An Intelligent Household Heart Rate Meter

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Abstract – The measuring instrument which uses Sunplus SPCE061A MCU as the controller is a practical intelligent household heart rate meter. It can serve all people timely and effectively to detect the heart rate. It rings some voice alarm if the HRV is abnormal. Then it is decided whether to see a doctor at a convenient time for further diagnosis. The instrument has a feature of voice guidance that can save keyboard steps, which extends the scope of use. All people, old and young, the blind and the deaf, can use it by themselves.

Key words* – *SCM*; *HRV*; *heart rate*; *voice guidance

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1 Introduction

With people's material and cultural life becoming richer and richer, health has become one of the most important daily concerns today. It will be one decisive factor for whether people succeed in the political, economic, cultural and other aspects of life. The heart disease has become one of the major diseases that threat people's health. The diagnosis and treatment of the cardiovascular diseases have been valued by the medical circle around the world. So, paying attention to the situation of the human heart is of great significance for timely treatment and prevention of sudden cardiac deaths.

In recent years, the market has launched various grades of Holter recording and analyzing system. However, the ECG instruments on the market are both expensive and inconvenient, and there are fewer apparatuses to detect HRV parameters. It is hopeful that there will be a medical device which enables the various groups the young, the old, the blind and the deaf to measure their heart rates anytime anywhere, and makes some judgments as to when it is convenient for them to hospital for further diagnosis.

The intelligent household heart rate meter is based on SPCE061A microprocessor[1]. It can test heart rate and catch the abnormal ECG signals timely and effectively. It has a variety of advantages that old-fashioned specification does not have, such as visualization, controlling, voice guidance, carrying easily, measuring HRV and telling the heart rate. It is suitable for personal, family and community health service stations.

2 Profiles

2.1 Human blood characteristics

Blood is a kind of highly opaque liquid[2], which contains large amounts of red blood cells that have a strong infrared absorption feature. If a pair of infrared transmitter and receiver is placed on both sides of the arteries and the arteries periodically contract or expand with the heart, the infrared receiver will receive periodic changes in systolic and diastolic signals.

2.2 HRV

Heart rate variability[3] refers to instantaneous small changes in the cardiac cycle. Most studies have shown that heart rate variability reflects autonomic nervous system's role in cardiovascular diseases, such as hypertension, acute myocardial infarction, heart failure and other diseases that have significant changes in heart rate variability. Now, more and more attention has been paid to heart rate variability clinical analysis. Doctors will greatly enhance the accuracy of the sentenced disease by analyzing heart rate variability.

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2.3 Optical tube

The optical tube is a photoelectric conversion device. It can convert the outside light signals into voltage signal. It consists of a transmitting tube and a receiving tube. When the light condition between the two tubes changes, it will cause the current of the receiver tube to change. The photoelectric sensor's schematic is shown in Fig. 1.

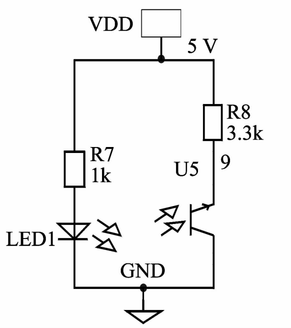

Fig. 1 Photoelectric sensor's schematic

3 The hardware design

3.1 Overview

This meter is mainly equipped with the Sunplus SPCE061 microcontroller. The photoelectric sensor collects the original heart rate signal. Then the signal processing module will reshape the signal . The MCU will process the heart signal. And the voice module and LCD will read and display the final result.

The instrument is mainly made up of the SPCE061 microcontroller, display module, keyboard module, FLASH store, voice module, optical sensor module, signal processing module and other components. The hardware of this instrument is shown in Fig. 2.

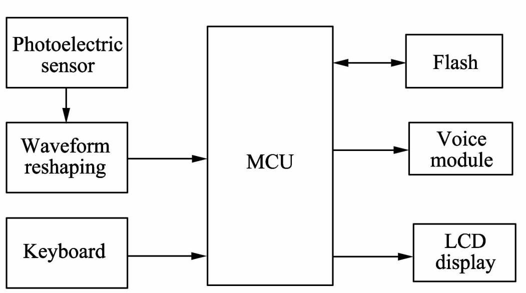

Fig. 2 The hardware of this instrument

3.2 Voice module

The process of sound playing[4]: The MCU extracts data from the FLASH. Then the data will be decompressed and sent into the output queue. The digital signal will be converted to analog signal under the control of the timer interrupt by D/A converter. Then the analog signal will be through the filter, be amplified and finally be outputted to bee Buzzer. It is shown in Fig. 3.

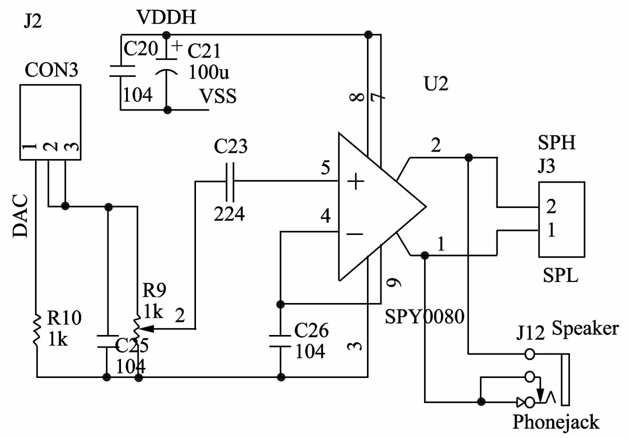

Fig. 3 Voice module

3.3 The keyboard module

The keyboard is a homemade 4 * 4 matrix keyboard. The main controller can get the key positions and key values by scanning the keyboard constantly. The schematic is shown in Fig. 4.

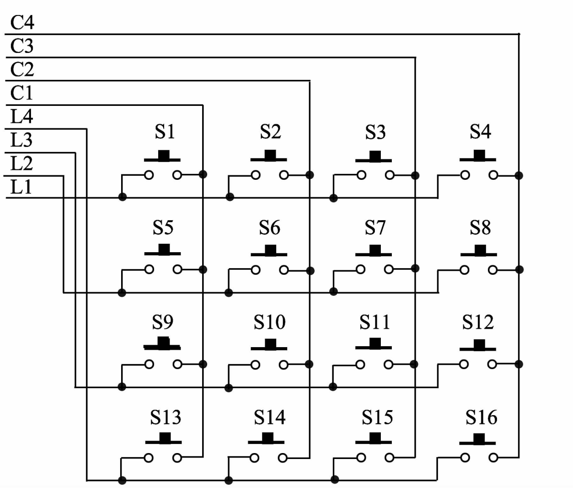

Fig. 4 The keyboard's schematic

3.4 Signal processing module

The receiving signal is very weak, easily disturbed by power frequency interference, high frequency interference and PCB wiring. So the circuit is expected to be high common mode rejection ratio, low noise and low price.

The circuit[5] is designed as shown in Fig. 5. The weak and noisy interference coupled signal firstly enters the low-pass filter which is made up of R8 and C2 to remove high frequency interference. When the sensor detects strong interference light, the output voltage signal there will change greatly. To avoid interference signals entering the LM324, the filter composed of C3 and R1 is used to smooth again. Operational Amplifier U2A will amplify the signal 50 times. Now, the output signal has become very smooth and the amplitude changes between 0 V and 0.5 V, but there is still some degree of voltage offset. Then the signal goes into a filter which is made up of C1 and R4. The Operational Amplifier U3A will magnify the signal again. Now the output signal has no interference, becomes relatively stable, and the amplitude ranges from 0 V to 4 V. The two Schmidt trigger will make the signal a standard square wave which can be recognized by the microprocessor. As shown in Fig. 6, this is a MULTISIM simulation diagram, and the input signal's duty ratio is 80%.

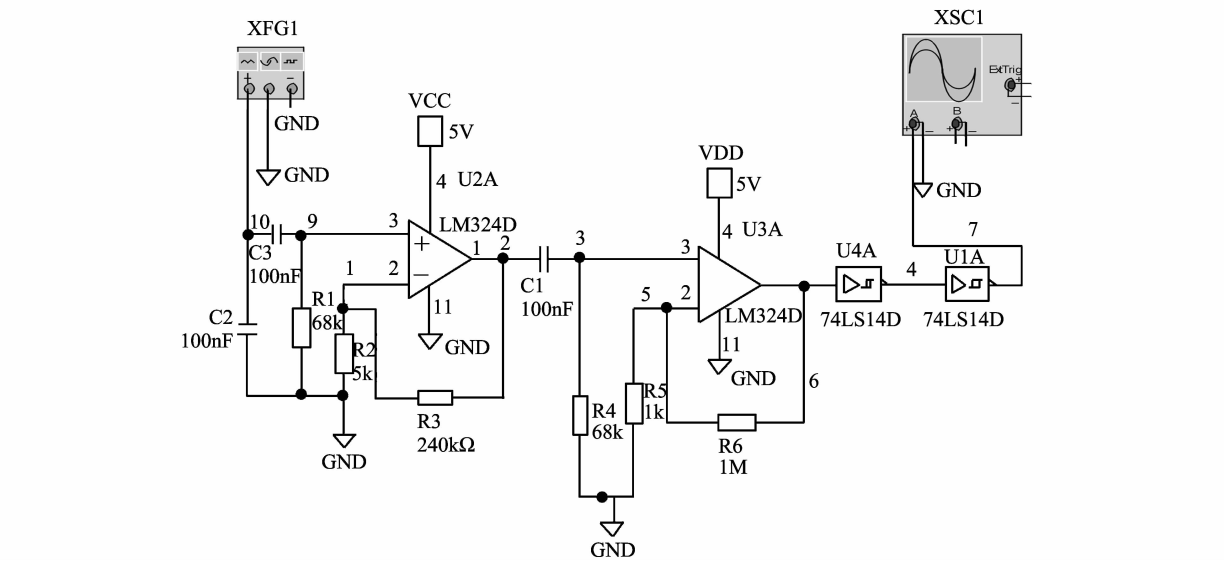

Fig. 5 The signal processing module

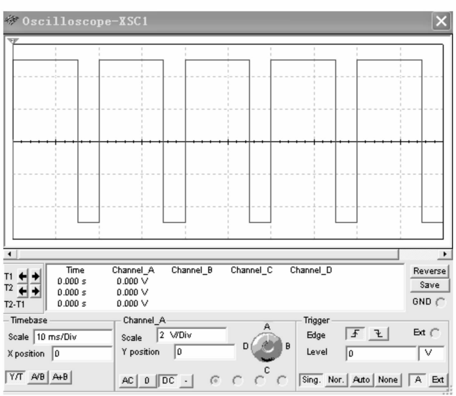

Fig. 6 The MULTISIM simulation diagram

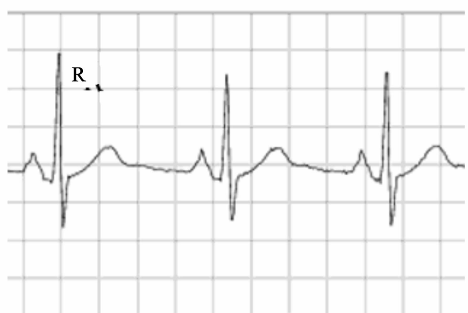

Fig. 7 ECG signal from MIT _ BIH standard library

4 Software design

4.1 Heart rate calculation

Firstly, the time between adjacent R waves is measured (as shown in Fig. 7), and then converted into heart rate. For example, the time between two R wares is T seconds. In that way, the heart rate is 60/T[6]. Part of the program is as follows.

```
for(i=0;i<=100;i++)
heartrate+=hearttime[i];
pingjun=heartrate/100;
for(i=0;i<=100;i++)
{fangcha+=(hearttime[i]-pingjun)*(heart
ime[i]-pingjun);
fangcha/=100;
}
heartrate/=1000;
heartrate=6000/heartrate.
```

4.2 Heart rate variability analysis

The most common and simplest method[7] to calculate heart rate variability is statistical methods. It can be calculated according to this mathematical formula

$$D = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(RR(i)-\overline{RR})^2}, \qquad (1)$$

where RR is the time between two R waves, $\overline{RR}$ is the mean of RR, N is the heart rate, D is an important index of the heart rate variability analysis. The greater the heart rate variability, the worse the situation. The normal value[8] is ranged between

50 ms and 100 ms.

4.3 The procedure flowchart

The main procedure flow is: When switching on the instrument, the machine will start initializing. Then select the working mode (voice guidance or key guidance). Follow on, the machine will measure the heart rate and calculate the HRV. Then it will display the results. Of course, it will alarm by voice if necessary.

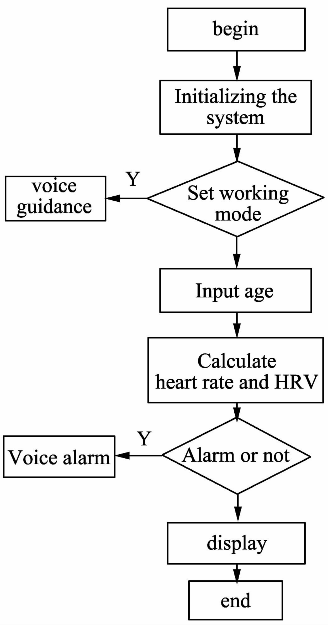

Fig.8 The procedure flowchart

5 Results and analysis

In order to verify the accuracy of the system, four men's heat rates are tested. The result is in the Tab.1. As shown in Tab.1, the result of the instrument's heart rate value is more accurate than the artificial result.

Tab.1 Table type styles(times/min)

No.	Artificial measured heart rate	Instrument's heart rate value	HRV values
1	62	62	0
2	78	79	1
3	90	91	1
4	101	100	2

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