point set in the system is generallyzero ofthe instrument detection point. The temperature value of the reference point is an important basis for calculation. The system takes the detection value of carbon dioxide, temperature, humidity and phosphine at the reference point as the basis for safe entry of the granary, calculate these parameters as dependent variables of mathematical model andgive alarm level and danger level. When an individual value exceeds the maximum threshold value, the external warning light of the instrument changes from green to red, indicating that it is unsafe; A preset standard parameter setting and modification window can be stored in the system source code, and SSI (safety index), MMI (migration index), critical point (CP), potential point (PP) and phosphine (PH3) can be set and changed according to the needs of the on-site situation.

5. Conclusion

The system can detect the temperature, humidity and various gas contents in the granary and display them on the touch screen. And through the control of the touch screen, the initial value can be set and modified, and each fan and pump can be controlled separately, and the gas extraction in the target granary can be detected by the gas sensor. The test results can also be stored in the SD card configured by the system, so as to extract and investigate at any time in the later stage. The

system increases the detection of three kinds of gases in the air, making up for the shortage of detection devices in the market and improves the security of the granary.

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