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Research Article

Design of Fruit Storage Monitoring System

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Abstract: Aiming at the problem of fruit storage time short because of the North China fruit storage warehouse equipment simple and single monitoring system, fruit storage monitoring system with C8051F410 SCM as the core is developed. According to the acquisition fresh-keeping storehouse parameters of O_2 concentration, CO_2 concentration, temperature and relative humidity, the system can control the pneumatic control machine, refrigeration equipment, circulation fan and humidifiers, so as to achieve the monitoring of multiple parameters in fresh-keeping storehouse and provide a comprehensive environment for fruit storage. PC Using LABVIEW in human-computer interaction, the PC will be real-time collection parameters of fruit storage, display and control. The monitoring system has high control precision, the precision of temperature is ±0.5°C, humidity is ±1%, O_2 concentration is ±0.5%, CO_2 concentration is ±0.5%.

Keywords: C8051F410, fruit storage, LABVIEW, monitoring, parameter

INTRODUCTION

Fruit is one of the indispensable foods in people's daily life, but the fruit production has strong seasonal and regional, while the fruit itself is easy to decay, which are contradiction to the diversity of consumer demand for fruits and the urgency of the off-season regulation, so the preservation of fruit storage problem is becoming more and more prominent (Peilong and Juan, 2014).

Picked fruits keep alive, they not only is living organisms, but also have complex lift activities of dormancy, evaporation, respiration and still maintain metabolism of the consumption of O_2 and the exclusion of CO_2. Metabolism of fruit is a series of enzymatic reactions complex process of glycolysis, three acid cycle and electron transfer chain. The activities are closely related with fruit storage, influence and restrict the fruit storage life, the external factors affecting the activity of fruit metabolism and storage effect are mainly temperature, humidity, O_2 concentration and CO_2 concentration (Zhang and Liu, 2014). Many scholars have designed or improved many control systems through the control influence factors of fruit storage effect by using different methods (Cen *et al*., 2015). However, these systems have many disadvantages, the control parameters of some systems is relatively simple, some systems lack friendly man-machine interface. Based on the above reasons, the fruit storage monitoring system is designed. The system through the acquisition and control the temperature, relative humidity, O_2 concentration and CO_2 concentration of fruit storage, the fruit in fresh-keeping storehouse can be stored in the best preservation environment, prolonged the period of fruit preservation. The PC using LABVIEW software can realize monitoring the parameters of fruit storage and PC interface more friendly exchanges, more comprehensive information.

MATERIALS AND METHODS

This system is made up of two modules which don't depend on each other and perform a specific function. The two modules is connected by bus. The lower computer is controlled by SCM to realize the functions of the fruit storage parameters acquisition, display, setting, storage and control. The upper computer adopts human-machine interface based on LABVIEW, mainly including data acquisition, real-time display, data storage, super warning alarm and parameter control modules. The structure of the system diagram is shown in Fig. 1.

The smallest single-chip system: This system has selected the chips C8051F410 and C8051F410 of the complete mixed signal system, which is an economic SCM with high performance produced by the company of Xinhualong. Its main internal resources and characteristics include: 32 KB flash, RAM of 2304 bytes, 4 general timers of 16 bit; 18 interrupt sources of variable priority; It can be fully compatible with the

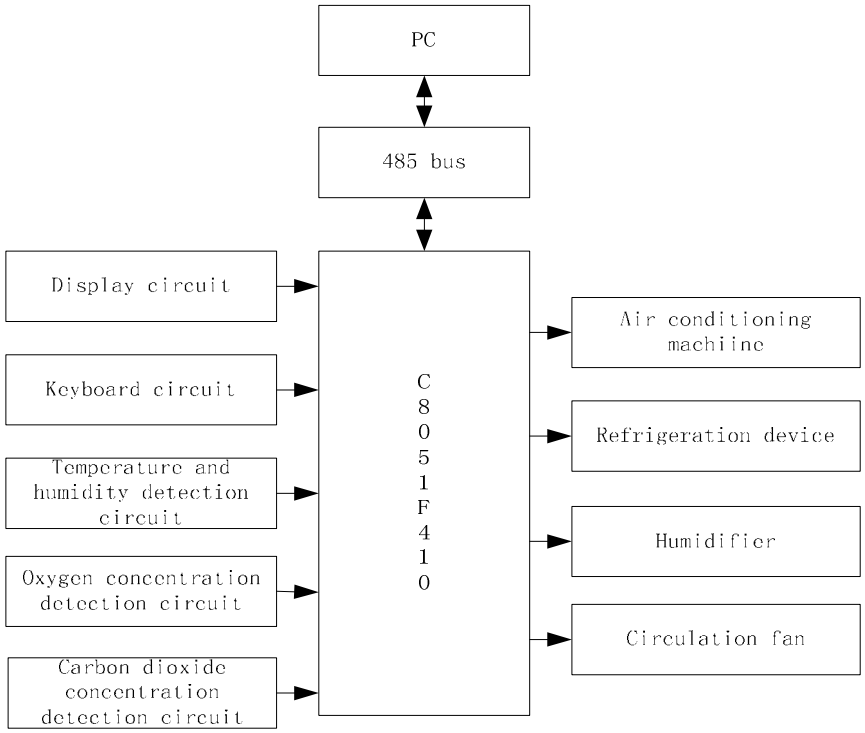

Fig. 1: The structure diagram of system

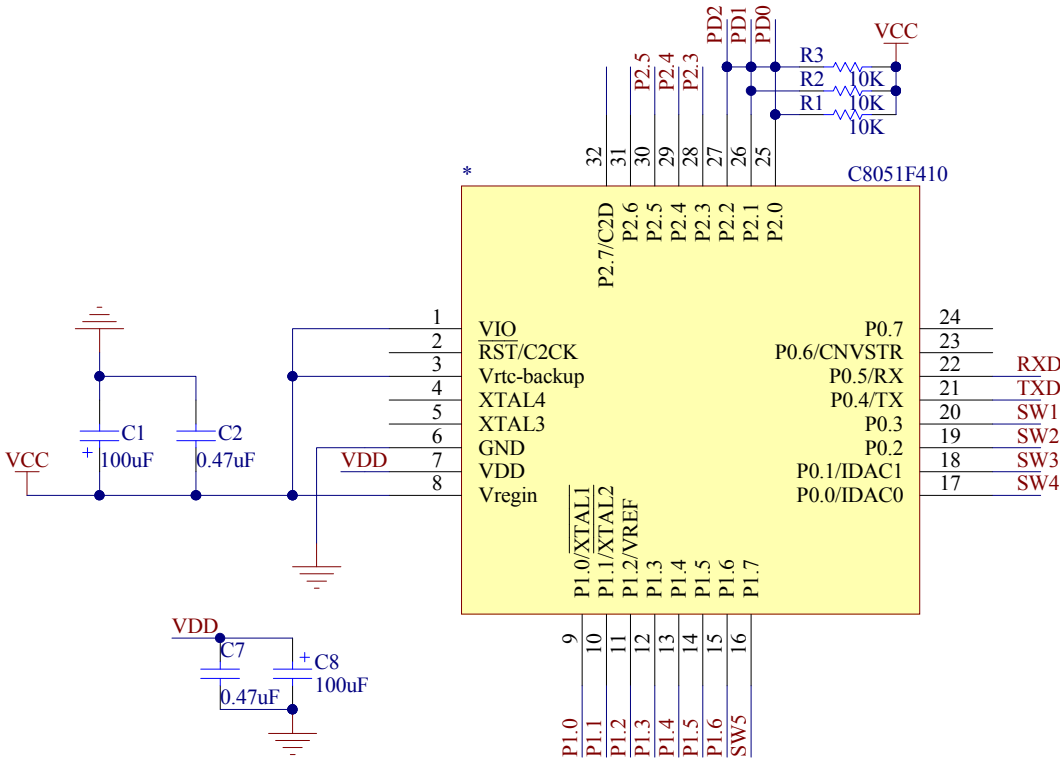

Fig. 2: Minimum system circuit

traditional 8051 instruction set and has rich interface resources to meet the requirements of negative pressure control.

SCM is the main control part of the system which uses C8051F410. The C8051F410 device is the system chip type MCU of the fully integrated low-power mixed

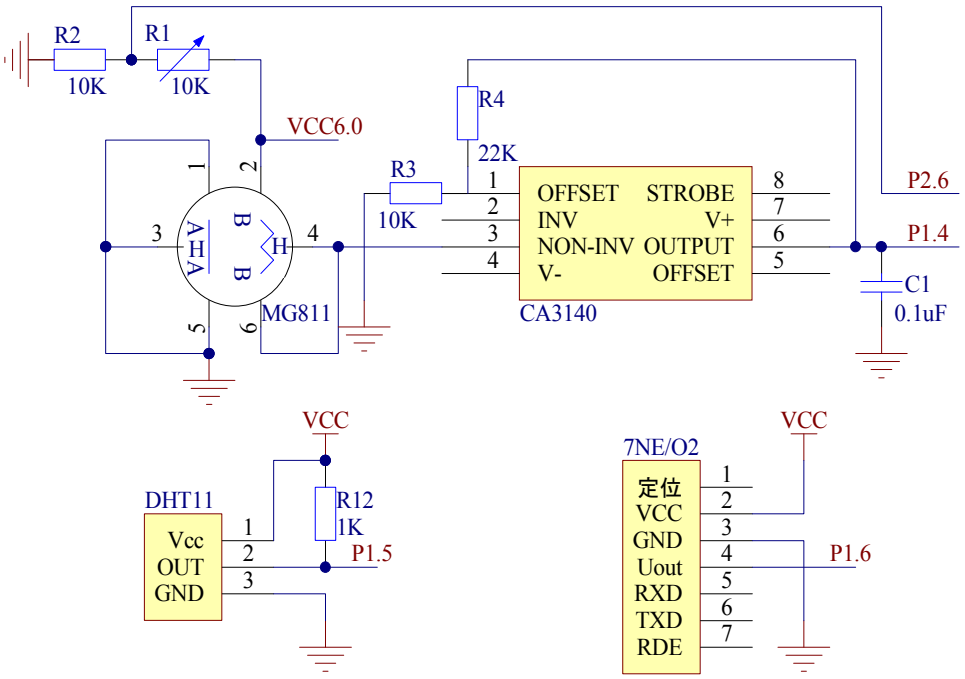

Fig. 3: Signal acquisition interface circuit

signal and C8051F410 has on-chip power on reset, VDD monitor, watchdog timer and clock oscillator, which is the chip system to be really able to work independently and have successive approximation type ADC with 24 channel and 12 bit; 2 current output DAC of 12 bit and the voltage source of the programmable internal reference. The smallest system of the single chip computer is shown in Fig. 2.

Preservation of data acquisition: The fresh-keeping storehouse is tested mainly in the detection of storage temperature, relative humidity, O_2 concentration and CO_2 concentration. The relevant information collected is processed and then sent to the upper computer. The acquisition circuit of the sensor signal is shown in Fig. 3.

Temperature and humidity acquisition uses the temperature and humidity digital sensor of DHT11 (Guang-Ting and Su-Rong, 2011). Because its interior consists of a humidity sensitive element of the resistance type and a NTC temperature sensor, which is connected to a SCM with high performance and single wire serial interface, the sensor has the characteristics of fast response, strong anti-interference ability and higher price. The measurement range of DHT11 humidity is 20-95% RH and humidity measurement accuracy is ±5.0% RH; temperature measurement range is -5 to +50°C and temperature measurement accuracy is ±10°C, the collection to the information collected of temperature and humidity is received P1.5 of C8051F410.

O_2 concentration collects 7 NE/O_2 smart sensor and this sensor has temperature compensation and need not calibration with the characteristics of the voltage and

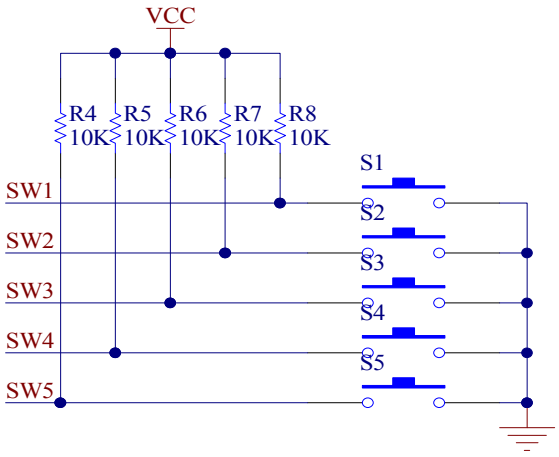

Fig. 4: Key interface circuit

serial output. The external circuit is simple and easily operated; the measurement range is 30% VOL and the accuracy is ±2%. O_2 concentration collected is received P1.6 of C8051F410.

The concentration acquisition of CO_2 uses solid electrolyte sensor, MG811. Because the output impedance of the sensor is very high, when it is used, the amplifier chip with high impedance, CA3410 is received at the output terminal. CO_2 concentration collected and the output terminal of the temperature compensation collected are received to P1.4 and P2.6 of C8051F410.

Keyboard and display circuit: In order to meet the needs of keeping different fruits fresh, the control

system designs the range of parameters. Through the keyboard input, the content is set including the upper and lower limit values of the temperature and humidity and the upper and lower limit values of the concentration of O_2 and CO_2. Figure 4 shows the interface circuit of the SCM and independent keys and each key function is shown as follows: S1 selection key, S2 plus, S3 minus, S4 confirm key and S5 reset key.

According to the system needs which information about the temperature, humidity, O_2 concentration and CO_2 concentration are displayed. The liquid crystal display 1602 is used as the display module. Since the I/O of SCM is less, the extension and parallel output port of the shift register 74LS164 of the serial input parallel output is used and LCD interface circuit is shown in Fig. 5.

Actuator circuit design: When the lower computer detects a certain environmental parameter exceeding the warning line, the SCM outputs low electrical level for the corresponding I/O actuator operation microcontroller output low level, triode opened, relay actuation to corresponding actuator operation. This system adopts P1.0 control the refrigeration device, P1.1 control humidifier, P1.2 control circulating fan and P1.3 control air conditioning machine. The specific interface circuit is shown in Fig. 6.

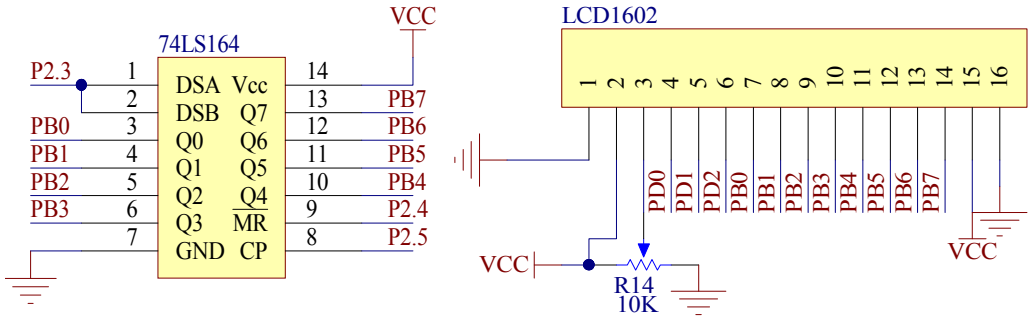

Fig. 5: Display interface circuit

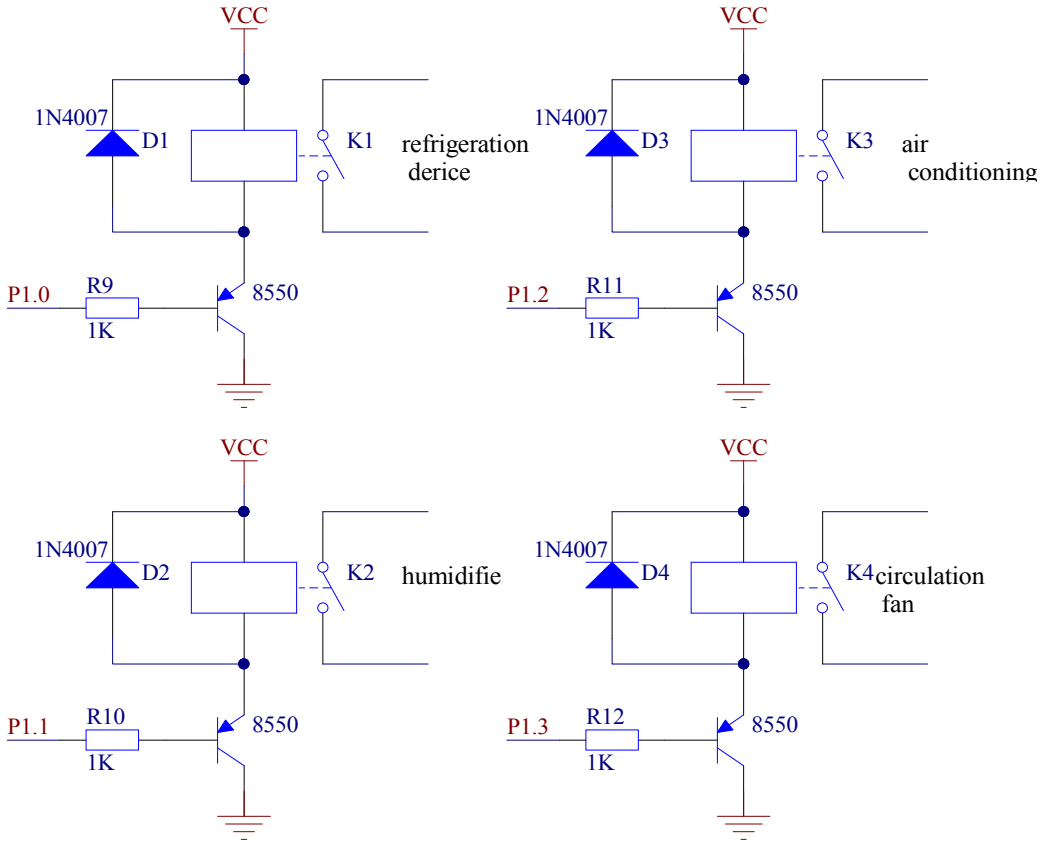

Fig. 6: Actuator interface circuit

RESULTS AND DISCUSSION

Fruit storage monitoring system is made up two parts including the lower computer software and upper computer software. Before the lower computer and host computer don't realize the communication, this monitoring system software is independent operated only by the lower computer system software which has been able to work directly to achieve environmental monitoring of fruit fresh-keeping storehouse, but the indicator functions weakened. The lower computer of this monitoring system software is realized by C8051F410. The whole framework of the upper computer system is written by LABVIEW 13.0, in which the data display, data analysis, data storage and data control are completed by this software which greatly shorten the software development cycle. The upper computer some advantages of easy use, good versatility and functional extension.

Lower computer software design: This monitoring system completes sampling to temperature, humidity, oxygen concentration and carbon dioxide concentration. After all sensor signals are processed, they are sent into the AD converter of 12 bit of C8051F410. After the SCM receive the information through the corresponding processing to display the information. The software system of the lower computer can be divided into four

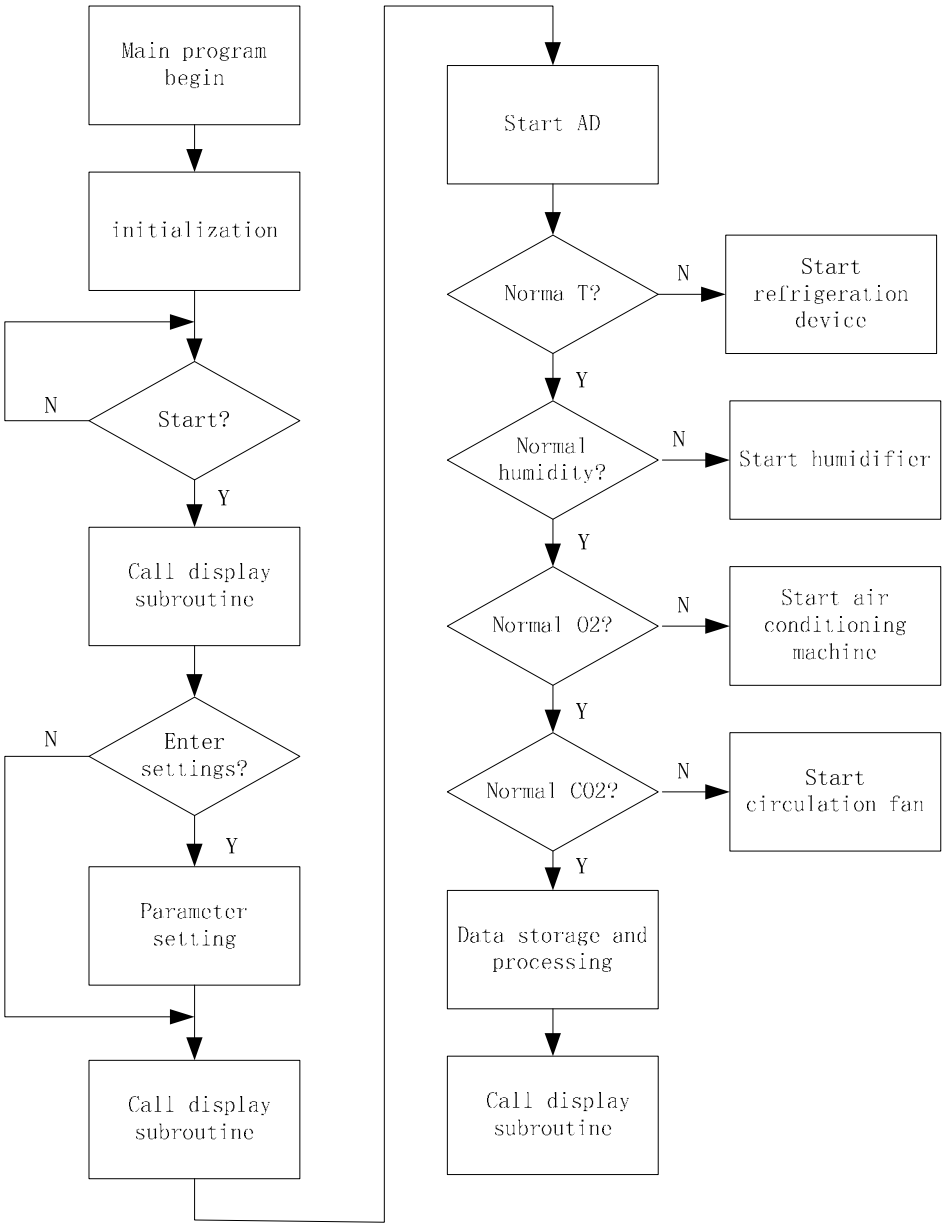

Fig. 7: Lower machine main flow chart

modules including system monitoring module, man-machine interface module, control processing module and data communication module. System monitoring module is a global module, including system initialization, signal acquisition, display, input and output operation of the system. The human-machine interface is able to complete the interactive function to operating personnel. The control processing module is able to complete the system input signal processing and analysis to give the output quantity. The data communication module can complete transfer data, command and information between the lower computer and the upper computer to output the storage data at regular time. The lower computer's overall program diagram of the monitoring system of fruit fresh-keeping storehouse is shown in Fig. 7.

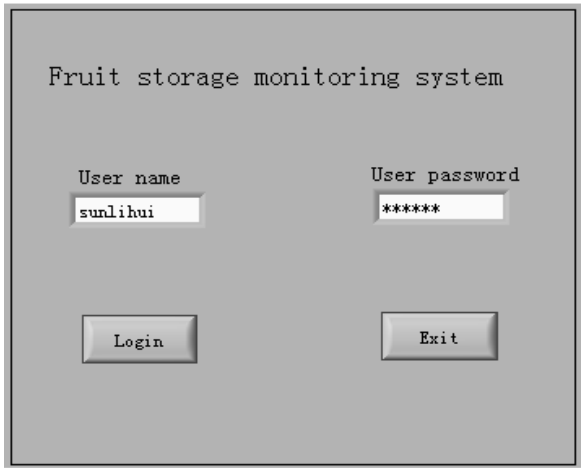

Fig. 8: System login interface

Design and implementation of upper computer: The upper computer software is mainly built on the LABVIEW platform (Gui-Li *et al*., 2015). LABVIEW is a graphical programming language, known as the "G" language. When this language is used for programming, complex language programming is simplified as visual data flow and an icon represents the function module. The connection line between icons represents the transmission of numerical values and its programming way is very similar to an electronic circuit formed by the original and the wire, which is vivid and intuitive.

The program of the upper computer receives temperature, humidity and oxygen concentration and carbon dioxide concentration sent by the lower computer mainly and directly sets the upper and lower limit of each parameter execution and control mechanism through the serial port. In addition to the

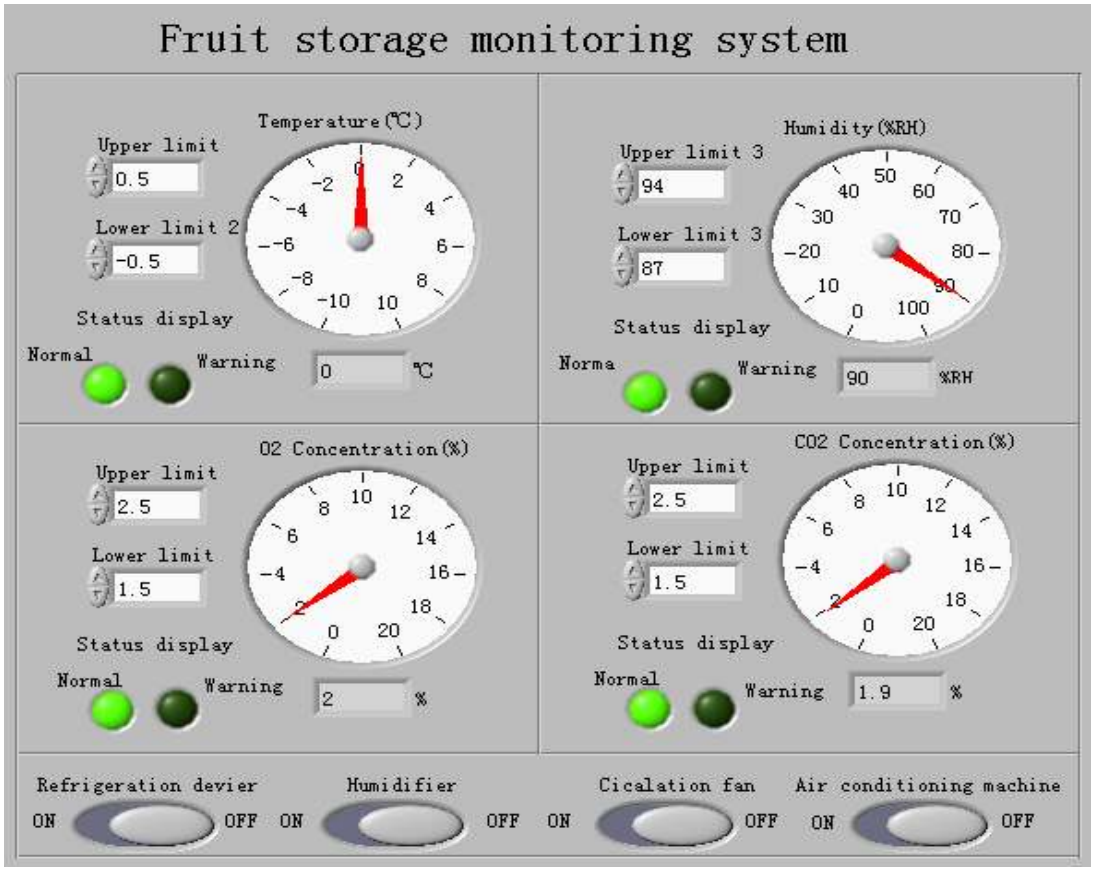

Fig. 9: Monitoring interface of normal

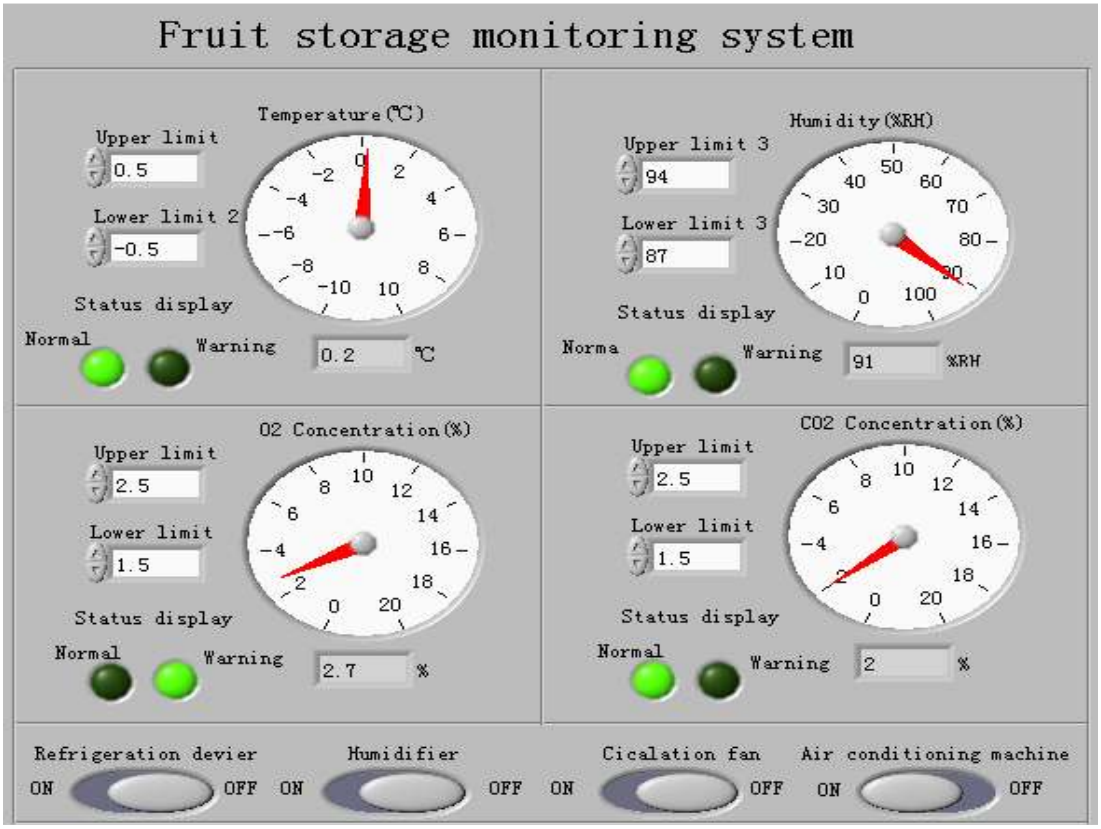

Fig. 10: Monitoring interface of abnormal

serial communication function, the upper computer needs to realize the following functions.

Each parameter display: The parameter values received is controlled to display through the numerical control instructions and waveform control.

Parameters alarm: When the measured value of the parameters exceeds the upper and lower limits set by the parameters, LED lamp control gives alarm and implement the corresponding execution unit.

The upper and lower limit settings of parameters: Setting upper and lower limits of the parameters through the text drop-down control and after clicking on the settings button through the serial port sending to the lower computer.

In order to test the effect of operation monitoring system of fruit fresh-keeping storehouse, Laiyang pear is placed in fruit fresh-keeping storehouse and the best preservation environment of Laiyang pear storage: reserve temperature is zero; relative humidity is 90% RH and oxygen concentration is 2%, carbon dioxide concentration is 2%. Operation monitoring system and the login interface of the host computer are shown in Fig. 8. After login, the monitoring interface is shown in Fig. 9. The real-time data of each parameter and working state of system are shown very intuitively. When one of the parameters (O_2 concentration) exceed the limit line, as shown in Fig. 10, O_2 concentration displays the alarm lights of the module and start the air conditioning machine, to adjust the O_2 concentration in order to achieve optimal environmental conditions of Laiyang pear.

CONCLUSION

Fruit storage monitoring system can ensure the fruit to be in the best environment and can improve the fruit storage time. The system has the following functions:

- Temperature and humidity, O_2 concentration and CO_2 concentration in fruit storage were measured and real-time displayed. Humidifier, air conditioning machine, circulation fan and cooling device were controlled by the output of SCM.
- The software is programmed by LABVIEW, the interface with real-time display, alarm, control and storage function was designed. Fresh fruit monitoring system has reached the purpose of monitoring the environment of fruit storage through the realization of the above functions. So the system can make the fruit in the best environment and meet the requirements of storage and preservation.

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