

Design of Portable Wireless Electrocardiogram Monitoring System

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Abstract. Cardiovascular disease is a major disease that seriously threat to people's health and life. And such diseases often have unexpected features. If it can't be timely detected and treated, it will have very serious consequence. So on cardiovascular disease in care becomes particularly important. This thesis investigate an ECG Monitoring System that based on a wireless transmission technology. The system contains three parts: ECG pretreatment, wireless transmission and central control. The ECG signal that from ECG collection device be pretreatment and by microcomputer control to complete A/D conversion, then wireless transmission chip nRF905 will send out the signals; wireless transmission chip nRF905 will receive the signal and transmitted to PC for analysis, complete ECG guardianship. The design is aimed at using wireless transmission to replace cable transmission, enable patients in free activities at the same time by the guardianship, it is also the innovation of this thesis. This thesis describes the design of the ECG monitor with portability and low power consumption advantages.

1. Introduction

As mankind enters the 21st century, people are facing unprecedented pressure of life, followed by the high incidence of various cardiovascular and cerebrovascular diseases. Such diseases are often accidental and sudden, if not detected and treated in time, it will have very serious consequences, which makes the demand for ECG monitoring equipment increase greatly. With the rapid development of science and technology, ECG data can be sent to ECG monitor through the largest Internet network in the world. At the same time, with the development of IC technology, the debugging and design of radio frequency module become simple. Nowadays, single-chip RF chip can easily realize low-cost, low-power, long-distance wireless transmission and strong anti-jamming ability. Small size, low-power CPU is a single-chip. Portable ECG collector provides strong processing capability.

Based on the above research and analysis, this topic will develop a portable real-time wireless ECG monitoring system with interactive function, which enables patients to move freely within a certain range while conducting ECG monitoring[1]. This system has strong applicability, and will not affect the daily life of patients during the whole monitoring process. This wireless portable ECG monitor system can be widely used in families. It can monitor the real-time ECG of patients with heart diseases. It also promotes the development of family health care. It plays an extremely important role in improving people's quality of life and promoting the coordinated development of social health.



2. Purpose and content

This design studies the wireless transmission of signals in portable ECG monitoring system. The main research contents are as follows: on the basis of researching bioelectric signals, the front-end amplification module of ECG collector is designed by choosing appropriate parameters of electronic devices to amplify weak signals; the filtering theory is studied; the hardware filter circuit and A/D conversion circuit are designed according to the frequency range of bioelectric signals; and the portable collector is dried by analyzing signal input, power supply and grounding. Relevant elimination measures are taken to improve the reliability of the system; antenna design theory is studied, and a microstrip ring antenna is designed with a single RF chip nRF905 to maximize the use of transmission power and improve the transmission distance [2].

ECG signal collector is an important equipment in ECG monitoring system. Its quality plays a decisive role in the success of the whole system. Traditional ECG monitors are seldom used in ordinary families. The key factor is the high price. This design uses AD620, ATmega8 and nRF905 chips, aiming at reducing costs and bringing more practical and convenient use to patients on the basis of satisfying the intellectualization and convenience of ECG monitor, which is also the main innovation of this scheme.

3. System Overall Design

3.1. General Requirements

Because the ECG signal is very weak, unstable and easily disturbed by external noise, the portable ECG monitoring system studied in this paper has the following requirements:

- 1) High accuracy (more than 90%) and small deviation between measured and actual values.
- 2) High input impedance (180M), so that the measured signal does not distort.
- 3) High sensitivity (10mm/mV) makes it more responsive to weak ECG signals.
- 4) Appropriate frequency response (0.05-100Hz) ensures that the ECG signal has a flat response in the passband.
- 5) Low drift (0.6 V /C) to prevent amplifier saturation.
- 6) High common mode rejection ratio (> 100dB) makes the amplifier have strong ability to suppress common mode interference.
- 7) Small size (750cm³), to ensure that the system function is perfect on the basis of cutting down the hardware circuit, the realization of portable system design.
- 8) Low power consumption (5V DC power supply can supply power continuously for 10 hours), so as to meet the requirements of long-term battery power supply in the system.
- 9) Transmission distance (1000 meters) to meet the communication requirements of patients when they move freely in the community.

3.2. ECG signal acquisition module

The ECG collector of this system takes the form of three leads to extract human ECG signals, and the right leg driving circuit is designed to reduce the interference of displacement current. Common mode feedback cancellation circuit can effectively suppress 50Hz power frequency interference. Because the skin impedance of human body is very large, the preamplifier uses the instrument operational amplifier AD620 with high input impedance, high common mode rejection ratio and low noise. The second stage amplifier circuit is composed of OP27, whose amplification factor can be adjusted to facilitate ECG signal pickup. In order to eliminate 50Hz power frequency interference, T notch filter is adopted to design [3]. The output impedance is minimized by impedance transformation of two A741 voltage followers, and the whole ECG acquisition module circuit is designed by adding a first-order low-pass filter.

3.3. Wireless Transmission Module

The ECG signal in this portable ECG monitoring system is transmitted by wireless to PC. At present,

the existing wireless transmission technologies are home RF, Bluetooth and ZigBee, but Bluetooth transmission distance is short, the above technologies can not be completely unified, the cost is difficult to reduce, and so on. There are few applications. And the wireless on-chip system, which is rising in the field of short-distance communication, has been widely used. This paper chooses the nRF905[4] wireless communication chip developed by Nordic Company of Norway to realize wireless data transmission. It is a miniature, low-power, high-speed wireless transceiver data transmission module. In addition, nRF905 has the characteristics of carrier detection, address matching, data readiness, automatic repeat, low power receiving mode and so on.

3.4. Central Control Module

Because the ECG monitoring system is portable and modular, the hardware circuit space should be reduced as much as possible. ECG signal is pre-processed by ECG collector and needs A/D conversion to realize wireless transmission by MCU control. If single A/D converter is used, hardware design circuit will be increased. So this paper chooses ATMEL AVR MCU-ATmega8, which has integrated analog-to-digital conversion function internally. Therefore, direct programming of ATmega8 can realize A/D conversion and wireless transmission control function. It also saves hardware circuit space. In addition, ATmega8 has high performance and low power consumption. It has advanced RISC reduced instruction set, and it integrates a large capacity of non-volatile programs and data memory.

Based on the above design ideas, the system consists of the following parts, as shown in Figure 1.

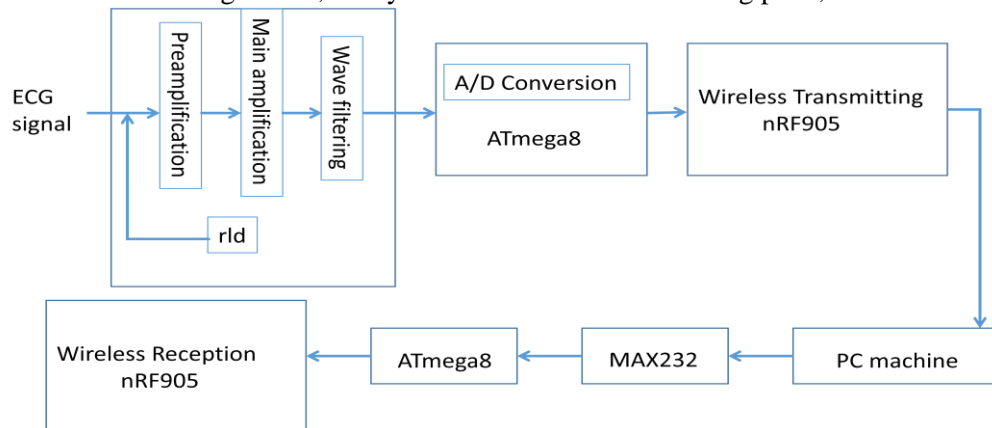


Figure 1. System block diagram

4. Design of Wireless Transmission Module

nRF905 monolithic wireless transceiver works in 433/868/915MHz ISM band. It consists of a fully integrated frequency modulator, a receiver with a demodulator, a power amplifier, a crystal oscillator and a regulator. ShockBurst mode is characterized by automatic generation of preamble and CRC. It can be easily programmed by SPI interface. The current consumption is very low. When the transmitting power is -10dBm, the transmitting current is 11mA and the receiving current is 12.5mA. It is easy to save electricity when entering POWERDOWN mode. Its internal structure is shown in Figure 2.

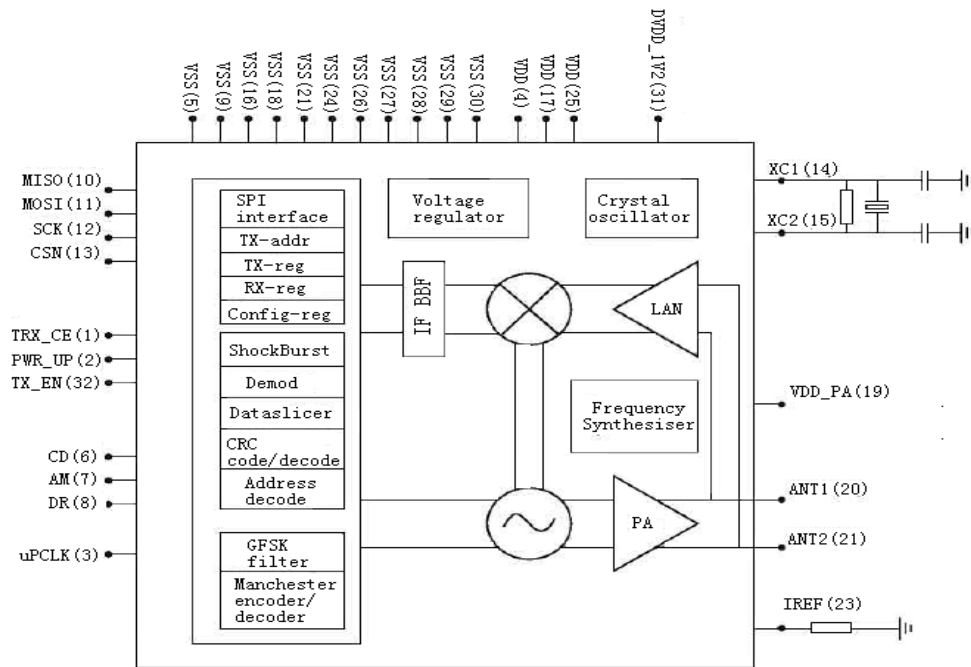


Figure 2. Internal structure of wireless on-chip system nRF905

The circuit connection diagram of wireless module [5] is shown in Figure. 3. It is mainly composed of wireless on-chip system nRF905, peripheral components, ring antenna and interface. From the circuit diagram, it can be concluded that the peripheral components are very simple, mainly some capacitors, resistors and inductors. Therefore, the main problems in the design are the design of the annular antenna and the wiring of the circuit board.

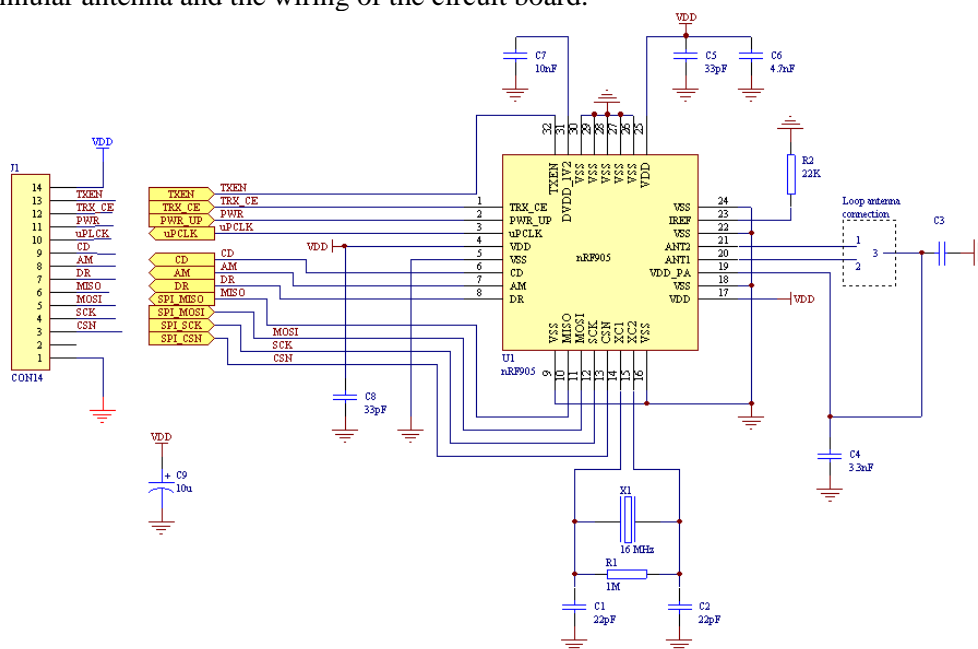


Figure 3. Reference design of wireless module

5. Conclusion

This design not only allows the attending doctor to obtain the patient's ECG data in real time, but also

allows the patient himself to observe at home according to the doctor's instruction. The patient can get ECG monitoring without going to the hospital, thus greatly reducing the cost of monitoring. At the same time, the limited medical resources are saved, so that doctors can get rid of the heavy auxiliary work, concentrate on providing patients with medical diagnosis and treatment programs, and leave some auxiliary nursing work to patients' families.

In recent years, with the rapid development of Internet, IC integration technology and wireless communication technology, it is possible to develop and popularize portable wireless ECG monitor system. The advantages of the system are low cost, low power consumption, and the ability to interact with medical centers.

In this paper, the basic problems of portable wireless ECG monitor system are discussed and the design principle of the system is described in detail.

1) Portability design: ATmega8, a low-power AVR microcontroller from ATMEL Company, is used as the core control unit of ECG acquisition. It has 1K RAM on chip, which can save the space occupied by expanding RAM, and also has its own analog-to-digital conversion function to reduce the power consumption and volume of the collector.

2) Long-distance wireless transmission design: In order to ensure that portable ECG monitor can be used freely within 1000 meters, the latest low-power, small-package wireless monolithic RF chip nRF905 is adopted. This makes the EMC performance of the RF module outstanding, and can reduce the interference of the RF circuit to the lowest level.

3) Anti-jamming technology and filtering technology: Using T-notch filter design, differential input and right leg drive technology, noise and 50Hz power frequency interference are effectively suppressed.

The main innovation of this design is that the ECG monitor system is modularized by the latest communication, computer and IC technology, which realizes the low power and small volume design of the acquisition terminal, and puts the large and high power network connection on the intelligent terminal equipment to realize long-term real-time tracking. In addition, with the development of family medical service in China, this product is widely used in the family because of its good portability, low power consumption, good performance and low cost. Real-time ECG monitoring for people with heart diseases is of great significance to improve people's quality of life.

Research Topics of Beihua University Student Innovation and Entrepreneurship Project: Detection device of accident vital signs.

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Research Topics of Education and Teaching Reform in Beihua University: The research and practice of "virtual Simulation online and offline" two-in-one practical education mode of medical workers' integration in new subjects.

Research Topics of Education and Teaching Reform in Beihua University: Research and Practice on Course Design of Medical Physiology and Engineering under the Background of Cultivating Innovative Talents.

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