Journal of Theoretical and Applied Information Technology
20th March 2013. Vol. 49 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

DESIGN OF A TEMPERATURE MONITORING AND ALARM SYSTEM BASED ON CAN BUS

[1]MA JIWEI, [2]ZHANG LIHONG, [3]MA JIMEI, [4]LIN ZHIPENG, [5]LUN CUIFEN
[1] Assoc. Prof.,[1.2.4.5] the College of Mechanical and Electrical Engineering,
Hebei Normal University of Science and Technology, Qinhuangdao China
[3] Department of Electronical Engineering, Hebei University of Technology, Tianjin, China
Email：[1] jdxbmjw@126.com

ABSTRACT

A portable instrument of multi-channel temperature tour measurement and control in which a high-speed single-chip of 51-series is taken as the core and single-wire digital temperature sensors are used is designed, and CAN bus controller is also extended in it. It is proved that it has low power consumption, high cost performance, high stability and reliability; and flexible monitoring and control terminals are provided for large-scale temperature measurement and control local area network by the extension of communication interface.

Keywords: *Multi-Channel Temperature, STC15F2K60S2, Measurement And Control, CAN Bus, Low Power Consumption*

1. INTRODUCTION

With the development of electronic and computer technology, smart sensors of various parameters have also been developed. New convenient monitoring methods in industrial and agricultural production and house environment are provided by the development and application of new technologies in the field of temperature measurement and control [1]. In the field of temperature measurement and control, application of digital sensor overcomes the complexity of circuit and poor interference of the traditional; at same time, development of high-speed 51 series also provides a high cost-effective CPU for measurement and control system. So a portable multi-channel temperature measurement and control instrument with CAN bus communication, MCU of high speed STC12C and single-bus digital temperature sensor DS18B20 is developed by the term. The instrument not only can operate in stand-alone form, but also can be formed to local area network through communication bus, and then the monitoring in industrial field, agricultural facilities, cold storage, and house environment can be realized. Tests showed it has high response speed, reliable communication, low power consumption and high stability.

2. HARDWARE OF THE MEASURMENT AND CONTROL INSTRUMENT

2.1 Hardware and Principle of the Instrument

Modular structure is adopted in the hardware and software design of the instrument. It is composed of core of MCU, LCD display, 3-8 ways temperature acquisition by DS18B20, CAN controller, keyboard input and alarm circuit and so on. In the system, STC12C5A32S2 with 40-pin dual in-line package is taken as the core, the MCU has an internal reset circuit, watchdog and E^2PROM, 1280B SRAM on-chip, 36 I/O ports and online programming function [2]. It enhanced 20%-30% in speed than STC12 series. In the common development software of Keil, STC51 series is added, so the simulation debugging is realized without hardware simulators. By using this kind of single chip, the product development speed is greatly improved and higher stable and reliable performance is gained too. Except the heating and the exhaust control circuit, power supply and a liquid crystal with backlight are designed so that the system can get lower power consumption and smaller volume. The power and backlight of LCD can be closed in normal and then be opened when any button is pressed, by which power consumption of the system can be reduced 30%-40%. Multiple temperature acquisition share one I/O port only, by which the instrument volume is decreased and the whole instrument size is

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

200*175*70 mm. The design of the power is also greatly facilitate the users, either 220V AC power supply (charging the battery, then disconnected automatically when full) or 5V rechargeable battery can also be used, which provides a convenience for the situation without electric supply. Hardware structure of the instrument is shown in Figure 1.

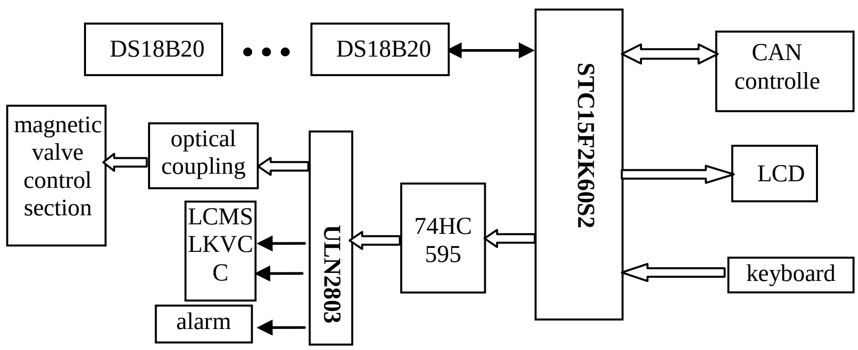

Fig1 The Hardware Structure Diagram Of Measuring And Controlling

According to actual needs, Users can set the setting points, upper limit and lower limit of the temperature of each monitoring point through functional menu and add and subtract keys, and then the parameters are saved to the E^2PROM of MCU; after real-time collection of temperature of each point, the instrument wil analyze the results. If the actual temperature is out-of-limit, then control procedures will be called to control the starting and stopping of the heating, refrigeration and ventilation equipment, at the same time alarm information is given. A piece of 74hc595 is extended, and concatenation extending of more pieces of 74hc595 to control more peripherals can be realized when needed.In the large-scale distribution temperature control LAN system, each measurement and control instrument is taken as a monitoring node; at same time, the real-time data collected and alarm information will be uploaded to the monitoring center via the CAN bus and then the storage, query, analysis and report form printing of large amounts of data are realized by the PC and management software.

2.2 Design of the Temperature Measuring Circuit

Comparing with the traditional 8051, significant improvements are gained in I/O ports of MCU STC12C. The internal structure design of four-ports are identical, each has four different ways of bidirectional I/O port, push-pull output (strong pull output) , high-impedance input, open-drain output.

The way of the push-pull output has the strongest driving capability; output current of each I/O port is up to 20mA. Testing showing, when data line is up to 20m, one I/O port can drive 12 DS18B20 reliably; then drive circuits must be added if the number of DS18B20 need to increase. According to actual demand, and to get the smallest volume, one I/O port connected with an external 10KΩ pull-up resistor drived 3-8 DS18B20 directly, and then software programming is used to identify the sensors through its SN [2].

2.3 Design of the Control and Alarm Circuit

To save the I/O port of MCU, an interface chip 74HC595 with serial input and paiallel output is extended through three I/O port of MCU, then 8-channel signal are output by ULN2803, one way is for the buzzer alarm control, 3-ways are used to control the starting and stopping of the solenoid valve of the heating, cooling and ventilation equipment, 2-ways are connected to the GND pin of LCD power and backlight power. For the instruments, we do the test, it is shown the backlight state of LCD needs large power consumption, so we turn off it when not needed and can even close the whole liquid crystal display, then the power consumption of the system can be reduced by 30%, which is very important to a portable instrument.

2.4 Designed of Can Bus Controller and Human Computer Interface

CAN bus has good performance such as low cost, strong fault tolerance, low maintenance costs, long transmitting distance etc [3]. Considering the characteristics of buses, CAN bus is chosen to form the large distributed LAN system of temperature measurement and control. The interface circuit is shown in Figure 2. The communication rate of CAN bus controller SJA1000 is up to 1Mb/ s, accords with protocol CAN 2.0A and CAN 2.0B and meets the requirements of system communication speed. The data is sent to the transmit buffer of controller through the port P0 by MCU, after processing then is sent to bus by TJA1050; at same time, control commands from the host computer and the set parameter values will be received by TJA1050, after treatment by SJA1000, then will be read by MCU by way of interrupt notice.

The system has simple and friendly human-computer interface and is easy to operate. To reduce power consumption, LCD160128 is chosen for display, port P1 of MCU is taken as the data port, P2.0-P2.2 control the C/D, WR, RD of LCD. The CS and RST of LCD are directly connected with GND and power. So that I/O ports are saved but meet the needs of the system. Three independent keys are set to achieve function of setting, confirming, "+" and "-". The user can set the parameters, when the confirm key (multiplexing with function key) is pressed, the main program is start running, and tour temperature detection of each point is starting, then the values of set temperature and actual temperature of each point and the alarm information (containing the alarming address) are shown in LCD.

3. SOFTWARE DESIGN

The software of the measurement and control instrument is composed of main program, subroutines of temperature collecting, display and alarm, keyboard, PID moderating and data communication, etc [4].

3.1 The Main Program

Initialization is composed of interrupt settings, working way setting of I/O, command writing of SJA1000 control. Main program loops to control the temperature detecting of each point of DS18B20 and display the setting value and collection value of all sorts of temperature, then comparing with the set value and control the output by PID regulator, if the actual value is over-limit, alarm will be given by the buzzer and the alarm address number is displayed in LCD. For large-scale temperature measurement and control network systems, measurement and control instrument is conectted to CAN bus as intelligent terminal. Except for the temperature acquisition and environmental temperature adjustment functions, data communication is also needed to send data of temperature acquisition and alarm information to the host computer from the acquisition nodes.

3.2 Subroutine Design of Temperature Acquisition

As DS18B20 is 1-wire sensor, MCU must operate in the timing of the sensor strictly. Basic operations of DS18B20 includes initialization, data writing and reading, in which bitwise operations should be done, and strict timing requirements must be ensured. The temperature program can properly be read by the traditional 8051 but can not work when replaced STC12C because STC12C belongs to a single type of machine cycles, 8-12 times faster than 8051. So the delay subroutine is modified to fit

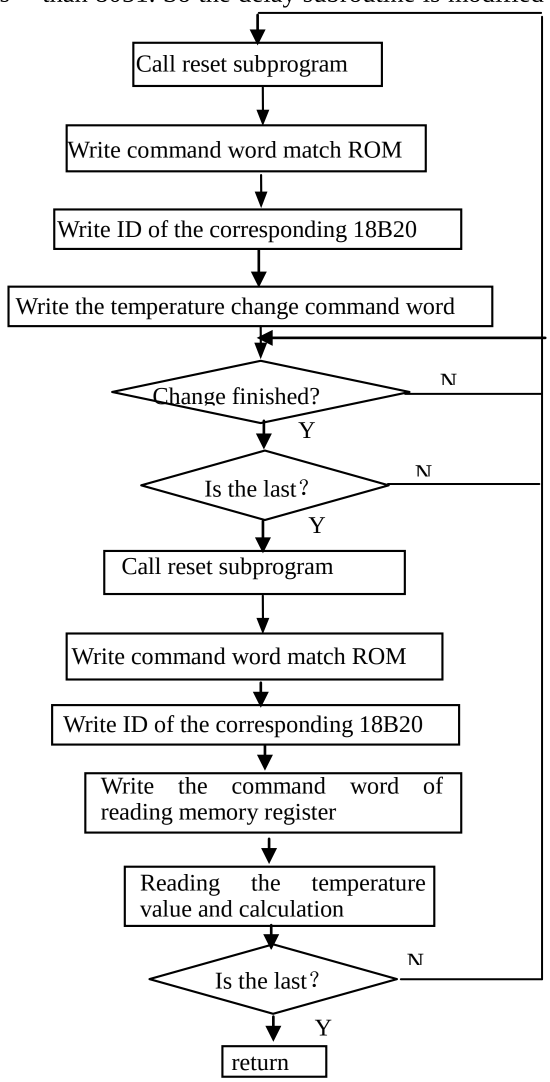

Fig.3 The Subprogram Flow Chart Of Measuring Temperature

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

for DS18B20, delay software is used to meet the special timing requirements [5].

The serial number in 64-bits lithography ROM of DS18B20 is phototched mask before they leave the factory, its sequence is: the first 8-bits is the product type number (28H), the next 48-bits is the serial number of the chip itself, the last 8-bits is the CRC (cyclic redundancy check code, CRC=X8+X5+X4+1）of the front 56-bits. The lithography ROM of Each DS18B20 is not identical; so that multiple DS18B20s can be connected to one bus.The read-write source program of DS18B20 can be referenced to the manual of the device. A piece of DS18B20 is connected to the bus first, and then ROM command (0x33) is carried out to get the 64-bits SN each chip. In the temperature acquisition subroutine, the SN numbers of several chips are designed to constant array, then reading subroutine is called to get the SN of each chip and it is stored in E^2PROM before entering temperature acquisition, then temperature acquisition, conversion and rending can be finished by using of the unique identification number of each chip. The subroutine process of temperature acquisition of multi-chip of DS18B20 through one I/O port of MCU is shown in Figure 3. To speed up the detection rate of the whole system, each 18B20 is started in sequence to temperature conversion, and then each value will be read in turn. The reset subroutine is called first, then the match command word(0x55) of ROM will be written, then the corresponding coding SN be written, the corresponding DS18B20 be start, the temperature conversion command word (0x44) be write, and so the cycle starts until the last piece. Then the reset subroutine is called, the matching command word (0x55) of ROM is sent out, the corresponding SN is written, the command words (0xbe) of reading temporary register is sent out, and then the integer temperature value collected by DS18B20 corresponding to the SN is read, at last the floating-point value of the actual temperature is calculated.

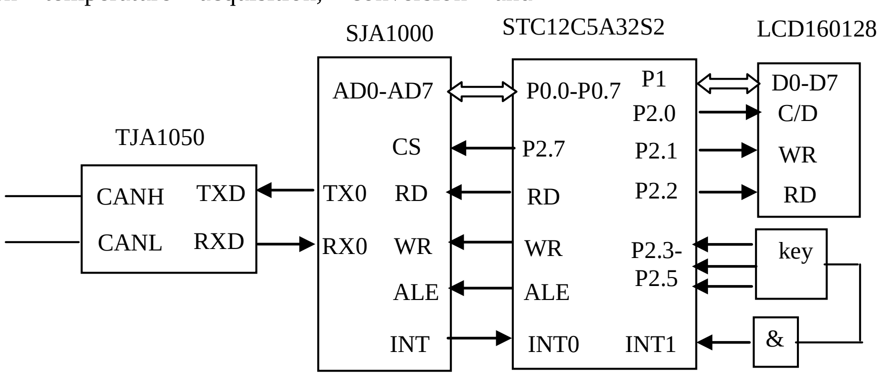

Fig 2 The Interface Hardware Structure Diagram Of CAN

3.3 The Management Software of PC

For large-scale temperature monitoring LAN, the PC management software is developed by using kingview. Kingview is a man-machine interface software running on Windows Chinese platform, in which such as the multithreading, COM+ component technology are adopted and the real-time multitasking is realized, and the software operats reliably.By using the software, database construction and external equipment defining can be realized, the picture development is simple and convenient. TOUCHVIEW completes the data acquisition from control equipment, then saving in real-time database, at the same time, completes variable alarm, operation recording and trend curve making etc. In the system, PC is taken as a monitoring center, and it can be connected to the CAN bus by use of USB-CAN interface, Kingview is used to develop the management software of PC, and the communication subroutine of slave computers will be developed according to the protocol between Kingview and MCU. The user enters management interface, you can set the value of temperature setting, the upper and lower limit of each node, get the actual temperature and alarm information of each node in real time, browse the actual temperature of other networked nodes, know the settings and changes of temperature of different nodes in real time, and can get a regular data forms. Users can also query historical data according to the time，and the results can be imported into Excel to generate reports or be drawn into a graph to print [6].

4 CONCLUSIONS

Field test is finished in eight greenhouses. In the system, PC is taken as the host, It communicates with 8 measurement and control instruments, and

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

one instrument is connected with 3 temperature sensors. Tests show the system has collection distance of 20m, wired communication distance of 1000m, measurement range of -10 ～ 60℃, resolution of ± 0.5℃, measurement accuracy of ± 0.1℃, response time of lower 15s.

In the sampling period designed, time redundancy is left, digital filtering is used in data acquisition, CRC is used in communication, photoelectric isolation is used in control, and fast microcontroller is used, so stability and reliability of the system is ensured. According to users' requirements, the system with a little development can be used in intelligent supervision of the residential area, agricultural production and industrial control LAN.

REFERENCES:

[1] Du Shangfeng, Li yingxia, Ma Chengwei etc. The research progress of hardware system of greenhouse environment control In China[J]. Transactions of the Chinese Society of Agricultural Engineering, 2004,20 (1):7-12

[2] Chen Guiyou. Technology of development of enhanced 8051, Beijing: Beihang University Press, 2010:25-35

[3] Wang Jiejun, Xu Chuanpei. Design of remote control system based on CAN bus [J]. Instrument Technique and Sensor, 2009 (02) :58-60

[4] Bao Changchun, Li Zhihong, Zhang Lishan, Design of monitoring system of grain depot based on ZigBee [J]. Transactions of the Chinese Society of Agricultural Engineering, 2009,25 (9): 197-201

[5] Chen Liangfu, Han Yujie, Xu Kaihong. A dynamic monitoring and control system of multi-point temperature based on wireless communication. Sensors and micro-systems, 2011,30(2):81-83

[6] Qi Yanlei, Chenjuan, Qi Xin. Design of temperature monitoring system based on SCM and Kingview. Electronic Measurement Technology, 2011,34 (7)