International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 02 - Issue 05 || May 2017 || PP. 24-29

Design of Temperature Detection based on Single Chip Microcomputer

Yang LIU
School of Information Science & Electric Engineering, Shandong Jiaotong University, Jinan, China

Abstract: In recent years, with the development and wide application of computer technology, wireless communication technologies and Internet technology, wireless transmission instead of the cable, transmits long-distance data. In various fields of industry, energy and construction, workers often need equipment to monitor the temperature data. This paper presents a temperature detection system using wireless data transmission mechanism. In the system a kind of single chip microcomputer, which is called AT89C51, is introduced as a core. Also sensing technology, wireless transmitting and receiving technology, and computer technology are all included into the whole system to realize temperature monitoring in real time. Each detection unit could complete its functions independently. Detection results could be displayed in LED screen and then transmitted to the upper computers by the wireless transceiver chip nRF905. In this way the temperature could be remotely monitored. Application shows, the temperature detecting machine has the following advantages: more juncture, long wireless transmission distance, convenient spread, low price and easy to form gathering system, which applies for detecting temperature of several sections, it can show temperature and it is easy to carry out long-distance control, furthermore, it can save time and energy.

Keywords: Temperature Measure, DS18B20 Digital Temperature Sensor, nRF905

I. INTRODUCTION

In various fields, such as industry, energy and building, the temperature data used for equipment monitoring is often highly needed[1][2].More and more monitoring and controlling equipment, and the intelligent instruments based on the single chip computer have to realize the data exchange and the transmission by using the Internet. However, there are some disadvantages in the traditional long-distance data transmission, such as incomplete acquisition parameters and derived parameters, unreasonable database structure, and defects in the format and display of data processing in Chinese and English[3][4].Meanwhile weak practicality, fault tolerance, delay and stability all limit the software and hardware applications.

In modern times, there are three stages in the development of temperature sensors[5][6].The first is traditional discrete temperature sensor. The second is analog integrated temperature sensor, which is widely used. The third is intelligent temperature sensor, namely digital temperature sensor. It has three notable features. One is that it could output the temperature data, which adapts all kinds of micro processor[7][8]. Another is that its composition is simple as well as cost-effective and powerful. The other is that the function of the system is realized by the corresponding software on the basis of hardware. In this way the level of intelligence depends on the level of software development[9][10].Intelligent temperature sensor is moving toward multi-function, high precision, high reliability, high security, bus standardization, virtual sensor, single-chip microcomputer temperature measurement system, and so on[11][12].

AT89C51 microcontroller is the core of the designed system, in which sensor technology, wireless transceiver technology and computer technology all used to realize the multi-point real-time temperature control and inspection[13].Each detection unit can complete their respective functions independently. Also Real time acquisition and timing acquisition can be completed respectively based on the different orders from the master control unit. The measurement results can be displayed in real time as well as transmitted to upper computers by wireless transceiver chip nRF905 using single chip. Then the remote monitoring of temperature could be realized finally[14].

The upper computer is responsible for the control of the lower computers to detect the temperature of each measuring point, collecting measurement data, and displaying and sorting the results for further analysis, storage, processing and research. The upper computer and the lower computer can communicate and coordinate with each other to make the monitoring more intuitive and effective. According to the actual requirements of the combination of theoretical knowledge and actual applications, the latest technologies are included in the system. Form the hardware and software design, the design methods and the overall framework of the system are demonstrated to well realize multi point temperature data detection and wireless transmission scheme.

The principle of the system, the structure of the hardware circuit, software design flow chart and power management of each part, and electromagnetic compatibility are all introduced in this paper. Instruments with low price, low power consumption and stable performance are taken into account during the system design

process[15].The applications show that this system has the advantages of more connection points, farther wireless transmission distance, more convenient expansion, simpler system structure and lower price. It is very suitable for multi-point temperature detection, which could display the temperature conveniently and accurately. It can also be controlled remotely, which further saves much more time and improves intelligent detection levels in the modern applications and industries.

II. HARDWARE CIRCUIT DESIGN

A. Circuit design of upper computers

When TRX_CE is high electrical level and TX_CE is low electrical level, the nRF905 enters the receiving mode.

(1) NRF905 began to listen to radio signals after 650 μs.
(2) CD becomes high electrical level when nRF905 detecting the carrier of the receiving frequency. AM becomes high electrical level when an effective address is received.
(3) When the received data packet CRC is verified correct, nRF905 will remove the header, address, and CRC bits. Meanwhile DR will be changed as high electrical level.
(4) TRX_CE is set as low electrical level by micro controller, which makes nRF905 into idle mode. The data is transmitted into microcontroller with certain rate through SPI port by the micro controller, itself.
(5) Once all the load data is transmitted, AM and DR will be set as low electrical level again by nRF905. The status of TRX_CE or TX_CE pins will change when a data packet is being received. Once the work mode is changed by nRF905, the data packages will be lost. After the microprocessor receives the signal, which is matched with the address pins, it will be known that nRF905 is receiving the data packets. In this way it can decide that nRF905 could go on receiving data or go into another work mode.

The transceiver circuit diagram is shown in Fig. 1. MOSI/MISO is the channel used for transmitting/receiving data. TRX_CE/TX_CE is the control terminal for the data receiving/sending. PWR_UP is the terminal for work mode controlling. SCK and CSN are used for serial interface controlling. CD is the output of carrier monitoring signal in receiving mode. AM is an output for chip indication signal after the correct addresses of the packets are received. DR is an output for chip indication signal after a data package is transmitted. UPCLK is an output terminal whose clock source could be set, which is given by the chip itself. ANT1 and ANT2 are both used for antenna. The external circuit of XC1 and XC2 can be used for the crystal oscillation circuit.

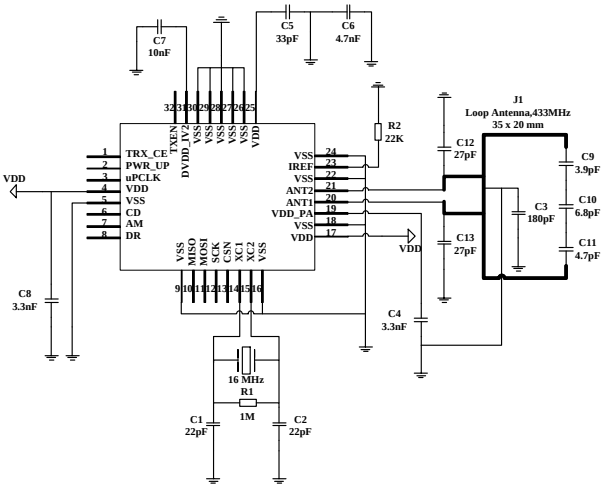

Fig. 1 The transceiver circuit diagram

B. Other circuit designs of the system

1. Clock circuit

There is a high gain inverting amplifier in the AT89C51 chip, which is used for the make-up of oscillator. The input and output terminals of the inverting amplifier are XTAL1 and XTAL2 respectively. A stable self-excitation oscillator could be formulated by connecting a quartz crystal and two capacitors. The values of the two capacitors, C1 and C2 respectively, are usually set as about 30pF, which is useful for oscillation frequency. The frequency range of oscillation pulse is U=0~24MHZ. The clock circuit diagram is shown in Fig. 2.

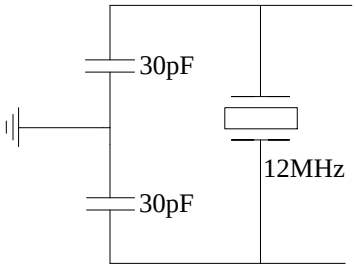

Fig. 2 The clock circuit diagram

2. Reset circuit

RST pin is the reset input. The reset signal works if it is set as high electrical level, which stays for more than 24 oscillation cycles. There are two kinds of reset modes, one is triggered by power automatically, the other is reset button manually. After the system begins working, only reset button manually is effective. Although reset circuit diagram is very simple, it is very important. The first thing when Single chip micro-computer system is to work, is that the reset circuit will be checked. The reset circuit diagram is given in Fig. 3.

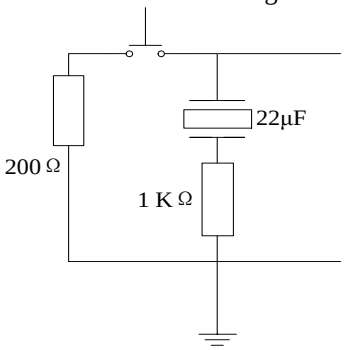

Fig. 3 The reset circuit diagram

3. Antenna design

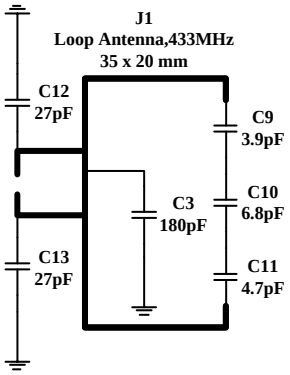

Fig. 4 nRF905 antenna design circuit diagram

A variety of forms of antennas can be selected as wireless transmission by nRF905 chip. For low loss and small size wireless module, the loop antenna with T matching network is a good solution. In this system, a ring antenna on PCB board is taken into account, which is a low cost, good direction and so on. nRF905 antenna design circuit diagram is given in Fig. 4.

III. SOFTWARE DESIGN AND IMPLEMENTATION

The main functions of the programs in AT89C51 are to finish the timed cycle sampling of the temperature signal, timed refresh display, and the wireless communication function under certain conditions.

A. The design of lower computer program

The lower computer program includes the following parts, initialization program, temperature acquisition program, LCD display program, and wireless transmission program. When the system is powered, temperature collecting unit calls initialization program, as well as the digital tube initialization to prepare to display the collected temperature data. Radio transmitter unit is then initialized and the packed data is transmitted.

1. The design of DS18B20 collection program

The work of DS18B20 follows a strict single bus protocol. The host sends a reset pulse, which causes all the DS18B20 chips on the signal line to be reset. Then in order to receive the following memory access command, the ROM operation command is sent to make DS18B20 matched with the serial number code activated. The DS18B20 working status selected by memory access command is used to realize the whole temperature conversion and data reading.

There are three key progresses for DS18B20's working status, namely the host searching DS18B20 serial number, starting the DS18B20 for temperature conversion online, and reading the temperature online. The operations of DS18B20 during the working are in the forms of ROM commands and memory commands. The length of ROM commands is 8 bits. The corresponding command codes are reading ROM (33H), matching ROM (55H), skipping ROM (0CCH), searching ROM (0FOH) and alarming search (0ECH).Memory operation commands are writing scratchpad (44H), reading scratchpad(0BEH), copying scratchpad (48H), temperature changing (44H), recalling EERAM(0B8H), and reading power supply mode(0B4H).

2. The design of wireless transmission program

There are two wireless transceiver modules during the system design, one is the sending module and the other is the receiving module.nRF905 in the lower computer is set as the sending module.The single chip microcomputer AT89C51 is used as the main control chip in the lower computer. When using the wireless transceiver module, RF module nRF905 is configured by single chip microcomputer with SPI communication. This configuration is completed by setting the registers. There is a configuration word with 144bits in RF module nRF905. This configuration word determines wireless transmitter mode, transmission frequency, transmission power, wireless transmission rate and the CRC calibration and the length of effective data. The wireless transceiver can only be in one kind of receiving or transmitting mode at the same time.

There are many steps for RF module nRF905 to send data.

(1) TRX_CE pin of RF module nRF905 is set as low electrical level by AT89C51 microcontroller to make RF module nRF905 in standby mode. Then the SPI communications with nRF905.
(2) The destination address is written into the RF module nRF905 by AT89C51 through SPI interface, which is sent to the address register TX-Address.
(3) The sent effective data is written into the RF module nRF905 by AT89C51 through SPI interface, which is sent to the valid data register TX_Payload.
(4) The RF module nRF905 is set at Shock Burst sending mode by making PWR_UP, TRX_CE, TX_EN pins at high electrical level, which is done by MCU AT89C51.
(5) The wireless system is powered automatically, and preamble and CRC check byte are added to the data packages atomically. Once the data sending is finished, data ready (DR) pin is set at high electrical level.
(6) When all the data is sent, TRX_CE pin of RF module nRF905 is set at electrical level by the microcontroller AT89C51. RF module nRF905 will go into standby mode again.

B. The design of upper computer program

1. The design of wireless receiving program

Single-chip AT89C51 is used as the master chip of upper computer. When the wireless receiving module works, the RF module nRF905 should be configured first by AT89C5 through SPI communications. There is configuration word with 144 bits in the RF module nRF905. This configuration word sets the radio reception mode, receiving frequency, receiving power, wireless transmission rate, the CRC calibration, and the length of effective data. There are following steps for RF module nRF905 to receive data.

(1) By setting TRX_C as high and TX_EN as low, the RF module nRF905 go into ShockBurst RX work mode, which is done by MCU AT89C51.
(2) The RF module nRF905 receives temperature information.
(3) If the RF modulenRF905 finds the same carrier as the receiving frequency, it will receive data and make CD as high.
(4) If the address of the received data package is the local address, the address matching pin AM will be set as high.
(5) If the address matching and CRC checking correctly, the RF modulenRF905 will delete the preamble, address, and CRC byte. Then data ready pin DR will set as high.
(6) MCU AT89C51 processes the temperature data.

2. The design of LCD display program

The RST is required to be triggered to make LCD initialization and then write to the LCD command to make it start. There are four parts to clean the LCD screen. The first is to locate left half, the first line and the first column. Write data 0x00to each location. And then write to the fourth column. Position to the fourth column, and then write data 0x00to each location. The right half is the same as the left half.8x16 lattice is needed to write a non-Chinese character. The code is divided into two rows and 16 columns, according to the order of each row to the LCD assignment, a total of two times.

IV. SYSTEM DEBUGGING AND SIMULATION

A. System initialization

In the display process, the LM016L is used to display temperature in the beginning. But LM016L can only display two lines, but also cannot display Chinese characters. So AMPIRE 128x64 is used instead of the LM016L. The welcome interface is given in Fig. 5.

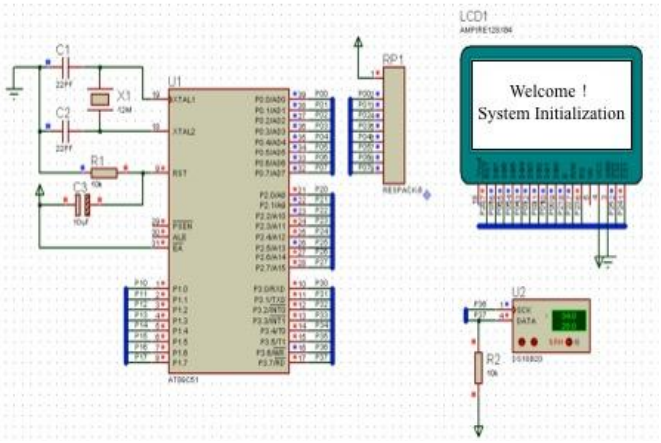

Fig. 5 Welcome interface

B. Temperature measurement

After the system is initialized welcome message is showed on the LCD screen. Then the system begins to measure the temperature of the environment. If the temperature changes, the measured value will change with the environment. Of course there will be errors during the measurement. The measurement process is shown in Fig. 6.

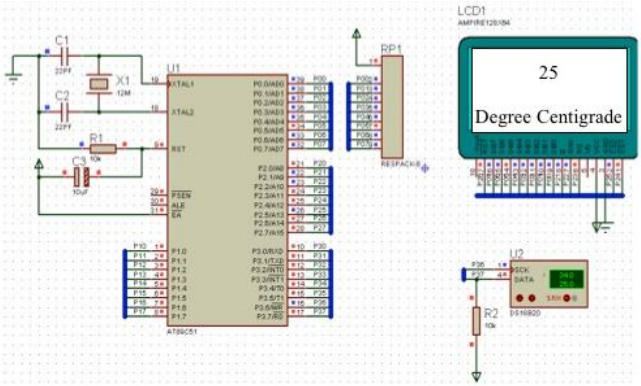

Fig. 6 Temperature detection interface

V. CONCLUSIONS

In this system, AT89C51, DS18B20 and nRF905 are fully used. DS18B20 is used to collect temperature data, which is displayed with LCD by AT89C51. Wireless transmission is realized by nRF905. DS18B20 sensor could code the temperature data with high precision and good interchangeability. Once coded the data could be transmitted with a single cable, which is convenient. The transmission distance is long and the anti-interference ability is good. Compared with the traditional multi-point temperature measurement system, it saves a large number of cables and also simplifies the system, which also makes the system expansion and maintenance very convenient. Data transfer can be completed between nRF905 and AT89C51 through SPI interface. Wireless data transmission is performed through Shock Burst transceiver mode, which is reliable and convenient. Temperature

measurement range of the system is between -20℃ and +50℃, which is displayed by the digital tube with high precision. By using PCB plate micro-strip antenna, the wireless communication is far away, which makes the received temperature data display correctly. The experimental results show the system with nRF905 works well with good real-time performance and strong practicability.

REFERENCES

[1] Nakamoto T, Okazaki N, Monumi T. High speed active gas/odor sensing system using adaptive control theory [J]. Sensors and Actuators B, 2000.
[2] Mehta J L. Transceiver architectures for wireless ICs [J].RF Design,2001.
[3] Yamamoto M, Kawasaki I, Inayoshi H, et al. Data processor and single-chip microcomputer with changing clock frequency and operating voltage: U.S. Patent 5,778,237[P]. 1998.
[4] Kobayashi J. Single-chip microcomputer using adjustable timing to fetch data from an external memory: U.S. Patent 6,125,431[P]. 2000.
[5] Habib M, Yahya K M. Making Vehicles Remote Controlled for Special People using AT89c51[J]. 2014.
[6] Yu L. Design of heart rate and body temperature measuring instrument based on AT89C51 MCU [J][J]. Foreign Electronic Measurement Technology, 2013, 3: 022.
[7] Ying M A. Design of the water meter IC card system based on AT89C51 [J]. Electronic Design Engineering, 2013, 7: 052.
[8] Dong T. A laser power measurement system based on AT89C51 SCM technology[J]. Journal of Xi'an University of Posts & Tele-communications, 2014, 3: 019.
[9] Babu R G. A Novel Solar Tracking System using AT89C51 Microcontroller and LDR[J]. International Journal of Research, 2016, 3(4): 166-170.
[10] Chandrasekhar T. Design and development of a colour identification system using AT89C51 microcontroller[J]. 2016.
[11] Hongbo L, Xiuli Z, LiYanjun X J. Design of the Biomass's Temperature Control System-Based on AT89C51 [J][J]. Journal of Agricultural Mechanization Research, 2013, 2: 056.
[12] Xia C J L. Implementation method on hardware and software about a fiber optic temperature sensor based on AT89C51 [J][J]. Electronic Measurement Technology, 2012, 12: 028.
[13] Gao X, An Y, Zhu K. 2FSK modem based on the microcontroller AT89C51[J]. Journal of Networks, 2014, 9(8): 2252-2258.
[14] Yongxiang W. Design of transmitter module closed-loop temperature control system based on AT89C51 MCU[J]. Industrial Instrumentation & Automation, 2013, 4: 023.
[15] WANG Y, YIN H, DUAN Z, et al. Grain Moisture Detection System Based on AT89C51 MCU [J]. Control and Instruments in Chemical Industry, 2013, 4: 009.