A ECG Signal Gathering and Displaying System Based on AVR

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Abstract: This article introduces a kind of system which is based on the AVR to acquire the data of ECG. Such system using the A/D function of ATmega8 chip and the lattice graph LCD to design ECG heart acquisition satisfies the demands above. This design gives a composition of hardware and programming of software about the system in detail which has mainly realized the real-time gathering, the amplifier, the filter, the A/D transformation and the LCD display. Since the AVR includes A/D transformation function and support embedded C language programming, it reduces the peripheral circuit, further more it also decreases the time to design and debug this system.

1. Introduction

Cardiovascular disease is one of the major diseases that threaten human life, and ECG is an important basis for evaluating cardiac function. ECG is a common diagnostic tool commonly used in clinical disease diagnosis. Acquisition system of ECG data is a key component of electrocardiogram[1]. The frequency range of human ECG signal is 0.05 ~ 100Hz, amplitude is about 0 ~ 4mv, the signal is very weak. As the ECG signal is usually mixed other bioelectric signals, combined with 50Hz frequency interference in the main electromagnetic field interference, making the ECG noise background strong, so the measurement condition is more complex. In order to detect the clinical value of the clean ECG signal, often require ECG data acquisition system with high precision, high stability, high input impedance, high common mode rejection ratio, low noise and strong anti-jamming capability. With the widespread use of microcontrollers in the field of medical devices, computer - based ECG signal acquisition, processing and display systems have been widely used.

The amplitude of ECG signal is small, random and strong noise background, with intermittent and need to reflect the local changes in the characteristics (such as ECG QRS wave), the statistical characteristics of the signal is time-varying non-equilibrium signal. Therefore, whether the extraction signal, or the analysis of signal characteristics are very difficult to do. With the extensive application of computers in the medical field, PC-based ECG detection system has got more attention. In this paper, an intelligent ECG signal acquisition, processing and display system based on AVR microcontrollers is designed in combination with the actual needs and research hospital. The system enables real-time data acquisition and display, digital filtering and processing of raw data.

2. Purpose and content

This paper designed an intelligent ECG signal acquisition and display system uses ATMEL's AVR

microcontroller (ATmega8 chip) as a core device. Under the control of the AVR microcontroller, the system can record the ECG signal of the patient in real time and accurately, and can be clearly and accurately displayed by the hardware circuit[2]. This article discusses the ECG acquisition human, ECG signal amplification, filter processing, using a signal processing chip ATmega8 finished performs A/D conversion, the signal is eventually processed by LCD（GXM12864）.

3 Overall design ideas

3.1 Design
According to the practical problems to be solved, the design idea, design principle and design block diagram of the system are put forward. The hardware structure of the design system is divided into three parts and the flow chart is show in the figure 1:

- ECG signal acquisition part, this part is use of connection multi-parameter patient simulator with the right leg drive circuit;
- The amplification and filtering part of the ECG signal, in which the amplification part is composed of preamplifier and secondary amplification, and the filter circuit is composed of band rejection filter and low pass filter.
- A/D conversion of ECG signal and liquid crystal display part are the core of the design system. Use ATmega8 chip built-in analog-digital conversion function to achieve ECG signal A/D conversion. ECG signal converted into the digital signal can be displayed through the ATmega8 chip and LCD.
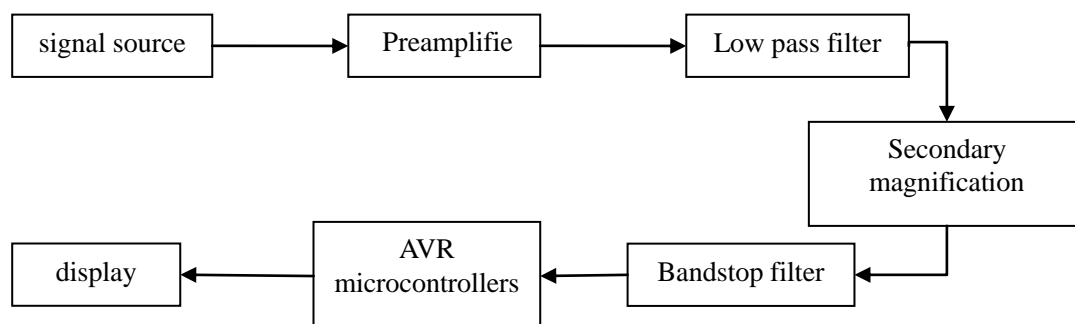

Figure 1. The overall design diagram

3.1.1 Main problem.
The main problem of this design system is need to filter out 50Hz frequency interference by using the μA741 notch filter.   In addition, ECG signal is real-time changes, so the zoom, filter and display systems should also be real-time.

3.1.2 Hardware circuit design ECG signal acquisition
ECG signal is a low-frequency weak signal, there is a strong interference detection, mainly 50Hz frequency interference. This requires the choice of devices and design of the circuit has a strong anti-interference ability. In this experiment, AD620 amplifiers, operational amplifiers LF365, OP27 and μA741 were selected.

- ECG signal preamplifier and secondary amplification

Preamplifier is the key part of ECG data acquisition. Because the human ECG signal is very weak, the background noise is strong and the signal source impedance is large, and the polarization voltage difference introduced by the electrode is larger than the amplitude of the ECG(A few hundred times greater than the magnitude of ECG). Therefore, the preamplifier is usually required to have a high input impedance, common mode rejection ratio is low, low noise, low drift, non-linearity, the appropriate frequency band and dynamic range performance, the design is generally used differential amplifier circuit. The first stage preamplifier circuit consists of AD620 and LF356. The AD620 bear

the amplification function making the ECG signal amplification of more than 30 times[3], through the R4 to adjust the magnification; The LF356 is composed of the right leg drive circuit, to further improve the circuit's anti-jamming capability, which is a feature of ECG detection method. This design uses the instrument amplifier AD620 as a preamplifier. AD620 having a low input bias current, low noise, high-precision, high settling time, and low power consumption characteristics, common mode rejection ratio is up to 130dB, very suitable for use as medical instruments preamplifier. The gain is adjustable (range 1 to 1000 times) and can be determined by the formula G = 1 + 49.4kΩ / R4. To prevent the preamplifier from operating in the full and / or cutoff area, the gain can not be too large. Experiments show that: about 30 times better. Common body signal can be detected through OP27 be used to drive the wire shielding layer to eliminate the distributed capacitance, improve the input impedance and common mode rejection ratio. The common mode signal of human body can be amplified with the "floating" drive circuit used to stimulate the human right leg, thereby reducing or even offset the common mode voltage, in order to achieve a purpose of strong 50Hz frequency interference. OP27, LF356 is mainly used to stabilize the input signal and improve the input impedance, to further improve the common mode rejection ratio. The magnification of the preamplifier circuit is:

$$G = 1 + \frac{49.4k\Omega}{R_4} = 1 + \frac{49.4k\Omega}{1.7k\Omega} = 30 \tag{1}$$

ECG signal comes from amplifier circuit about 1mV or so, preamplifier circuit will amplificate ECG signal for 30 times. Since the circuit need to be A/D conversion after amplified and filtered, the A/D conversion function in AVR microcontroller requires the input signal amplitude for 0 ~ 5V. So the second stage amplifier circuit needs to amplify 100 times, the total magnification is 3000 times, ECG AVR microcontroller is about 3V. The magnification of the second stage amplifier is:

$$G = \frac{R_8}{R_7} + 1 = \frac{4.56K}{470} + 1 = 100 \tag{2}$$

- Electrocardiogram filtering

As the ECG signal is usually mixed with other bio-electrical signals, ECG background noise is strong, the measurement conditions are more complex. In order to detect the clinical value of clean ECG signal without distortion, the ECG data acquisition system has high accuracy, high stability, high input impedance, high common mode rejection ratio, low noise and strong anti-interference ability, etc. The main function of this filter circuit is to filter out the 50Hz frequency interference, so that ECG signal can be clearly displayed.

$$\text{cut-off frequency:} \quad f = \frac{1}{2\pi RC} = \frac{1}{2\pi R_{13}C_5} = \frac{1}{2\pi 1500 \times 10^{-6}} = 106 H_z \tag{3}$$

- Design of Interface Circuit between LCD and AVR Microcontroller

The interface circuit is shown in Figure 2: the ECG signal after amplifying and filtering from the input port PC0; PC1, PC2, PC3, PC4, PC5 port of ATmega8 combine with the control port of LCD for input control signal; PC6 port connected to a reset circuit ; PB port is the two-way input and output to control the LCD waveform display; INT0, INT1 are connected with the switches K2, K1 respectively.

The whole circuit work process: After power on, there will be a graphical interface selection. It will conduct A/D conversion through the A/D conversion function built-in ATmega8 when the PC0 port accesses analog signal after acquisition (after amplification, filtering) the chip[4]. The converted digital signal is output to the LCD display via port PB. INT0 and INT1 two interrupts are used to control the selection of the program entry. Capacitors C2, C3, C4 role for the A/D conversion to provide a stable reference element, so that A/D conversion of the data is more accurate, or due to the instability of the reference element, will make A/D conversion data not accurate, thus resulting in distortion of the output waveform, affecting the user's observation of the waveform.
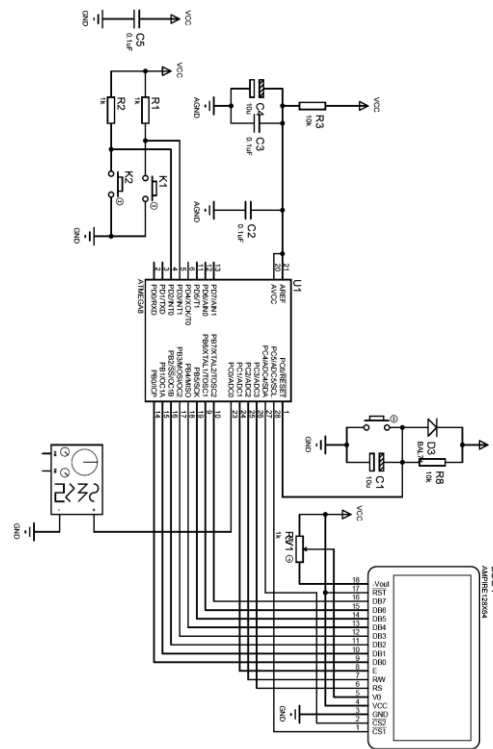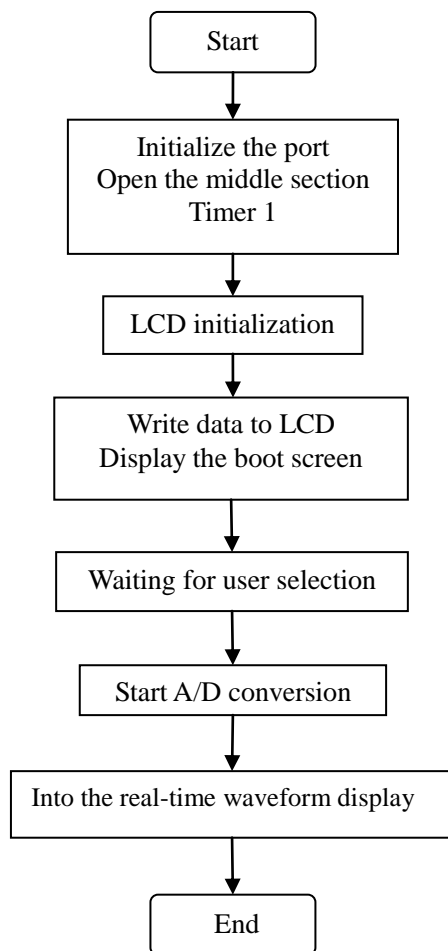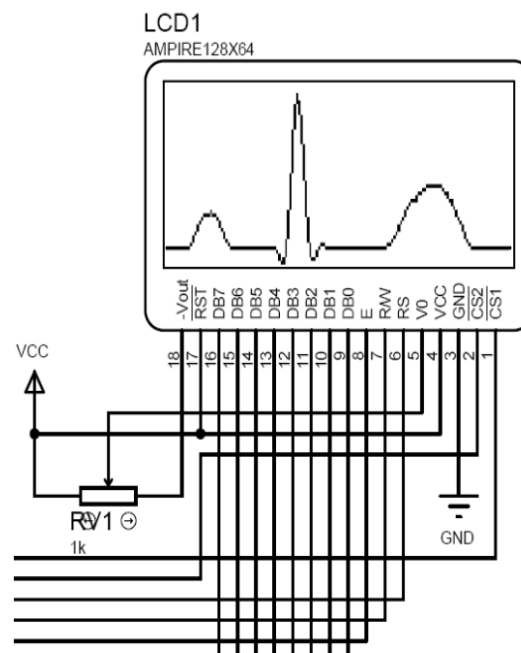
Figure2. Interface Circuit

3.1.3 Software circuit design. The focus of the software design is on the LCD module drive. Since the GXM12864 contains a controlled drive, it is necessary to know the instruction set of the controller and how to use it. In this design, a major part of the collected ECG signal is real-time A/D conversion and display[5]. As the GMX12864LCD itself consists of eight pages, you must press the page, press the column, press the left and right half-screen display control. In order to ensure the continuity of the display waveform, in each display must ensure that the two points between the LCD part to show all. And in order to control the exit of normal display, in the display of the death cycle by adding a control flag to control it can be promptly exit, exit and return to the main program.

As the liquid crystal itself read and read out the time delay, single-chip A/D conversion delay and program execution time delay, the final output of the waveform frequency limit below 140Hz. But because the frequency of ECG signal between 0.05Hz to 100Hz, so fully meet the ECG signal display[6].

ATmega8 has a 10-bit successive comparison of ADC. The ADC is connected to an 8-channel analog multiplexer capable of sampling 8 single-ended voltage inputs with the PORTC port as ADC input pins. See the main program flow chart figure 3. And figure 4 is ECG waveform display results.

Figure3. Main program flow chart   **Figure4.** ECG waveform display results

4. Conclusion

This article designed an acquisition module based on the characteristics of the ECG signal. The use of pre-differential amplifier circuit configured by AD620 can amplify ECG signal for 30 times. Because ATmega8 built-in A / D conversion function requires the input signal amplitude of 0 ~ 5V, therefore, need to be composed of μA741 as secondary amplifier circuit to amplify ECG signal for 100 times. This ECG signal is amplified 3000 times, access AVR microcontroller ECG signal is about 3V. As the ECG signal is usually mixed with other bio-electrical signals and 50Hz power frequency interference, the use of dual T-band filter and a low-pass filter filter out 50Hz frequency interference and other high-frequency interference signal. Pre-processed ECG signals with AVR microcontroller performs A/D conversion, and through the embedded C language programming and LCD liquid crystal display (GXM12864) interface to achieve ECG waveform display.

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