Design Of Low-power Blood Oxygen Pulse Rate Detecting Device Based On STM32L151

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Abstract

The sub-health problem of modern society is outstanding and the parameters of blood oxygen saturation can reflect the health status of human body. Focusing on oxygen saturation can detect the possibility of disease in advance. Aiming at this scenario, this paper designs a low-power oxygen saturation detection device, which uses the low-power Micro processing STM32L151 as the control and signal processing core, adopts the principle of transmissive oxygen saturation detection, and red light and infrared light as signals. The light source uses TAOS TSL237 optical frequency converter as the transmission signal receiver, uses digital signal processing method to filter the high frequency noise of the collected signal, uses Bluetooth technology to transmit the collected sign data, design the charging circuit and power management, and ensure the safe use of the device. And reusability. The blood oxygen error detected by the test is ±4%, and the pulse rate error is ±6 times/min to meet the required medical requirements.

Keywords

STM32L151; blood oxygen; Bluetooth; pulse rate.

1. Introduction

All walks of life in modern society, whether white-collar workers, businessmen or students, are under great pressure and work intensity. They are prone to cause their own sub-health and cause various diseases. Many diseases are related to blood oxygen, and the movement of human tissues and organs is inseparable. Open blood oxygen. The low blood oxygen state of the human body will not only cause respiratory diseases, but also cause oxygen damage to the vital organs such as the heart, brain and liver for a long time. This kind of injury is irreversible; before daily exercise, if the human body is already in hypoxia State, re-exercise will cause bad state, and even cause shock; and the pulse rate is abnormally elevated, and the decrease also indicates that the health condition has already occurred. Therefore, blood oxygenation and pulse rate monitoring have become important physical parameters for daily household testing and hospital monitoring.

In this paper, a low-power blood oxygen detecting device is designed, which can complete long-term monitoring of human body parameters through power consumption control. It is based on the principle of transmissive blood oxygen detection, with red light at 660 nm wavelength and infrared light at 905 nm wavelength. Light as the light source, TSL237 optical frequency converter as the device signal front end, low-power processor STM32L151 as the back-end digital signal processing and the whole system control core, low-power wireless Bluetooth as the wireless transmission mode, the whole device is adapted to the daily blood oxygen Pulse rate sign detection.

2. Measuring principle

2.1 Principle of blood oxygen measurement

Oxygen enters the pulmonary capillaries through gas exchange, and combines with deoxygenated hemoglobin (Hb) in the arteries to produce oxyhemoglobin (HbO2), which flows along the arterial blood to various tissues throughout the body. Oxygen saturation is the proportion of oxyhemoglobin in all blood-binding hemoglobin. Its definition expression is as shown in Equation 1.

$$SpO_2 = \frac{C_{HbO_2}}{C_{HbO_2}+C_{Hb}} \times 100\% \tag{1}$$

At present, non-invasive blood oxygen detection methods mainly include transmissive and reflective methods, which are mainly based on the difference between the position of the light intensity detector and the light-emitting diode at the detection site, and the blood oxygen saturation detection is divided into reflective and transmissive. In the blood oxygen saturation detection method of the transmission detection method, the photodetector and the photodiode are mainly on the two sides of the detected portion, mainly receiving light transmitted through the tissue, and the photodetector and the photosensitive in the reflective blood oxygen saturation detection. The diodes are placed on the same surface of the site to be inspected, primarily receiving light that is reflected in the tissue. The reflective method has many parts to be detected, but the reflective type is not easy to fix, and is easily affected by the movement of the tester, etc., while the transmissive type, although the test part is limited, has better fixation and the test result is more accurate. Therefore, the transmission type is selected as the blood oxygenation test result [1-3].

2.2 Pulse rate measurement principle

The pulse rate wave is caused by the periodic beat of the heart. The correl

ation between the pulse rate and the heart rate is extremely high. When observing human health, the pulse rate can be used as a reference factor. The peak value of the photoplethysmographic pulse wave is related to the contraction of the heart. It is only necessary to calculate the interval between the peaks. Equation (2) is the calculation formula, where p_1 and p_2 are the peak positioning values, and 6000 is the frequency and the number of minutes. Value [4].

$$P = \frac{6000}{p_1 - p_2} \tag{2}$$

3. System design

The overall design of the system is shown in Figure 1. The single-chip microcomputer controls the light-emitting diode to emit light through the driving circuit, and the optical-frequency converter converts the light passing through the fingertip into a week. The square wave proportional to the light intensity, the single-chip microcomputer detects the square wave period by the timing capture, that is, the light intensity, and collects 500 sets of light intensity data to have 4~5 complete pulse waves, and finally the blood oxygen calculated by the single chip microcomputer, The pulse rate is sent by Bluetooth to other receiving devices to view the vital data [5-7].

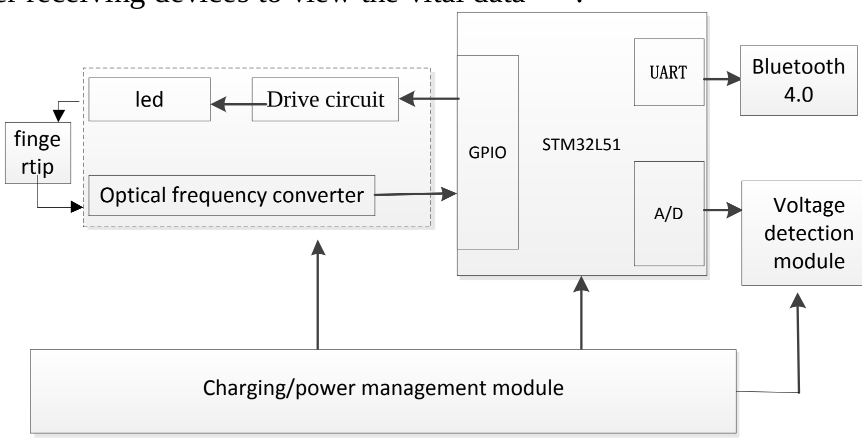

Figure 1 overall system design

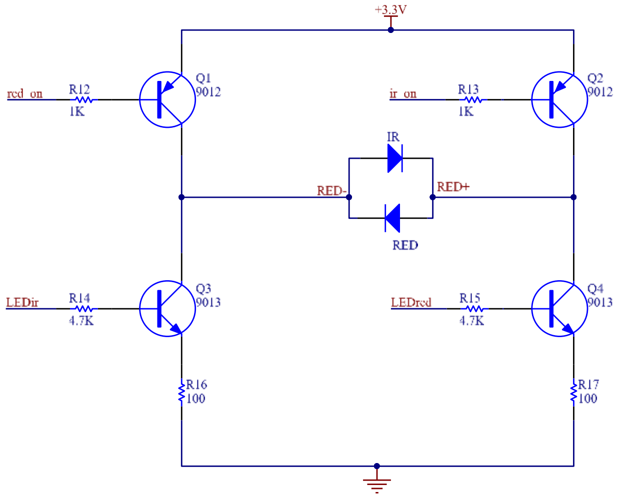

Figure 2 overall system design

3.1 Hardware Design

3.1.1 LED driving circuit

The LED driving circuit is shown in Figure 2. The LED used in this article is an integrated two LED device. The integrated LED emits red light and the other emits infrared light. Since the STM32L151 pin can only supply 8mA current and requires external drive circuit, this article uses H-bridge driver circuit, built with 9012 and 9013 transistors, which can provide 500mA current to meet the design needs. The control logic is red_on and LEDred input high level and ir_on and LEDir input low level, red light source emits light; ir_on and LEDir input high level, red_on and LEDred input low level, the infrared light source emits light. By setting the timer 10ms to collect the light intensity signal, the sampling frequency is set to 100Hz. Since the human body photoelectric statistical pulse wave frequency range is 0~6Hz, the sampling theorem is satisfied.

3.1.2 Power Management Circuit and Charging Circuit

Power management circuit shown in Figure 3, the regulator chip uses Texas Instruments TLV70033, the chip is a low-dropout linear regulator, with a wide voltage input range, 1.4V ~ 5.5V, can provide 300mA current, output voltage 1.0V ~ The 3.3V adjustable voltage range, small package, is ideal for portable devices. The output voltage set in this article is 3.3V. The use of disposable batteries not only causes harm to the environment, but also the user's expense. The design of the charging circuit shown in Figure 4 is used in this paper. This paper uses Nanjing TP4057 power chip, which has a thermal feedback pin. The current is automatically adjusted by electromagnetic heat, and the standby power consumption is 40μA, which is suitable for charging small lithium battery devices.

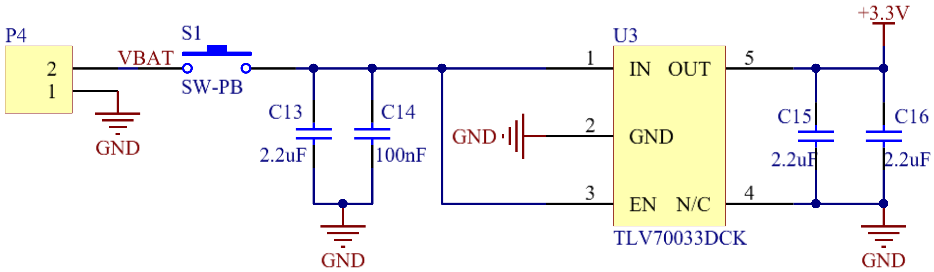

Figure 3 power management circuit

3.1.3 Bluetooth circuit

This article uses the low-power Bluetooth module to meet the company's HC-08, the module supports Bluetooth 4.0 communication protocol, using simple AT command, data can be transparent transmission, communication distance up to 80 meters, standby current is only 0.4μA.

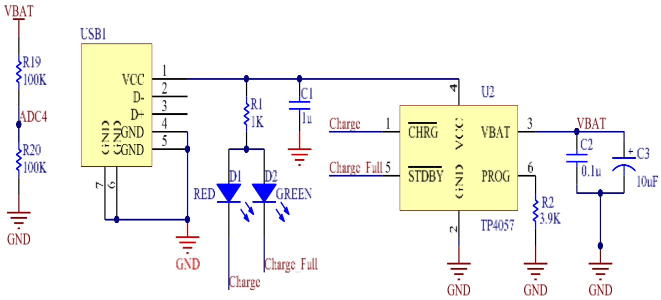

Figure 4 charging circuit

3.2 Software Design

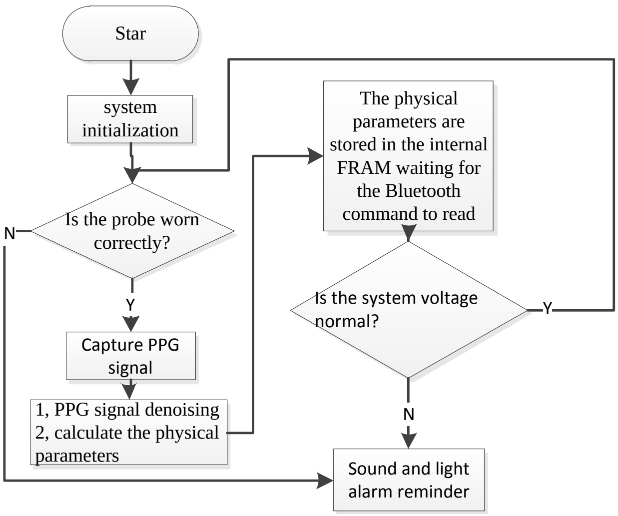

Figure 5 software design flow chart

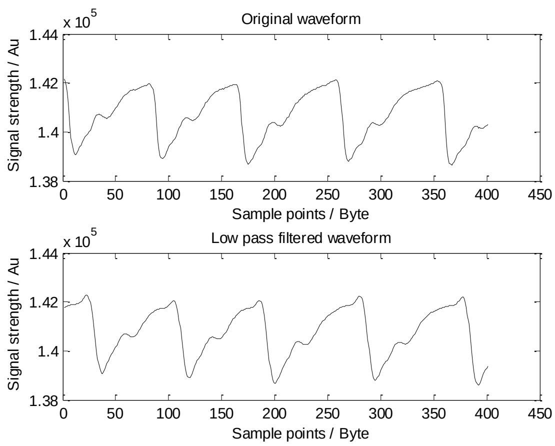

Figure 6 signal filtering effect diagram

The overall software design is shown in Figure 5. After the system is initialized, whether the device has been worn by the light intensity detection, after the device is normally worn, the photoelectric volume pulse wave is collected, the pulse wave after the acquisition is subjected to the denoising preprocessing, the physical parameter calculation, and the Bluetooth data. Transmission, etc. In this paper, the window function method is used to design the low-frequency filter to filter the high-frequency noise in the signal. The Hanming innovation is used to achieve the signal filtering effect shown in Figure 6. The filtered signal is used to calculate the vital parameters, and the blood oxygen is calculated by the method (3), wherein R is the ratio of the ratio of the direct current to the alternating current signal of the red infrared light, and other parameters are obtained by experimental calibration. The calculation formula of the pulse rate is as shown in Equation 2. After the pulse wave peak is located, the pulse rate can be calculated.

$$SpO_2 = A + BR \quad (3)$$

4. Analysis of experimental results

Table 1 Comparison of test results with standard device parameters

Number	Blood oxygen /%		Error/%	Pulse rate /bpm		Error/byte
	Device	PC-304		Device	PC-304	
1	97	99	2.02	68	69	1
2	98	97	1.03	78	75	3
3	97	98	1.02	75	79	4
4	98	96	2.08	72	76	4
5	95	98	3.06	76	70	6

The experimental device was compared with the standard oximeter. Five healthy testers aged 23 to 26 were selected. The results are shown in Table 1. The blood oxygen measurement error does not exceed ±4%, and the pulse rate error does not exceed ±6 times/Minute, the device basically meets medical requirements.

5. Conclusion

According to the principle of transmissive blood oxygen, this paper designs a set of low-power equipment, including circuit management, battery charging, Bluetooth circuit, etc., using digital signal processing methods to pre-process the signal to make the measurement result more accurate, and other portable parameters. The device provides a reference.

Acknowledgements

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