A Study on Intelligent Greenhouse Temperature Measurement System Based on RS485BUS

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Abstract: This paper introduced a multi-point intelligent environment monitoring system of greenhouse based on RS485 BUS technique, which performed real time measurement of temperature in the greenhouse. The administrator could monitor the environment conditions in the greenhouse by using it. The system consisted of the master processor and slave processor. The slave processor mainly collected and conducted temperature. Then the data would be transmitted to the mid-controller through RS485 BUS. There was one mid-controller in each greenhouse that displayed the data transmitted by the slave processor and gave off an alarm signal when the data was beyond the threshold value that was set by users. The master processor yet performed the threshold value of environment element setting and then achieved uniform management of all the greenhouses.

Keywords: Greenhouse; RS485 BUS; SCM; Temperature Measurement.

1 Introduction

The temperature of greenhouse was important factor that affects the crops growth and the yield. Nowadays there were measure and control systems used in greenhouse in the market, but the control and monitoring systems suited the real-time multi-point temperature were rare. This paper introduced an intelligent greenhouse multi-point temperature measurement system based on RS485BUS. The greenhouse could control suitable temperature according to the natural environment, the physical condition as well as the crop assortment difference.

2 The System General Design

Taking 51 monolithic chip as the core, real-time multi-point temperature inspection was achieved. The master processor and slave processor in the system plan were fulfilled completely by monolithic chip, and may satisfy the majority of demands in the industry. Some functions of the slave processor were almost equal with master processor, but it would accept orders from the master processor. Fig.1 showed the system diagram.

In the system plan, it used the simulation integration temperature sensor AD590 as temperature sensor, AD620 as signal amplifier. They had the great scope, the high accuracy characters for gathering temperature signals. Opposite to other plans, it had a greater promotion in the function, the performance
3 The System Hardware Composition

3.1 The Temperature Measurement Element

There were many temperature measurement methods. Having the sensor nature mainly had the thermal resistance, the thermo-element, the simulation integration temperature sensor, the intelligent sensor, the hypothesized temperature sensor and the network temperature sensor, monolithic temperature measurement system and so on.

Based on a comprehensive analysis of temperature change situation in the agricultural greenhouse and the environmental condition of the measured object, the simulation integration temperature sensor AD590 whose precision was ±0.5°C was adopted. It was the special temperature measurement IC chip which could perform the temperature measurement and analog signals output functions. Its characteristic was small measurement error, low price, high response speed, far transmitting range, small volume, low power loss and so on. It not only suited the long-distance temperature measurement and control, but did not need non-linear proofreading and the periphery electric circuit was simple. Based on these characteristics, it was extremely suitable for sensitive unit to measure temperature in this system.

For amplifying the signals, we used the low price, high-precision instrumentation amplifier AD620 which used conveniently to adjust various gains (1-1000) through external resistance.

3.2 A/D Conversion Design

Because the temperature change was quite slow, therefore, the speed request of transforming to A/D was not high. A comparative analysis of each A/D converter showed that it was extremely suitable to use the A/D converter composed by VFC. VFC was called the voltage frequency converter, which transformed the simulated signal voltage inputted into the pulse signal whose frequency was proportional to the voltage's, and then took count of the pulse signal in the fixed time. Theoretically speaking, this kind of ADC resolution may infinitely increase. As long as the sampling time was long enough to satisfy the accumulation pulse integer width requested by the output frequency resolution.

3.3 Communication Modules Design

The output of SCM serial mouth was the TTL electrical level, only which was transformed to the commonly used serial communication bus standard interface electrical level, such as RS-232 or RS-485. RS-485 had high transmission speed, long transmission distance (may pass on 1200m) and strong anti-clutter ability and so on advantages, and it allowed one sender unit to drive the many load equipments in one pair of twisted pair lines. Therefore, this system used the RS-485 main line to carry on the transmission and used the MAX485 driving chip to carry on the level transformation. As was shown in fig.2&3.

![Fig 2 Interface Circuit Diagram between Slave Processor and MAX485](image-url)
3.4 Keyboard Circuit Design

Because the LED module was used to carry on the demonstration of the temperature data in this system, therefore the interface between HD7279A and microprocessor was extremely simple. It only needed 4 interface lines. Among them, CS was the chip select signal, DATA was the serial data terminal, CLK was the synchronous clock input terminal of data serial transfer, and KEY was the output terminal of push button signal. In order to increase the driving force of HD7279A, 4 100kΩ pull-down resistors were added on the SA~SD pin. In order to adjust the current value through the keyboard and make the key value that HD7279A read was more accurate. Four 10kΩ and four 200Ω resistors were increased. As was shown in fig.4.

![Fig 3 Interface Circuit Diagram between Master Processor and MAX485](image)

![Fig 4 A schematic diagram of Keyboard circuit](image)

3.5 LCD Module Design

The module was one kind LCD with the 5x7-lattice graph demonstrating the character, and it may be divided 2 lines of 16 characters the capacity, which demonstrated.

The module interior CGROM already stored 160 different lattices character graph, including Arabic numeral, big and small English letter, commonly used mark and Japanese fictitious name etc. Comparing with other modules, this module was low power loss, small volume, light weight, long life and simple interface with MCU. Furthermore, CCFL back light inversion and DC-DC demonstrating actuation power source were not needed.

3.6 SCM Peripheral Circuits

The master controller mainly was responsible to control slave processor, including the establishment information of slave processor and the collection the examination signal from slave processor. Then the data collected would be stored, analyzed and displayed. It could carry on the acousto-optics reports to the police according to the alarm limiting temperature established by the user. This part of hardware circuit design increased 24C04 to preserve temperature data besides keyboard, liquid crystal and so on routine external device, and it also increased a calendar clock chip PCF8563. As was shown in Fig.5.
4 Software Design

The program was formed primarily by master processor program and computer program. The main program achieved the initialization of system chiefly, indicated that data, established the related information of the slave processor and dealt with the communication. The gathering temperature signal program and the response master processor order program made up the slave processor program. Using asking the mean value to increase the precision of gathering temperature signal, and added up to 160 samplings. Asked the mean value and judged whether beyond the limiting temperature. Fig. 6 shows the routine flow chart.

Actually, the program of slave processor responding main controller was an interrupt processing routine. In the course of the slave processor words, when the demand from main computer was detected, the slave processor would change the gathering temperature signal program to respond the request of main computer. The order or the request of the main computer had following four kinds: reporting to the police and inquiring, the establishment the time of slave processor, the establishment alarm limiting time and inspection the temperature. When the inquiry condition could not be satisfied, slave processor would open the interruption automatically, and continue to gather the temperature signal.
The system initialization included the initialization of register (control register, stack, interrupt register and so on), the communication initialization (the serial mouth initialization, the MAX485 initialization, Communication buffering initialization), the liquid crystal initialization, the output terminal initialization and sampling and integrating data initialization.

The demonstration data included the data conversion (all kinds of parameter, survey data, calculational integrating value were transformed data type needed by liquid demonstration) and the refreshment of the display screen (including the refreshment of gathering data screen and changed display screen with pressed button).

Communication processing aimed at mainly information exchanging and processing of the master controller and the slave processor.

5 Error Analysis

This system error mainly came from the temperature gathering circuit and the temperature signal transfers circuit. As for temperature gathering circuit, we used the Over-Sampling and asking the average value technologies to reduce the error. The so-called Over-Sampling technology was higher sampling frequency than the Nyquist’s to sampling. In other words, while sampling to the signals, ADC could increase the effective bit number. Every time one-bit resolution was increased, the signal must be four times velocity over-sampling. Meanwhile to the signals extracted were asked the average value, it could effectively reduce error.

6 Conclusion

The electric circuit structure of the multi-spots temperature measurement system was simple, the work was reliable, the function was toward perfection.

(1) System time and temperature correction were established together by master controller.
(2) It could perform collecting data from each slave processor at fixed time and the integral point function. Using I2C to serial E²PROM, might preserve respectively formerly 24 hours data from slave processor. Moreover, it could perform renewing data and power-off protection function.
(3) It brought +5V and +12V direct-current stable power.
(4) The alarm bounds of every slave processor were established separately by master controller. Both master processor and slave processor had acousto-optic alarming function.
(5) It could perform storing data function. It might inquire respectively formerly 24 hours temperature state from slave processor. The slave processor may display the current temperature, time, alarm-limiting temperature etc. The master processor and slave processor used the Chinese lattice type LCD and user-friendly interface.

The design fully took advantage of the chip's low power consumption and extended the battery duration effectively; wireless data transmission was convenient and agile. The system hardware was simple and reliable; moreover, it was easy to use and maintain. After using this ACS, the greenhouse reduced manpower costs and increased their economic results by a large amount; thus realized the intelligent and scientific management.

Reference