Design of the Human Body Infrared Temperature Measurement System Based on SCM

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Abstract

To decrease the limitation of traditional method of temperature measuring such as close contact between measurer and the target and inconvenience when measuring, we developed a non-contact type piezoelectric infrared thermometer, realizes fast and accurate surface temperature measurements. In this paper, the overall system architecture of infrared temperature measurement system was designed. Then under the piezoelectric principle, aimed at human body temperature measurement for a specific design, development including hardware, peripherals technology and the host program, etc. Designed by using the infrared temperature measurement system were measured on the human body temperature measurement error is less a ±0.1℃ improve the measurement accuracy, to satisfy the demand for no-contact, speedy body-heat measurement.

Keywords

Temperature measurement, Piezoelectric, AT89C51.

1. Introduction

In recent years, we have successively suffered from various epidemic diseases like SARS, H1N1, etc, the typical characteristics of which are high body temperature, strong infectiousness and latency. Therefore, it has been a significant means of preventing such kind of diseases to timely discover and segregate the patients. [1] A fast and effective measurement method must be used to find out the patients especially in densely populated places like railway station, market, school, etc. Body temperature measurement in public places must take the following three basic requirements into consideration: non-contact, fast measurement, and veracity. Therefore, infrared temperature measurement method is able to meet the requirement.

2. Infrared temperature measurement principle

Due to the molecular thermodynamic movement, all objects in natural world whose temperature is higher than absolute zero (-273.15℃) will constantly radiate electromagnetic wave including infrared band to the surrounding space. The relationship between radiation energy density and objects' temperature is in accordance with radiation law. It is shown as formula (1):

$$E = \delta\varepsilon\left(T^4 - T_0^4\right) \tag{1}$$

E refers to radiant existence with its unit as W/m^3;

δ refers to Stephen-Boltzmann's constant, $5.7 \times 10^{-8} W/(m^2 \cdot K^4)$;

ε refers to objects' radiance;

T refers to objects' temperature (K);

T_0 refers to the environmental temperature around the objects (K).

Radiance means a coefficient used to embody the objects' ability of transmitting electromagnetic waves with its numerical range as 0~1.0. The value of all real objects including the surface of human body is lower than 1.0. Human body mainly radiates infrared ray with wavelength as 9~10 μm. Light ray within this wavelength cannot be absorbed by the air, so human body surface temperature can be correctly measured through measuring human body's infrared ray radiation energy. This kind of measurement doesn't need contact with measured objects, so it belongs to non-contact measurement.

3. Hardware design of human body infrared temperature measurement system

The hardware design of human body infrared temperature measurement system adopts modularized design idea, which is made up of single chip processing control module, infrared temperature measurement module, signal amplification, filtration module, A/D conversion module and LCD display module. Infrared temperature measurement module takes responsibility of turning light signals to weak electrical signals and then passing the signals to amplified filter circuit for amplification; A/D conversion module turns analog signals to digital signals, passes the signals to single chip for processing; single chip serves as the control and treatment center of the whole system. It adopts AT89C51 chip, takes responsibility of starting temperature measurement, receiving measured data, and calculating the temperature value; finally, LCD display module displays the temperature value of human body. The hardware structure of human body infrared temperature measurement system is shown as Figure 1.

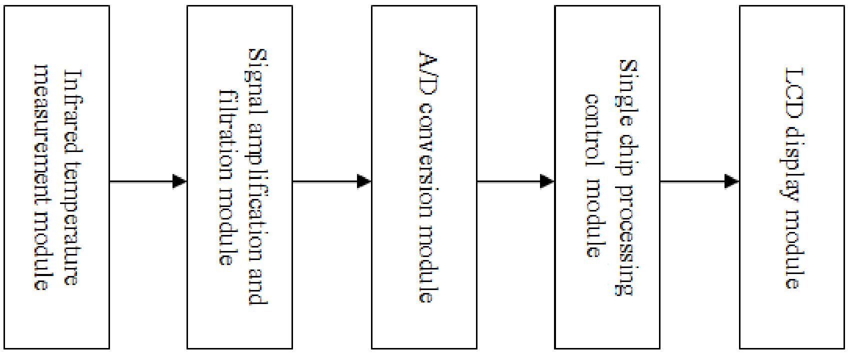

Fig. 1 The hardware structure of human body infrared temperature measurement system

3.1 Circuit design of infrared temperature measurement module.

Any objects higher than absolute temperature will generate infrared spectroscopy, and objects with different temperature will release different infrared energy. Therefore, the infrared wavelength and temperature value are closely connected with each other. [3]This system adopts RE200B pyroelectric infrared sensor which serves as a kind of device able to radiate infrared ray to measure human and some animals and turn it to electrical signals. The sensor is made of crystalline material. When the crystalline surface is exposed to the infrared ray, electric charge will be generated on the crystalline surface. With the change of infrared ray for crystalline surface, the quantity of electric charge will also be changed. Human body temperature is generally 37℃, and infrared radiation is the most stable, so infrared ray with wavelength as about 10 μm will be generated. It is exactly within the detection range (7~14 μm) of RE200B. The interior circuit of RE200B pyroelectric infrared sensor is shown as Figure 2.

3.2 Circuit design of amplification and filtration module.

Human body infrared ray signals measured by RE200B are relatively weak, so amplifier is needed to amplify the weak electric signals. [4]At the same time, the measured signals may be mingled with some noise waves of surrounding world, so filter circuit is needed to filter the noise wave signals. The amplification and filtration circuit is shown as Figure 3.

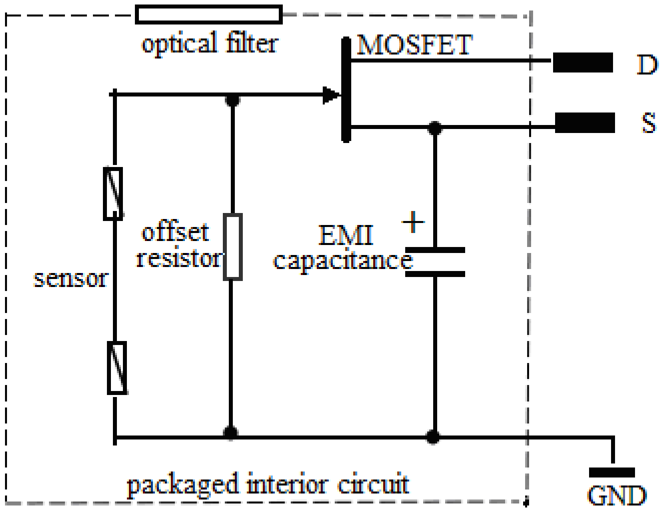

Fig. 2 The interior circuit of RE200B pyroelectric infrared sensor

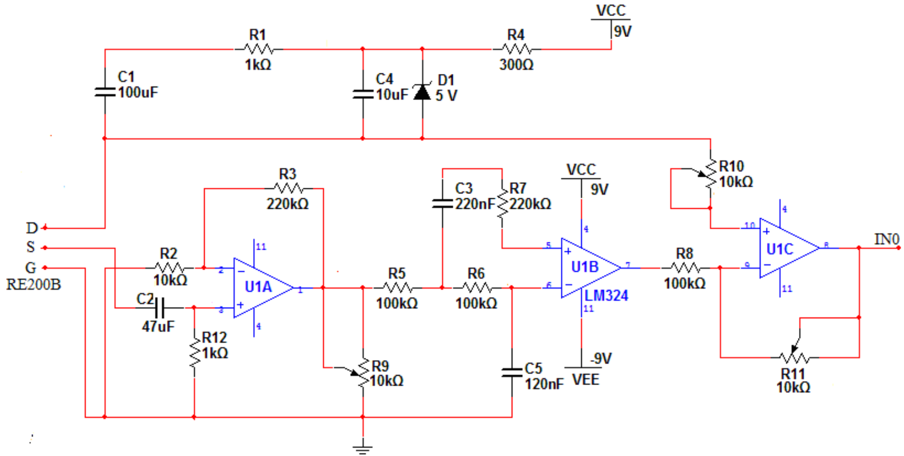

Fig. 3 The amplification and filtration circuit

Signals outputted by pyroelectric infrared sensor reach the first noninverting amplifier through 47μF capacity coupling. Meanwhile, the first noninverting amplifier also serves as high-pass filter with its cut-off frequency as 0.3Hz. The second amplifier is a low pass filter with its cut-off frequency as 7Hz. Two amplifiers respectively filter the signals lower than 0.3Hz and higher than 7Hz, making the outputted signals merely 1Hz infrared radiation signals which are modulated by amplifiers. The third amplifier turns signals to voltage and then sends it to the VIN+ terminal of A/D convertor.

3.3 Design of A/D conversion circuit.

What single chip processes is digital signal, but amplification filter circuit outputs analog signal. Therefore, this design adopts ADC0804 chip to finish the functions of analog-digital conversion. The 8–bit output of switching circuit can directly be connected with the I/O connector of single chip. This design adopts the combination of CLK R port and CLK IN port. The chip will generate clock pulses. When the /CS chip selection terminal and /WR signal input terminal are both low level, the A/D conversion will be started, and analog signal received by VIN+ terminal will be turned to digital signal. When /CS and /RD are both low level, the digital signal will be outputted through the DB0~DB7 terminal of A/D convertor and sent into single chip through the P1 port of AT89C51 single chip. The A/D analog-digital conversion circuit is shown as Figure 4.

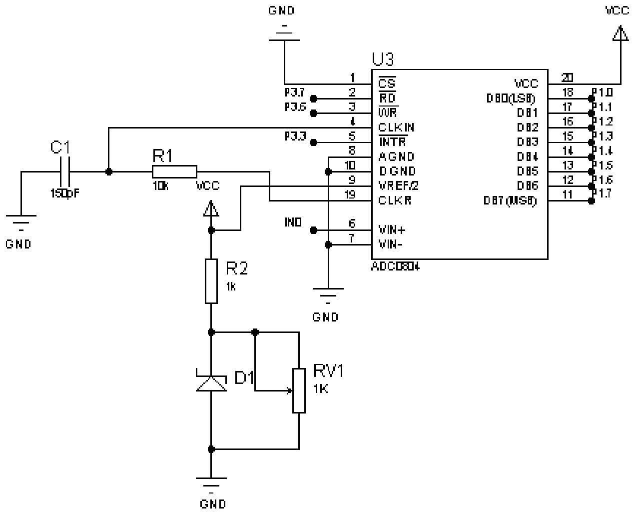

Fig. 4 ADC0804 analog-digital conversion circuit

3.4 Design of LCD display circuit.

Due to various advantages of liquid crystal display like micro-power consumption, small volume, rich display contents, and ultrathin, light and handy nature, it has been widely applied to pocket-size instrument and low-power dissipation application system.

This design adopts LCD1602 displayer. It's D0~D7 is respectively connected with the P0.0~P0.7 of AT89C51 single chip. When VEE terminal is connected with positive power, the contrast ratio is the weakest; when VEE terminal is connected with ground, the contrast ratio is the strongest. Too strong contrast ratio will cause "ghost", and too weak contrast ratio will cause fuzzy screen. Therefore, a 10K potentiometer in circuit is used to adjust its contrast ratio. RS register of LCD1602 connects its terminal with P2.1 port of single chip. Register is determined by the setting of terminals in software program. RW terminal of liquid crystal display is connected with P2.2 port of single chip. When it is high level, the imputed digital signals will be read. Enabled E port is connected with P2.3 port of single chip. When the enabled port is turned from high level to low level, it will executive command and display the reading number. LCD1602 display interface circuit is shown as Figure 5.

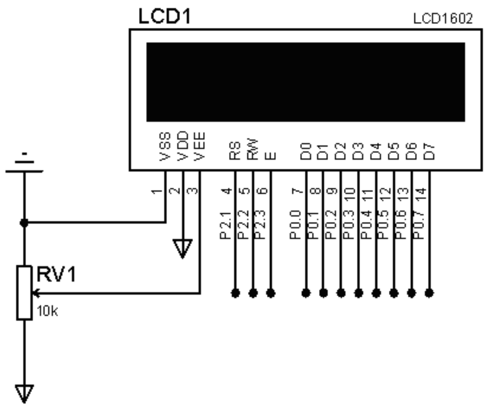

Fig. 5 LCD1602 display interface circuit

4. Software design of infrared temperature measurement system

Main program mainly realize the following functions:

(1) Initialize equipment automatically in starting up or restoration process, and guide correct execution of program.

(2) Start A/D conversion after starting up and restoration, take samples for environmental temperature, and display current environmental temperature on displayer.

(3) Keep displaying environmental temperature, conduct conversion and sampling for infrared radiation of human body surface, and compare various sampled values until the sampled values reach the crest voltage of pyroelectric detector.

Main program flow figure is shown as Figure 6.

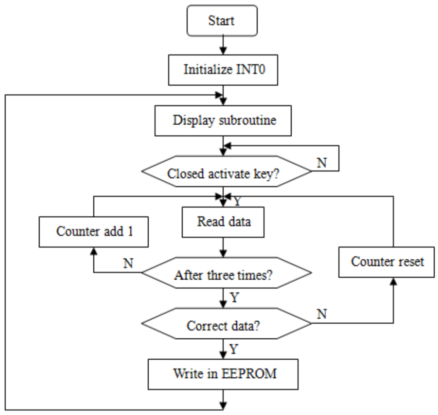

Fig. 6 Main program flow figure

Firstly initialize the system, execute display subroutine, reset various ports after temperature measurement, and carry out analog-digital conversion for signals through amplification and filter by A/D analog-digital converter, and set the /CS and /WR of A/D converter as low level. When the chip generates a pulse, the conversion will be started. Then when /CS and /WR are both low level, the conversion date will be read and sent to P0 port of single chip through D0~D7 of output port. The data will be read for three times, and then the correct reading number will be put in the EEPROM memorizer of single chip. At the same time, the counter will be added with 1 for reading next group of data. If the reading number after three times is not correct, the single ship should be reset for measuring reading number again.

5. Conclusion

This paper mainly carries out the design of human body infrared detection system hardware and software, and accomplishes the non-contact measurement of human body temperature through the cooperation of hardware circuit and corresponding programmer. This design still needs to be perfected and improved, and there is still certain distance between designed products and actual application. For example, the temperature measurement can be controlled more flexibly by button and it will be even better with voice broadcast function. Therefore, these aspects remains to be further investigated.

References

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