A Portable Electrocardiograph System Design based on STM32 Chip

Tianyi Zhang*, Huating Liu

College of Electronic Information and Automation, Tianjin University of Science and Technology, 300222, China

*E-mail: * zhangtianyi085@163.com*

www.tust.edu.cn

Abstract

ECG monitoring instruments occupy an important position in the medical field of application.It has a great reference value for the testing of basic cardiac functions and its pathological studies. For the shortcomings of conventional ECG monitoring instruments and equipment, which are large and not easy to carry, this paper designs a portable ECG monitor. In this paper, we designed a portable infrared induction heart rate measurement device, using STM32C8T6 as the core chip, to complete the extraction and processing analysis of ECG signals. The complete set thus composed can make basic diagnosis of the collected data and is successfully applied to daily life.

Keywords: signal acquisition, digital signal process, embedded system, STM32

1. Introduction

With the progress of society, economic development and the gradual improvement of people's living standards, the aging of the population is becoming more and more serious. The incidence of heart disease is also on the rise. [1]. However, the prevention, treatment and control rates are still low due to limitations in detection methods. Prevention rates are a key factor in the effective prevention and treatment of cardiovascular disease. Effective and convenient ECG monitoring instruments are a powerful tool to accomplish this task.

Conventional ECG monitoring devices are bulky, expensive and not portable, and can only record ECG activity while the patient is lying down for a short period of time, obtaining very little information. In order to enable more convenient diagnosis in more settings, a great variety of portable ECG devices have emerged.

Portable monitoring device can monitor and store data anywhere and anytime. This paper mainly designs a portable ECG device, which collects ECG signals through sensors, performs processing operations such as filtering and enhancement by STM32 chip, and finally is displayed by the display. It has the features of low price, small size, easy to carry and easy to use.

2. General Design

By combining embedded technology, digital signal processing technology and signal acquisition technology, we design an embedded ECG monitoring system that can perform signal extraction and analysis functions. [5-8]

The whole system consists of six modules: signal acquisition module, signal process module, keypad module, display circuit module, PC communication module and MCU module. The system structure schematic diagram is shown in Fig.1.

The ECG signal is acquired by electrodes and subsequently sent to the ECG acquisition circuit. After processing by preamplification, main amplification, high and low pass filtering, the system gets the ECG signal that meets the requirements and sends it to the STM32 ADC for AD conversion.

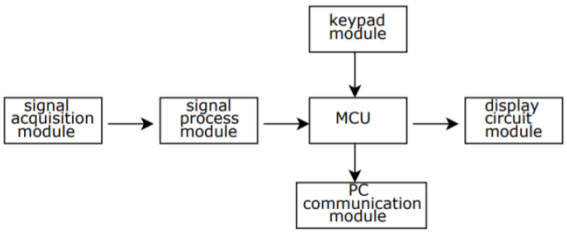

Fig.1. The system structure schematic diagram

The system control chip adopts STM32 and the display adopts TFT-LCD. Its touch function plus a small number of keys can establish a good human-computer interaction environment, which can be displayed and played back in real time by LCD. The data can be reliably transferred to a PC via USB for further analysis.

3. System Hardware Design

The hardware selected for the system includes the following two aspects: choice of processor and the human-machine interaction interface.

3.1. Choice of processor

The selection of the processor should consider five issues such as processing speed, complexity of the completed task, complexity of peripheral circuits, production cost and high power consumption.

Considering the above aspects, we finally chose STM32F103C8T6, a new 32-bit ARM core processor chip from STMicroelectronics, from the STM32 family. The main control chip is shown in Fig.2.

Fig.2. STM32C8T6 chip

In the design, the processor is responsible for signal acquisition, signal filtering and processing, display of ECG waveforms, data storage, and communication.

3.2. Human-machine interaction interface

Human-machine interface is a device for communication between human and machine, which can transmit human commands to MCU and also let the device display the information we want to know. This part of the display interface design choose color LCD screen, power consumption and size of the choice to combine the actual use.

According to the above points this design chose 3.2 inch true color TFT LCD touch screen, with 320 * 240 pixels, 260,000 colors, 16-bit parallel interface, it can be directly driven by AVR, ARM7, STM32 and other MCUs. The screen-related parameters are as follows:

- Resolution: QVGA 240 x 320
- Size: 3.2 inches
- Controller: IL9320
- Touch screen: 4-wire resistive type
- Pins: 30PIN
- Backlight: 4 LEDs in parallel

The touch screen is shown in Fig.3.

Fig.3 The touch screen

4. System Circuit Design

In the circuit design, this design adopts Pre-amplifier circuit, right leg driver circuit, filter circuit, trap circuit and power supply circuit. These modules greatly improve the function of the device.

4.1. Pre-amplifier circuit

The pre-amplifier circuit has to perform the function of differential signal amplification. this part of the circuit is crucial in the whole acquisition circuit, so it is necessary to choose a suitable differential op-amp chip. The following points are generally considered in the selection.

- Gain

- Frequency Response
- Common Mode Rejection Ratio
- Input Impedance
- Low noise, low drift

4.2. Right leg driver circuit

The right leg drive circuit is typically used in biosignal amplifiers to reduce common mode interference. Due to the large amount of external interference to humans, the capacitive coupling between the ECG electrodes and the power lines generates displacement currents[1].

We use a right-leg drive circuit, which can have a suppressive effect on 50Hz interference and does not come at the expense of losing the frequency component of the ECG signal.

4.3. Filter circuit and trap circuit

To filter out interference, a band-pass filter is designed so that ECG signals with frequencies from 0.05 Hz to l00 Hz pass through. signals outside this range will be substantially attenuated.

The active bandpass filter is used in this design. The bandpass filter is composed of a high and low pass filter with a high pass filter as of f=0.03Hz and a low pass filter as of f=110Hz.

Although the design of the right leg drive circuit, but there is still 50Hz interference into the circuit, so this design adds a 50Hz trap circuit. By this method to filter out the industrial frequency interference, the experimental results show that the signal waveform is clear and distinctive by high and low pass filtering followed by trap circuit.

4.4. Power circuit

The power supply circuit design mainly considers which type of power supply device to use, the input and output voltages, the output current, and the control state [15]. The ECG acquisition circuit requires a $\pm 5V$ power supply, the STM32 operates at 3.3V and this design is powered by a 7.2V battery.

5. System Software Design

Software Flow DiagramThe system software is divided into two broad parts.

(1) Lower computer software, i.e. STM32 application.It mainly completes the acquisition of ECG signals, signal filtering, RTC module, LCD display and serial communication, etc.; (2) the upper computer management software. Its function is to complete the reception and processing of data, which mainly includes the reception, display and storage of data [2].

Software Flow Diagram is shown in Fig.4.

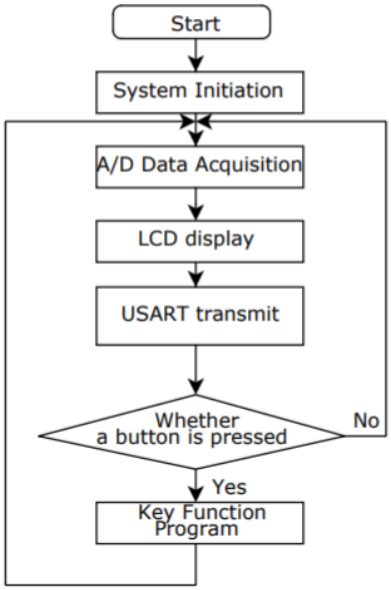

Fig.4. Software Flow Diagram

6. Conclusion

The system is a portable and miniaturized ECG monitoring system, using the cost-effective Cortex-M3-based STM32 chip as the microprocessor. Thus, we designed a portable ECG signal collector based on STM32 chip with real-time monitoring and low cost.

It is easy to carry the characteristics of storing data, can complete a long period of ECG monitoring, and real-time ECG waveform display through TFT-LCD color LCD, through the key to make the system has a good human-computer interaction interface. According to the debugging results, the system has completed the expected vision better and can collect signals from the human body and process and display them more correctly.

References

1. Zhou J . Elimination of Power-line Interference from ECG Signals. *Journal of Biomedical Engineering Research*, 2003.
2. Wang D X , Wang G J . Development of a portable ambulatory ECG monitor based on embedded microprocessor unit. *Space Medicine & Medical Engineering*, 2005, 18(3):196-200.

Authors Introduction

Ms. Tianyi Zhang

She is a second-year master candidate in Tianjin University of Science and Technology, majoring in brain-computer interface, machine vision.

Ms. Huating Liu

She is a second-year master candidate in Tianjin University of Science and Technology, majoring in flushbonading