Design of Mouse Pad Monitoring Heart Rate and Bloody Oxygen Saturation Based on Microcontroller Control Unit

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Abstract

Heart rate and bloody oxygen saturation are significant human's health parameters. This design is a mouse pad monitoring heart rate and oxygen saturation, to reduce the risk of undetected heart state change after concentrating on computer for a long time. Optical power signals reflected by blood are collected by reflective photoelectric sensor, NJL5501R, and then through filtering and amplification of integrated analog front end, AFE4490, are collected by MCU, STM32F103.The MCU calculates out the values of P-P interval, heart rate (HR) and bloody oxygen saturation (BOS) and transmits them to upper computer via USB or smart phone via Bluetooth, resulting in real-time monitoring heart state. The experiment shows the accuracy of this mouse pad: P-P interval±10ms, HR±1 and BOS±3%, and human's health situation can be indicated.

Keywords

Mouse pad; Photoelectric sensor; Heart rate; Bloody oxygen saturation.

1. Introduction

A rapid increasing number of people work with computers with economic growth. Meanwhile, people pay more and more attention to self-health. Concentrating on computer for a long time will pose a health risk [1]. The corresponding market demand for health monitoring devices is gaining its popularity. This design takes MCU, STM32F103 as the core of control, photo reflector, NJL5501R as the sensor measuring heart rate and bloody oxygen saturation. By laying several sensors on the surface, a mouse pad with a function of monitoring HR and BOS in real time is made. This pad transmits data via USB or Bluetooth and users are able to check self P-P interval, HR and BOS using computer or smart phone.

2. The system composition of mouse pad

This design is composed of sensors, analog front end, MCU, USB interface and Bluetooth module. Values and waveform are observed by software on the computer or APP on the phone. The system composition and modules connection are shown in Fig.1.

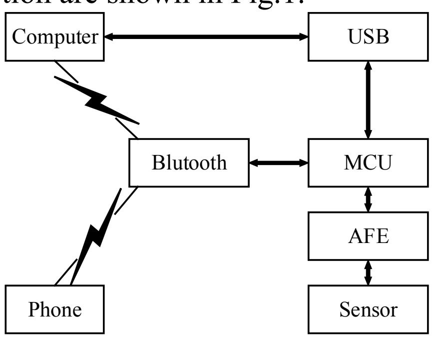

Fig.1 System composition block diagram

When using a mouse on the pad, it is normal to move the wrist. In response to this phenomenon, this design adopts the program that laying several reflective photoelectric sensors on the surface guarantees continuous signal acquisition. The sketch of program with several sensors is shown in Fig.2.

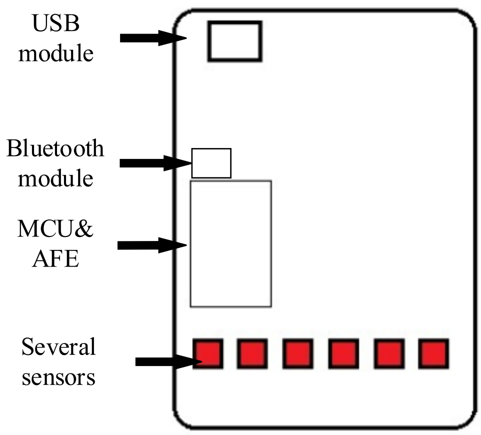

Fig.2 The sketch of mouse pad

3. Hardware circuit design

3.1 The peripheral connection of AFE

In 1939, Karl Matthes published that oxygen saturation of the blood in ears was detected consciously by red and infrared light. Generally, the pulse oximeter uses SpO2 Probe fixed on fingers to measure bloody oxygen saturation. The probe takes red and infrared light as light source and photosensitive diode as photoelectric converter, measuring reflected light intensity in artery blood. Ultimately, the pulse oximeter works out the value of HR and BOS. [2-3]

NJL5501R, integrated reflective photoelectric sensor is specially applied in reflective pulse oximeter [4]. Two LEDs which emit red light of 660nm and infrared light of 940nm and a phototransistor are integrated in a package of this sensor. In this way, by putting sensor on the skin, measurement is available, avoiding the bitterness of finger caught and poor blood flow. Because the output signal of NJL5501R is weak and disturbed by noises easily, AEF4490 serves as integrated analog front end for the pulse oximeter. The signal outputted by photoelectric sensor NJL5501R is processed by AEF4490 and then collected by MCU.

AEF4490 is designed for the research and development of pulse oximeter, and the 22-bit high-precision inside ADC is quite suitable for accurate measurement [5]. The peripheral circuit of AEF4490 is shown in Fig.3.

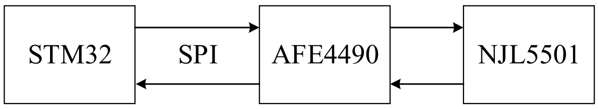

Fig. 3 The peripheral connection of AEF4490

This design adopts AEF4490 as signal conditioning. The controlling core, STM32F103, initializes AEF4490 and collect data from it through SPI communication. After being configured parameters by MCU, AEF4490 drives LED according to configuration, gathering and converting data at the same time.

One driving period contains four parts for the influence of ambient light. Driving schedule is shown in Fig.4.

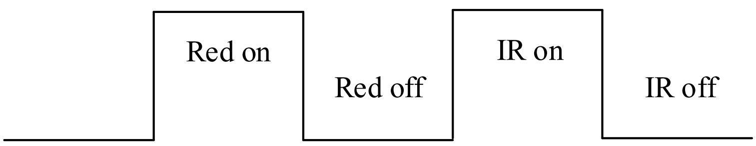

Fig.4 The driving schedule of LED

In real application, it is not essential to guarantee the strict quarter schedule. The schedule is determined when the measurement is correct. The drive current for different Red and IR led is different, which is implemented by setting internal current registers of AEF4490. In order to get more precise and stable result, it is common to delay for one or two clocks after starting sampling.

3.2 The circuit of Bluetooth module interface

Bluetooth asynchronous serial port module based on kernel chip BC417 designed by CSR® Bluetooth2.0TM is chosen, supporting Universal Asynchronous Receiver / Transmitter (UART) protocol, frequently-used baud rate and odd-even check. The power supply of this module is 5V or 3.3V. The Bluetooth module has the ability to pair, connect and communicate with computer or smart phone expediently. Therefore, the MCU only needs to provide a UART interface, realizing wireless communication. The UART interface of the Bluetooth module is shown in Fig.5.

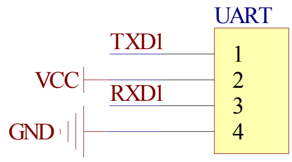

Fig.5 The circuit of Bluetooth module interface

3.3 System power supply circuit

This design adopts 5V power supply by USB, with a big electrolytic capacitor filtering low frequency noise and chip capacitor filtering high frequency noise. The circuit of system power supply is shown in Fig.6.

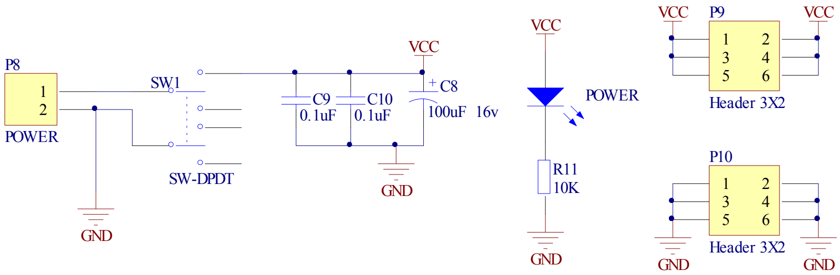

Fig.6 System power supply circuit

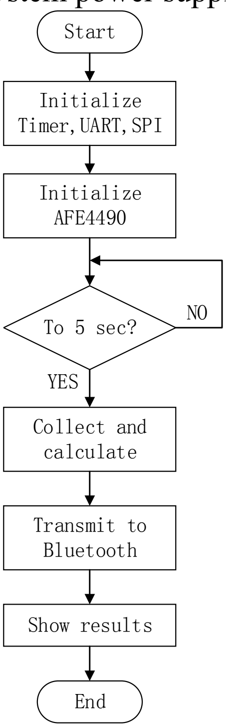

Fig.7 The flowchart of main program

4. System software design

The software of the system is composed of the initialization of Timer, UART, SPI and AFE4490, and data processing. The flowchart of main program is shown in Fig.7. After initialization, the program comes into loops, starting to check whether the 5-second timing flag is set. If set, the MCU begins collecting output signal from AFE4490 and calculating the value of P-P interval, heart rate and bloody oxygen saturation. Next, data are transmitted to computer via USB or to smart phone via Bluetooth. If not, the MCU will be waiting to achieve 5-second acquisition cycle.

5. Experiments

This design guarantees touch and continuous signal acquisition when using mouse by laying several reflective photoelectric sensors on the surface. After the mouse pad was completed, eight experiments of 30 seconds were performed. It was connected to smart phone and data were observed in APP for four times. It was connected to computer and data were observed in PC program that was wrote in Labview for another four times. Eight results were averaged and shown in table 1.

Table 1 Experimental measurement results

Order	1	2	3	4	5	6	7	8
P-P interval/ ms	719	725s	718	725	723	725	722	716
HR/ beats per minute	83	82	83	81	81	81	82	83
BOS/ percentage	98	99	98	98	98	98	98	99

6. Conclusion

This paper designs a mouse pad monitoring heart rate and oxygen saturation based on MCU, takes NJL5501R photo reflector as sensor for HR and BOS, STM32F103 as controller and AFE4490 as signal conditioning. Software code was wrote in accordance with hardware, the measurement and display of HR and BOS basically achieved. The experiment indicates that the accuracy of this mouse pad: P-P interval±10ms, HR±1 and BOS±3%, and human's health situation can be hinted.

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