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Design of Intelligent Human Pulse Tester

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Abstract

The system adopts the infrared reflection sensor ST188 to collect the pulse signal, After amplifying, filtering, shaping and other conditioning circuits, the pulse signal is converted into a pulse signal of the same frequency,and the STC89C51 is used to calculate the pulse. The intelligent human pulse tester has the advantages of simple structure, low cost, good expansibility and popularization value.

Keywords

Intelligence, Pulse test, Singlechip, Infrared sensor, lcd.

1. Introduction

Pulse is a palpable arterial pulse on the body surface. Blood flows into the aorta through the contraction and extrusion of the heart, and into the major arteries and microvessels of the whole body. When a large amount of blood enters the artery, the diameter of the artery will expand, and the artery can feel the expansion in the shallower part of the body surface, which is called pulse. The pulse is produced by the periodic contraction of the heart. The pulse starts at the root of the aorta and propagates in waves along the arterial wall, also known as the pulse wave. The shape, intensity, speed and rhythm of the pulse wave reflect the blood flow characteristics of the physiological and pathological aspects of the human cardiovascular system. The detection of pulse signal can evaluate the health level of cardiovascular and cerebrovascular system. Therefore, portable, intelligent and cheap human pulse tester is necessary for every family.

2. Design of Intelligent Human Pulse Tester

The key point of human pulse tester is sensor. At present, there are pressure sensor, photoelectric sensor and ultrasonic Doppler technology used in pulse test. The measurement site of the photoelectric volume pulse sensor is the fingertip, which is divided into two ways by the common digital artery from both sides of the finger trunk to the fingertip, then diffused by the abundant coronary arterioles to the capillaries, and then returned from the vein. A beam of light passes through the capillary bed at the end of the finger. As the microvascular bed at the end of the finger changes with the pulsation of the artery, the light intensity through the finger changes with the absorption of light before and after the pulsation of the pulse. The light intensity signal that changes with the change of the volume of the blood vessel can be measured by using the photosensitive element and converted into an electrical signal for output This reflects the change of pulse wave, that is, the volume pulse wave signal of finger tip is obtained.

According to Lambert's law, the absorption capacity of a substance at a specific wavelength is directly proportional to its concentration.When the light of constant wavelength irradiates the human tissue, the light intensity measured after absorption and reflection of the human tissue will reflect the structural characteristics of the irradiated tissue to a certain extent. Blood is a highly

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opaque liquid. The penetration of light beam in blood is lower than that in general human tissues. The optical capacitance product method is to use the reflection and transmission principle of light, through the light source placed in the finger end photoelectric volume sensor to shoot out the light beam to the finger, and re receive the transmitted light beam intensity after passing through the finger end tissue. The human tissue at the finger end absorbs light energy in varying degrees. According to Lambert's law, the absorption of light energy can be seen:

$$log(I_i/I_o)=\varepsilon Cl \quad (1)$$

In the above formula

I_i:Incident light intensity

I_O: Light intensity after transmission

ε: Absorption coefficient of light（It is related to the wavelength of the incident light and the nature of the penetrant itself）

C: Concentration of penetrant

l: Propagation distance of light

It can be seen from the formula, The absorption of light energy by other tissues is stable except that the volume of blood in the blood vessels changes periodically due to the contraction and relaxation of the heart during beating. Therefore, the change of the wave form of the photoelectric volume signal can follow the change of the blood volume in the blood vessel of the finger end to reflect the change of the pulse wave of the finger end.

Therefore, the ST188 infrared sensor is used to collect the pulse signal. After signal amplification, filtering and shaping, it is sent to the main controller with STC89C51 as the core to calculate the pulse signal and displayed by the LCD, The scheme design is shown in Figure 1.

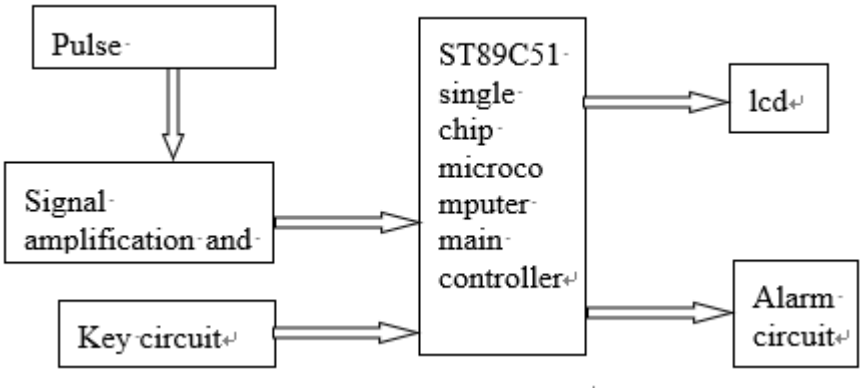

Figure 1. Design block diagram of pulse tester

3. Hardware Circuit Design

The hardware circuit of the intelligent human pulse tester includes pulse signal acquisition circuit, signal conditioning circuit, MCU main control circuit, display and alarm circuit, etc. the details are as follows.

3.1 Pulse signal acquisition

Blood is a highly opaque liquid, and the penetration of light in general tissues is dozens of times greater than that in blood. According to the characteristics, the photoelectric effect pulse sensor ST188 is used to pick up the pulse signal. ST188 appearance and signal acquisition circuit are shown in Figure 2. ST188 consists of infrared transmitting tube and receiving tube, A and K is the positive and negative pole of the infrared transmitting tube, C and E are the positive and negative poles of the receiving tube, R1 and R2 are current limiting resistors, 510Ω for R1 and 20KΩ for R2. Clamp the

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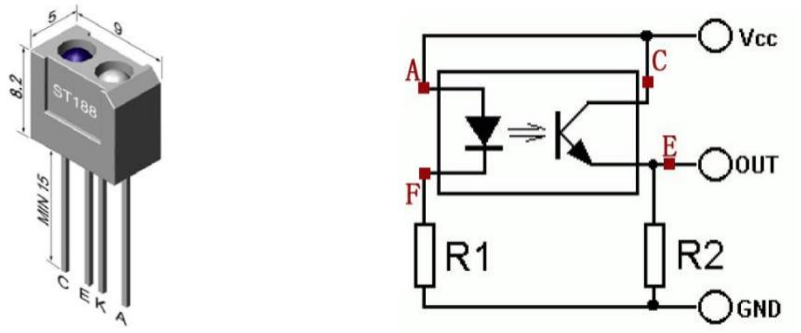
infrared tube on the end of the finger, the blood concentration through the finger will change with the beating of the heart, and the corresponding signal of the infrared tube will change accordingly. This detection method has the advantages of high sensitivity, easy operation, fast response and simple structure. Although the change of the external light source has an impact on the measurement results, if the measurement place is indoors and there is a stable light source, only a little attention should be paid to the light source in the normal operation process.



(a) Outline drawing (b) Circuit diagram

Figure 2. Pulse signal acquisition

3.2 Signal conditioning circuit

The pulse wave signal from the sensor needs to be amplified, filtered and shaped into a rectangular wave before it can be input into the single chip computer for pulse calculation. If the human pulse is at least 40 times / min and at most 150 times / min, i.e. 0.67hz-2.5hz, so a band-pass filter needs to be designed. LM324 integrated operational amplifier is used to form two-stage amplifier, wherein U1A is the first- order active low-pass filter circuit, with cut-off frequency of:

$$f_{0=}1/(2\pi R_5 C_1)=2.5\text{Hz} \quad (2)$$

U1B forms a first-order active high pass filter circuit with a cut-off frequency of:

$$f_0=1/(2\pi R_8 C_2)=0.43\text{Hz}\ 0.66\text{Hz} \quad (3)$$

In this way, the bandwidth requirements of 0.67hz-2.5hz are basically met, and band-pass filtering is simply realized. As shown in Figure 3, ± 5V DC power supply is adopted in the circuit. After amplification and filtering, the pulse signal is still irregular pulse signal and still does not meet the requirements of the counter, so the shaping circuit must be used. As shown in Figure 4, the circuit of voltage comparator converts pulse signal wave into rectangular pulse and sends it to MCU for pulse counting.

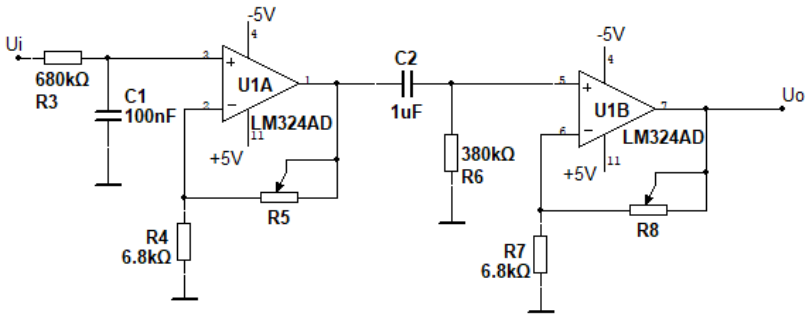


Figure 3. Two stage amplifier and filter circuit

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After amplification, the peak voltage is about 1.3V, Therefore, the design voltage comparator threshold voltage is 1V, and the circuit is shown in Figure 4. Take R9 as 40KΩ, then the comparator threshold voltage is:

$$U_T=R_{10}/(R_9+R_{10})=1V \quad (4)$$

That is, when the input voltage is greater than 1V, the output high level, and when the input voltage is less than 1V, the output low level.

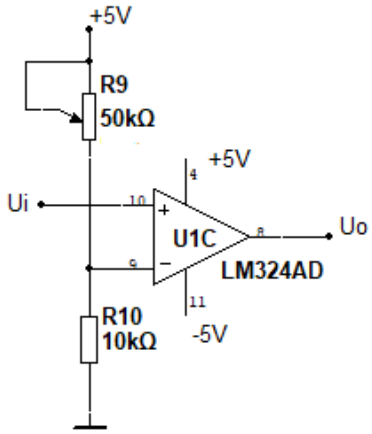

Figure 4. Voltage comparator circuit

3.3 Main control circuit

It is realized by 51 series single chip microcomputer, including keyboard circuit module, clock circuit module and crystal oscillator circuit module, as shown in Figure 5. The pulse level from the sensing and shaping circuit input into 89C51, which is set as the negative jump interrupt trigger mode, so when the falling edge of each pulse arrives, it triggers the single-chip microcomputer to generate an interrupt and timing.When a pulse is added, the number of human pulse will be increased by one; Timer interrupt mainly completes one minute timing function. The MCU accumulates the number of pulses in a minute, and sends the measurement process and results to LCD1602 for display through port p0-p7. When STC89C51 single chip microcomputer system is selected, the reliability of the system is improved, and the circuit is simplified, so that the system consumables are reduced and the cost is reduced.

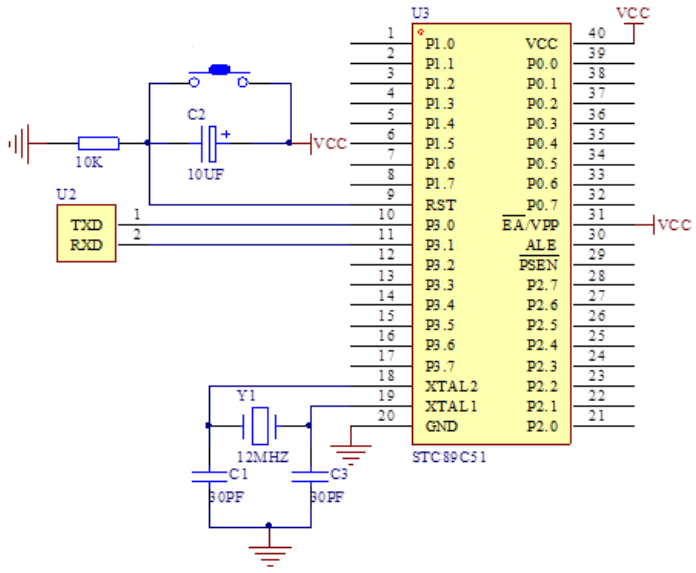

Figure 5. Microcontroller control circuit

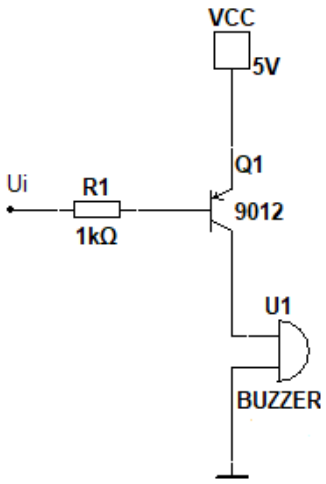

Figure 6. Alarm circuit

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3.4 Display and alarm circuit

Choose LCD screen, LCD screen has a large amount of information, long service life, and can be driven under low pressure. When in use, connect d0-d7 to P0 of 51 single chip microcomputer to facilitate data transmission, and connect V0 port with an adjustable potentiometer. When the position of the adjustable potentiometer changes, the voltage connected to V0 changes with it, and the clarity of display changes with it. Therefore, in actual use, the use of potentiometers instead of fixed resistance is to be able to easily adjust to use in different voltage situations.

The 24 pin output of MCU is connected with alarm circuit. The pulse rate of normal people is 60-100 times / min, therefore, in the process of pulse measurement, according to the set upper and lower limits, when the pulse is greater than the upper limit 100 times / min or less than the lower limit 60 times / min, the buzzer will give an alarm. The output current of MCU port is small, and the output power is increased by triode 9012 to drive the buzzer. The circuit is shown in Figure 6.

4. Program System Design Conclusion

4.1 Main program design

The main program of the system controls the single-chip microcomputer system to run according to the predetermined operation mode and can call subroutines, which is the framework of the single-chip microcomputer system program. After the system is powered on, initialize the system, LCD displays and turns on the timer, enters the cycle, starts to scan the key program, then displays it, scans the key program again, and ends the program. The program design idea is shown in Figure 7.

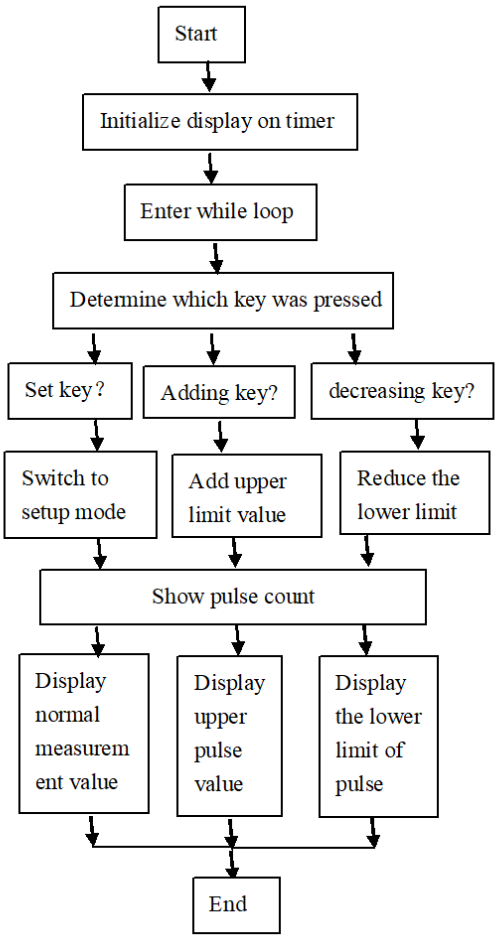

Figure 7. Programming ideas

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4.2 Interrupt programming

Timer service program,Timer initialization, timer 10ms. There is a timing interrupt, Return to timing interrupt when there is no signal, When there is signal input, Maibo_ Con add one. When Maibo_ con is not greater than or equal to 3, return to timing interrupt. when Maibo_con is greater than or equal to 3, the signal input is maintained for 30ms, indicating that it is a pulse signal. If it is the first pulse signal, then returns to the timing interrupt to continue to detect the second pulse signal. If it is the second pulse signal, the time difference between the two pulses is calculated to get the pulse number of one minute, Then display it on the display module. The flow is shown in Figure 8.

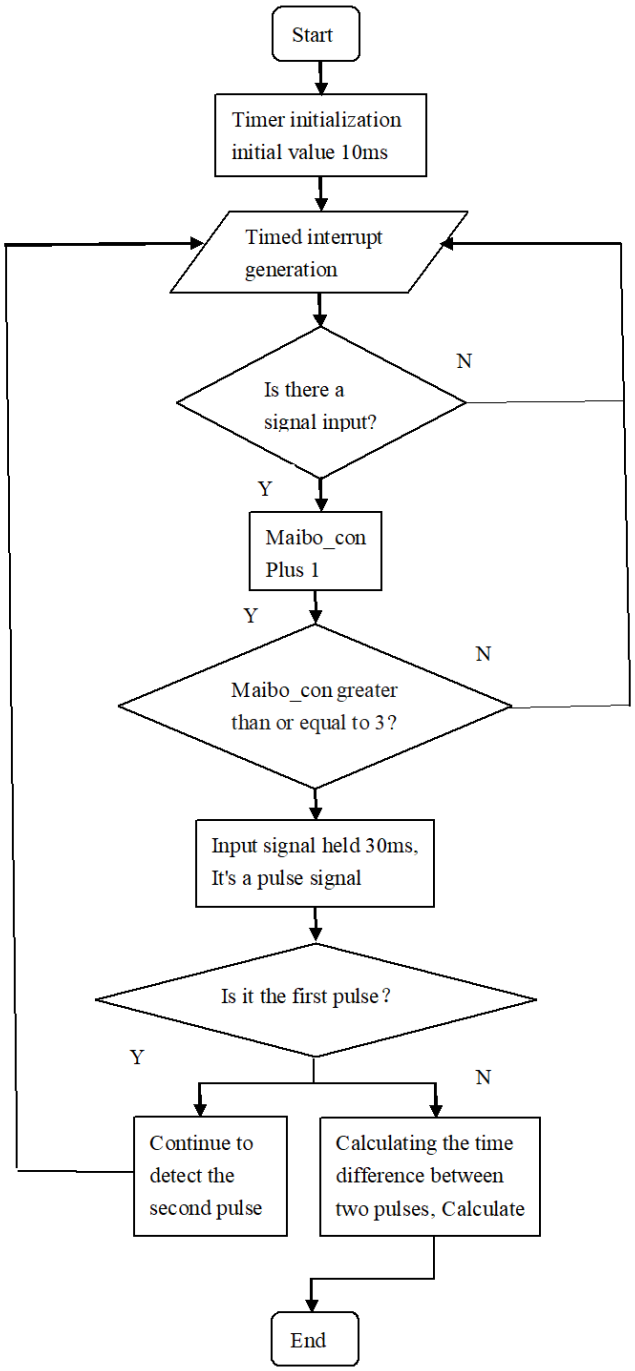

Figure 8. Interrupt procedure flow chart

5. Conclusion

Compared with the high-quality electronic pulse meter, the test result of this tester has the advantages of small error, high precision, convenient use and low price. It can also send the test result to the

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guardian or the bound mobile phone through the GSM module. Doctors can analyze the data and make further arrangements.

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